Unit 25: Land Navigation VII: Communicating Location (Grids and GNSS)
Date Last Updated: February 19, 2020

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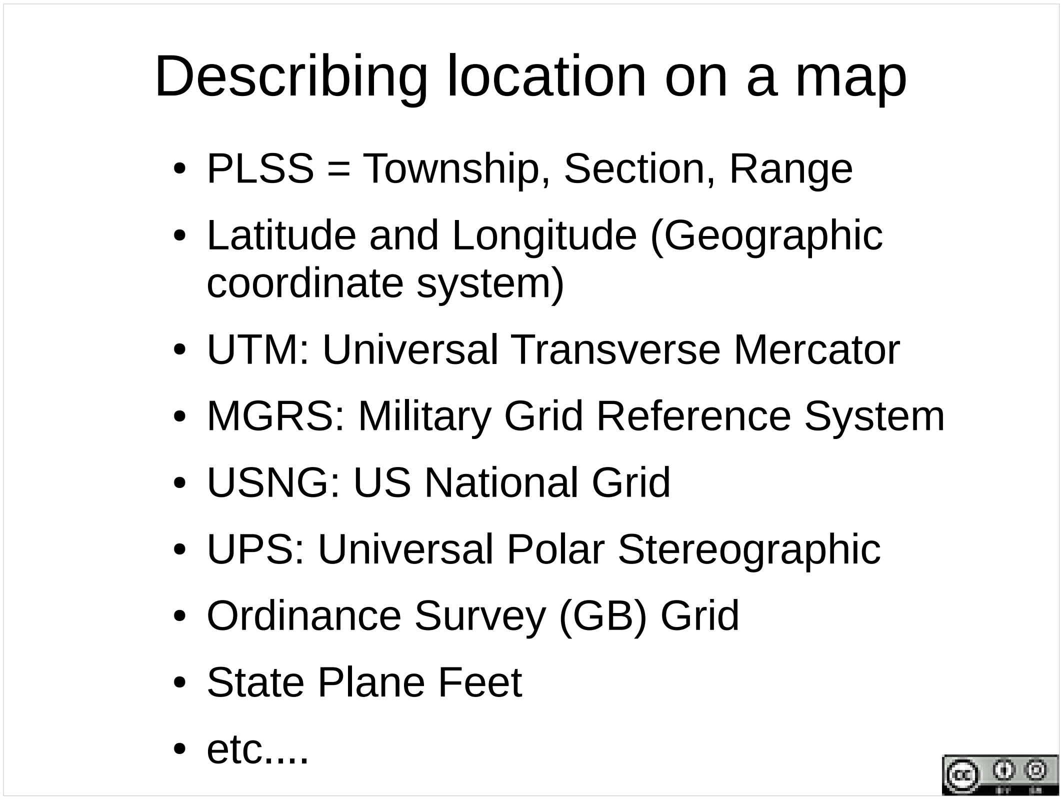
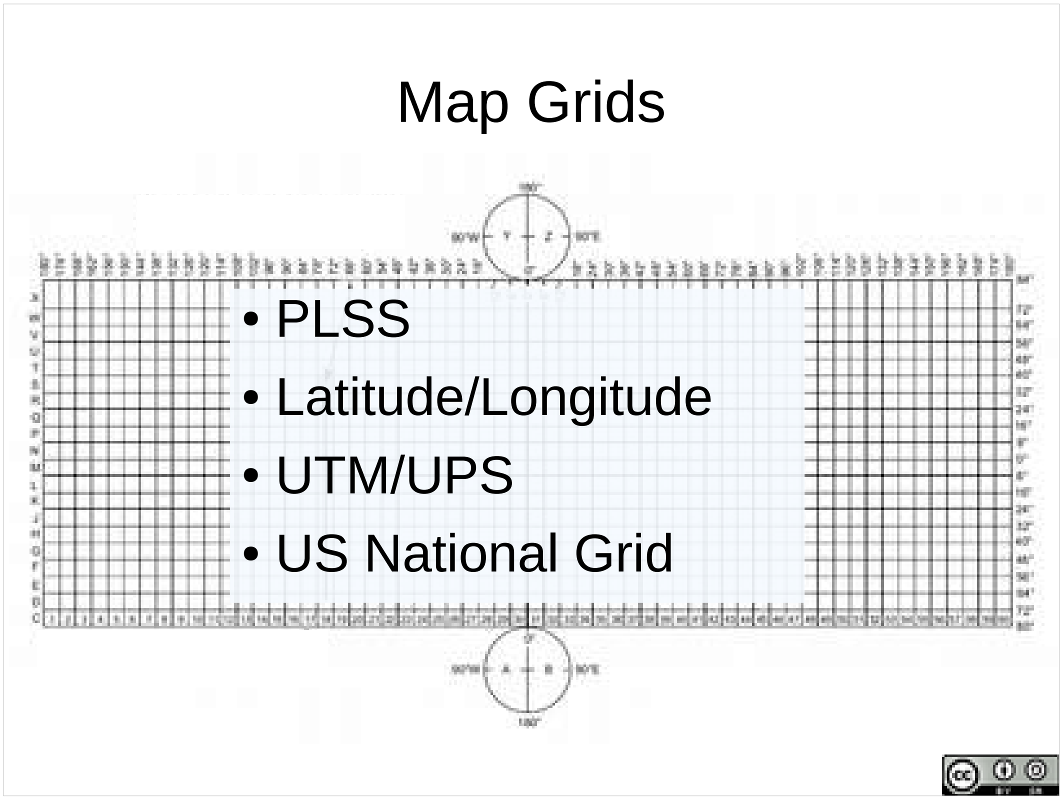


There are many ways to describe a location on the surface of the Earth.

Most place some sort of a grid on the map.

Some are only used in some parts of the world, some can be used anywhere.



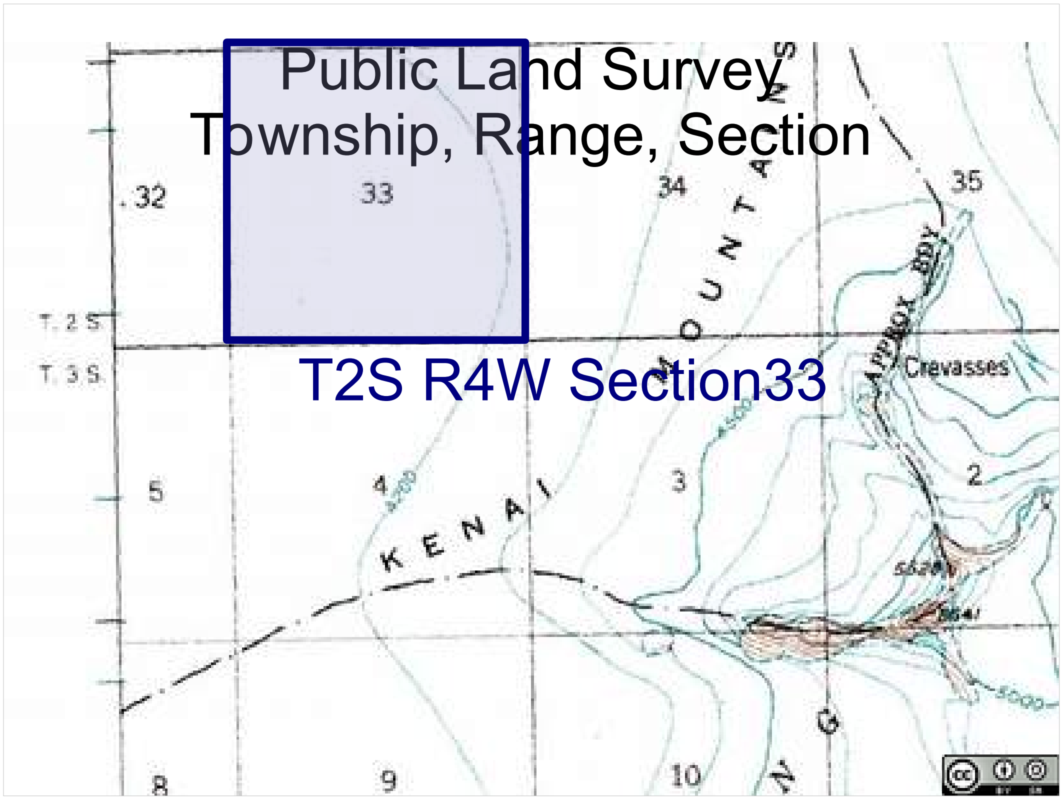
We will look at a few of them.

Public Land Survey System (Township/Section/Range) widely used in the central US and Canada. A regional grid.

Latitude and Longitude. One grid for the entire world.

UTM: Universal Transverse Mercator. The whole world in 62 grid zones *(60 zones, plus 1 UPS zone at each pole)*.

and a variant of UTM: US National Grid. Defines ways to simplify UTM coordinates.

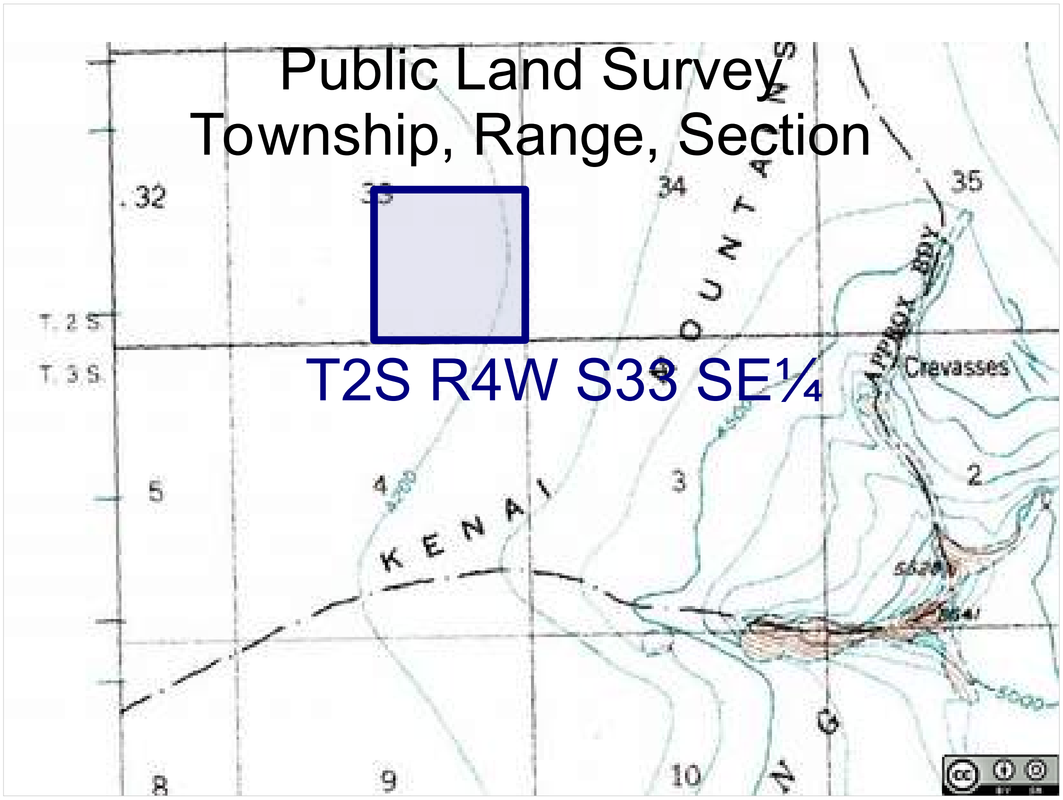


The Public Land Survey System divides portions of North America into a grid of east-west Township lines and north-south Range lines. Township and Range lines are each 6 miles apart from each other and form a grid of 36 square mile squares (these run off of baselines, thus Township 2 South is the second township south of some baseline).

Each Township/Range is divided up into 36 one mile squares called sections. The sections are numbered (with one pattern in the US and a different one in Canada).

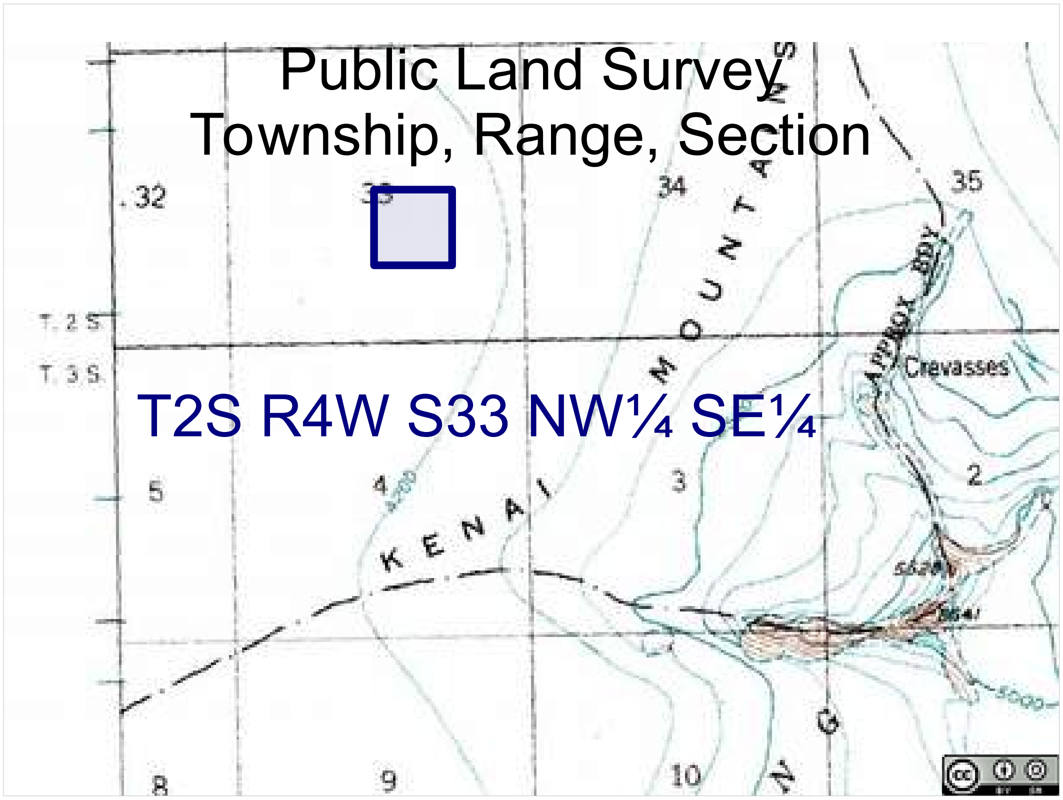
A single one mile square can thus be referenced by township, range, and section: Township 2 South, Range 4 West, Section 33.

(Locations aren't unique, there are multiple baselines).



To describe a position more precisely than a one mile square, sections can be divided into quarters.

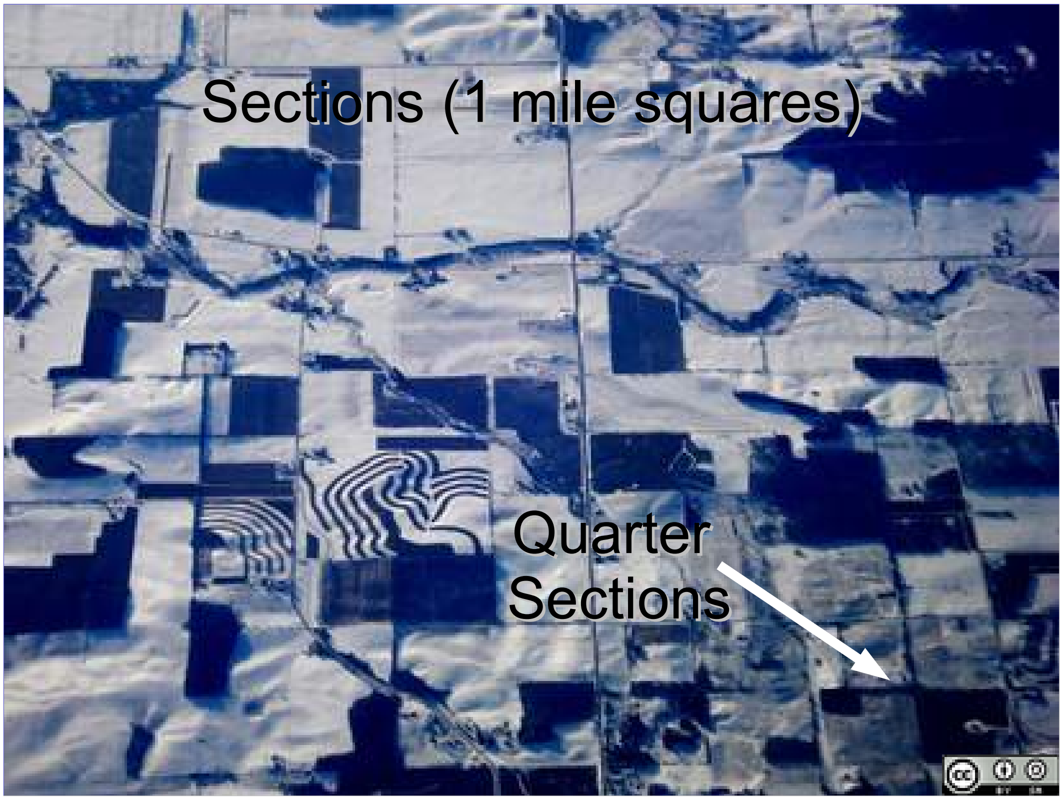
Here is the South East quarter of Township 2 South Range 4 West Section 33.



Quarter sections can be further divided into quarters.

North West quarter of the South East quarter of Township 2 South Range 4 West Section 33.

And so on.



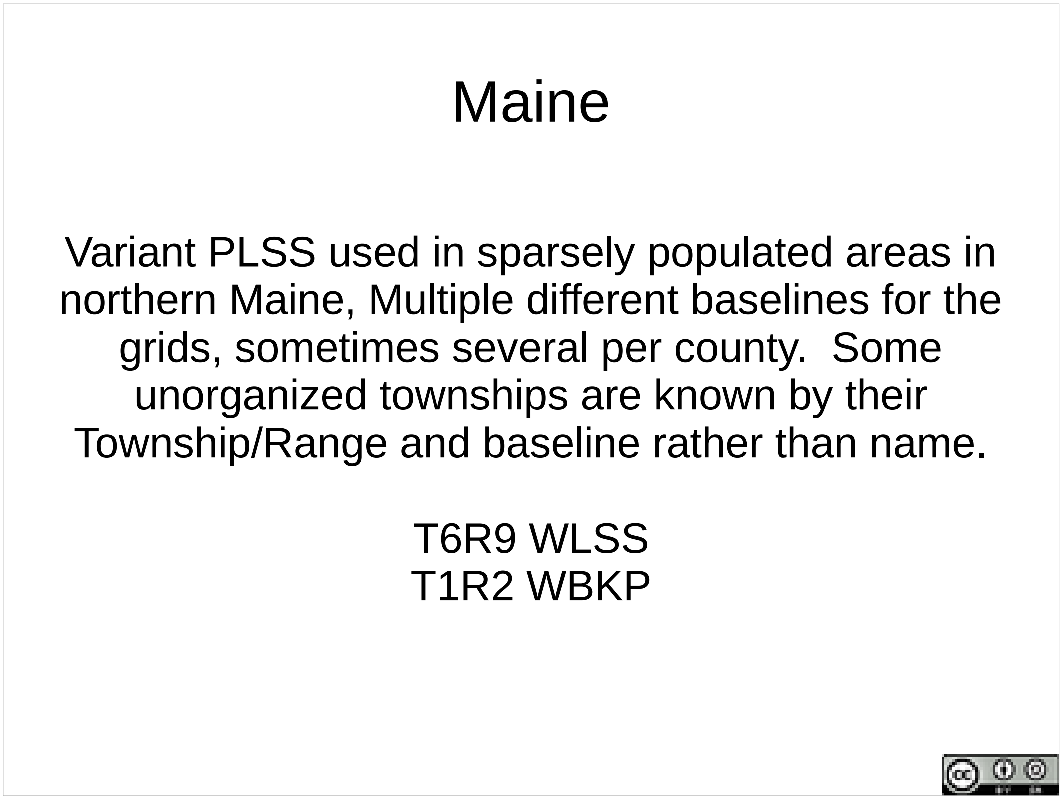
You fly over the middle of the country and you see the PLSS grid laid out on the ground in roads and fields.

The PLSS dates from the time of settlers moving west.

In the central US and Canada, the grid has the advantage of being laid out physically on the ground with roads, fences, and fields.

There are multiple other regional grid systems in use in the world, PLSS is unusual in that humans made roads along the grid lines – there is a physical grid on the ground.

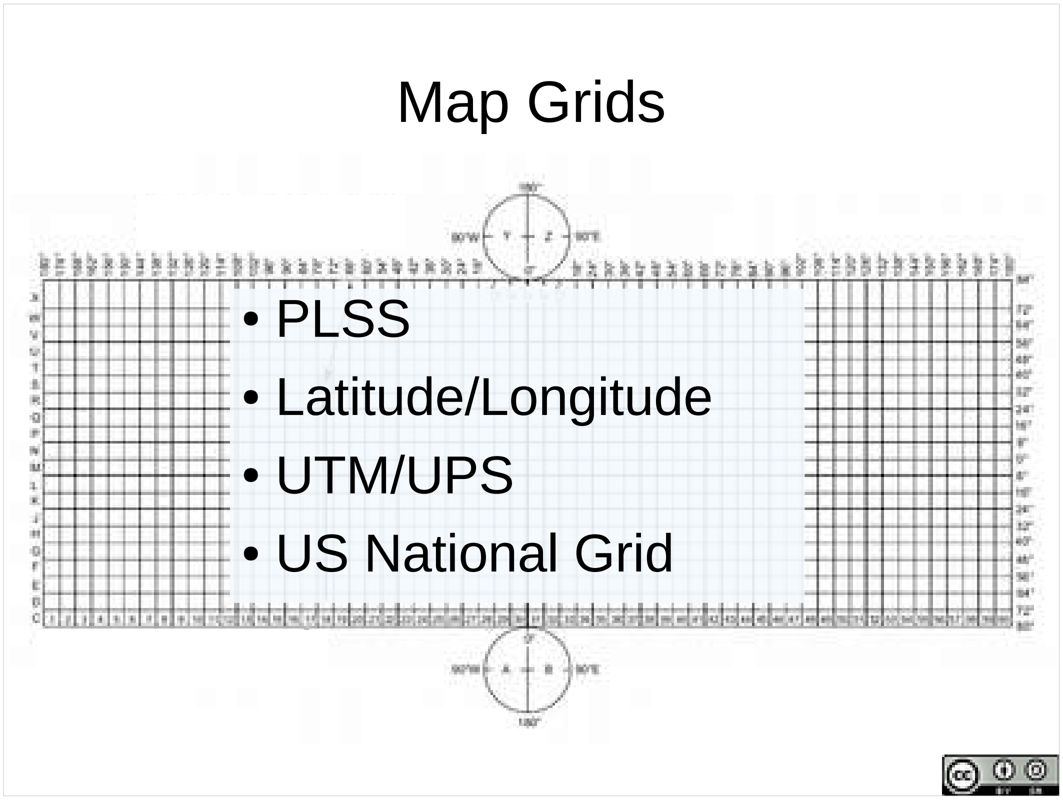
What use in New England?



None, except in some parts of rural Maine.

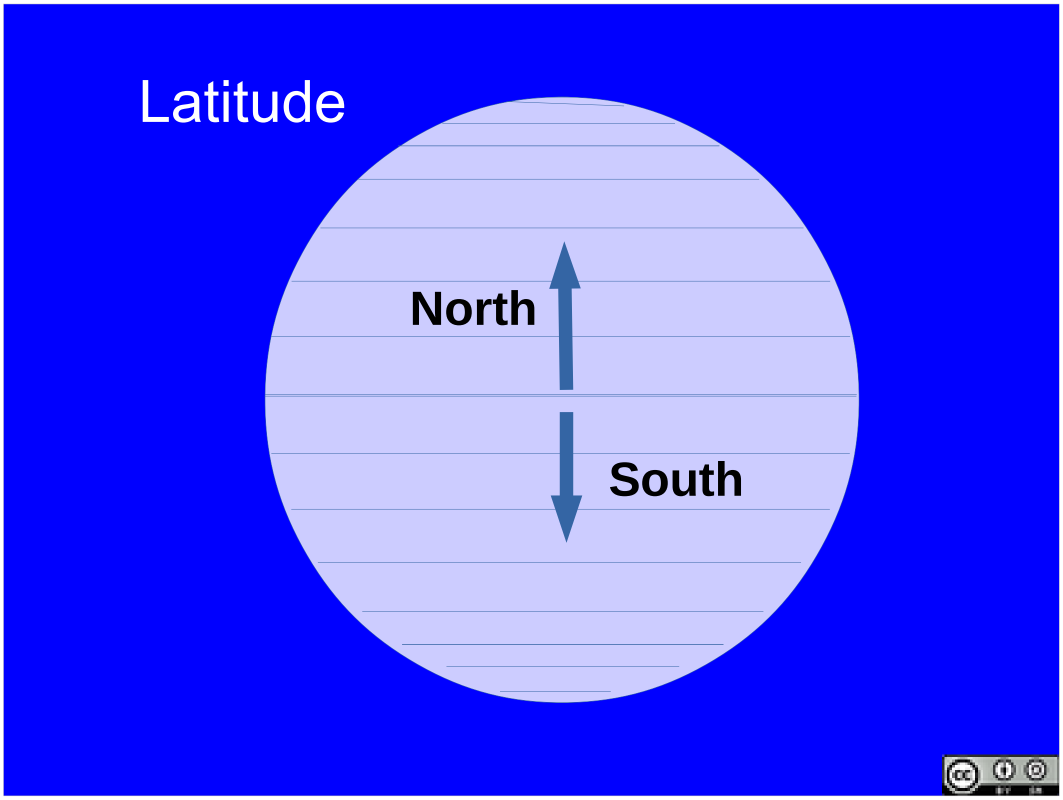
There are unorganized townships in Maine known by their Township and Range, not by name.

T6R9 WLSS refers to a 36 square mile area, Township 6 Range 9 off of the WLSS baseline.



Next: Latitude and Longitude.

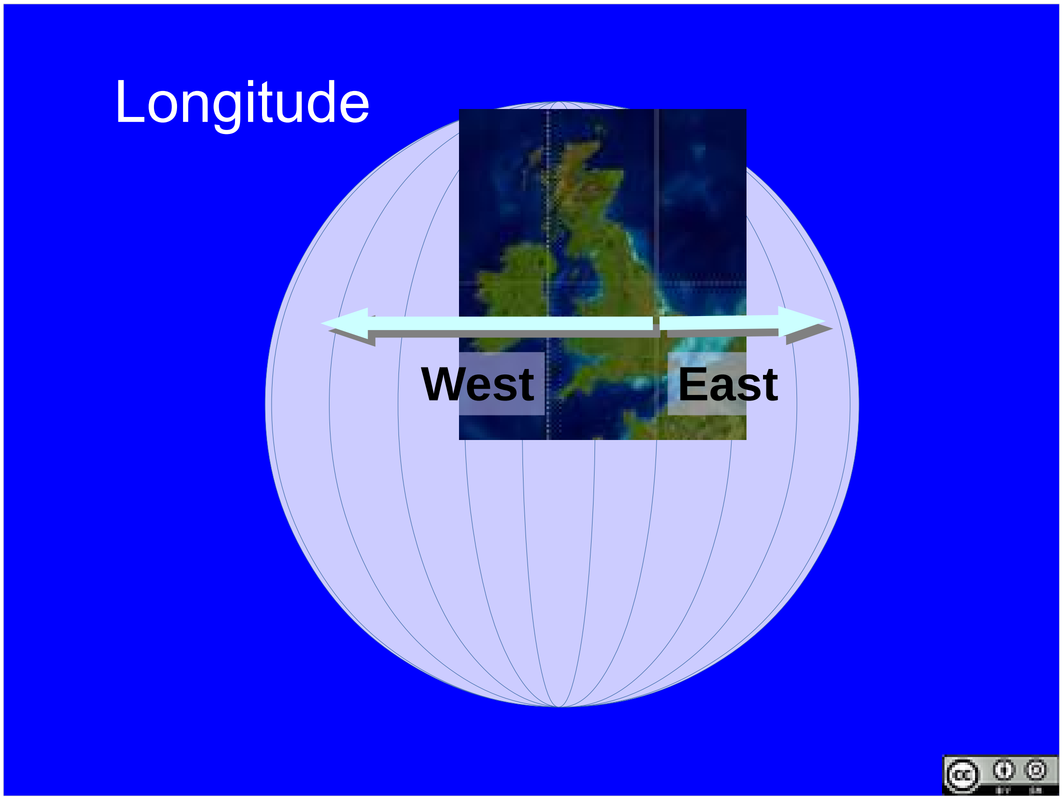
Latitude and Longitude allow you to describe your position anywhere on the surface of the Earth with a pair of numbers.



Latitude is position north or south of the Equator.

Equator is 0 degrees. North pole is +90 degrees. South pole is -90 degrees.

Lines of Latitude are evenly spaced on the surface of the Earth. One degree of latitude is 60 nautical miles (or 69 miles or 111,194 meters). (one minute of latitude is one nautical mile thus 1.85 km, one second of latitude is 1/60th of a nautical mile thus 30.8 meters).

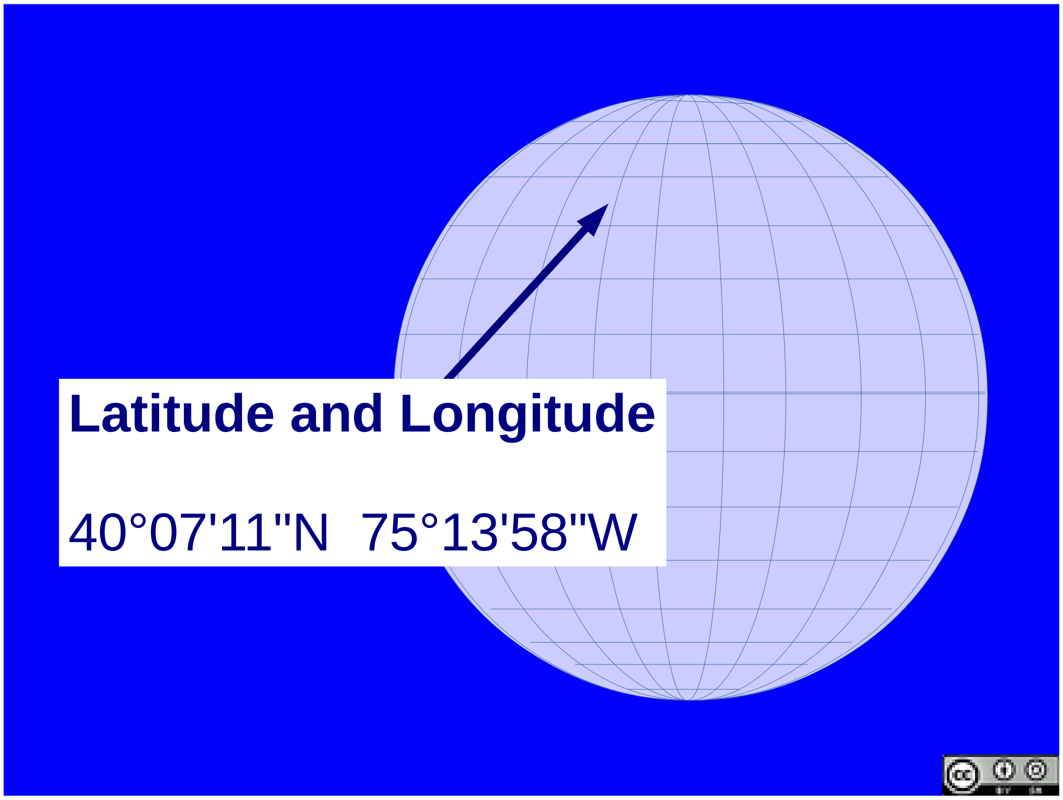


Longitude is position East or West of an arbitrary line (which runs through Grenwich, England). Lines of longitude are called meridians.

Longitude is conventionally a number in the range 0 to 180 degrees West or 0 to 180 degrees East.

Meridans converge towards the poles, so the distance represented by one degree of longitude varies depending on how far the position is from the Equator. At the Equator, one degree of longitude is 111,194 meters (or 60 nautical miles). Move north or south and this gets smaller (just for longitude).

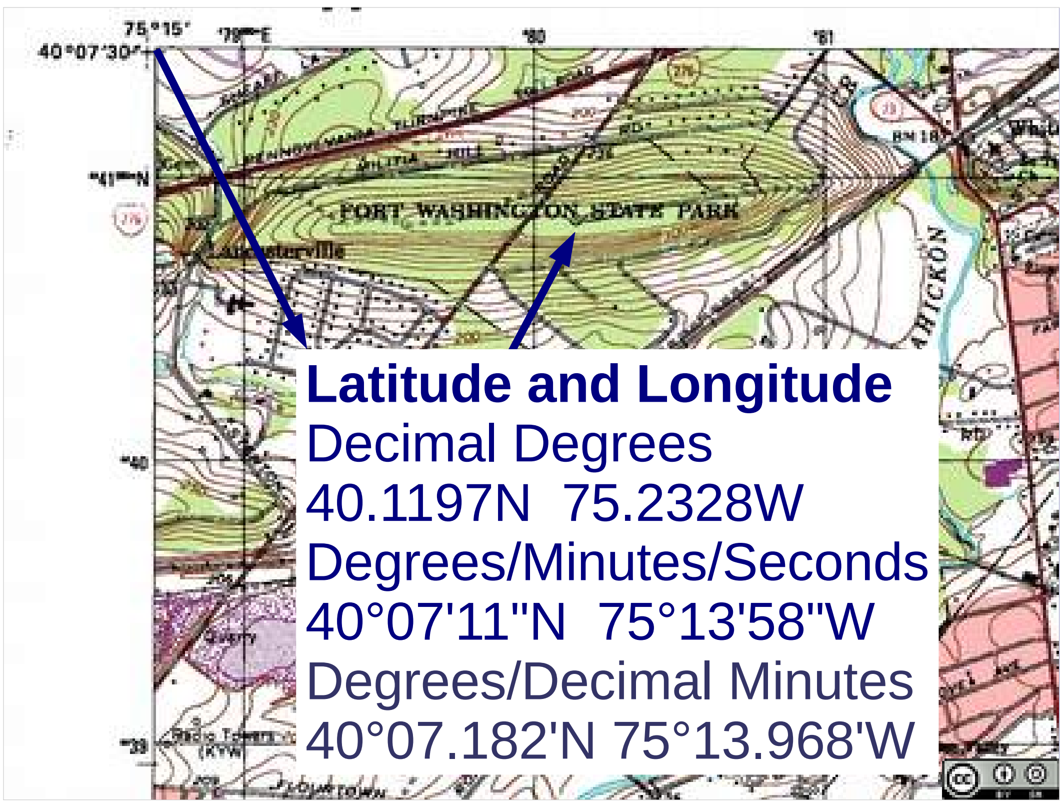
Degrees of longitude do not translate easily to distances (in miles or meters). This is a disadvantage of Latitude/Longitude.



A particular point on the surface of the Earth is described with a Latitude and a Longitude.

Latitude and Longitude can be expressed in Degrees, Minutes, and Seconds (with 60 Minutes to a Degree, and 60 Seconds to a Minute.

Here we have a position of 40 degrees 7 minutes 11 seconds North, 75 degrees 13 minutes 58 seconds West.



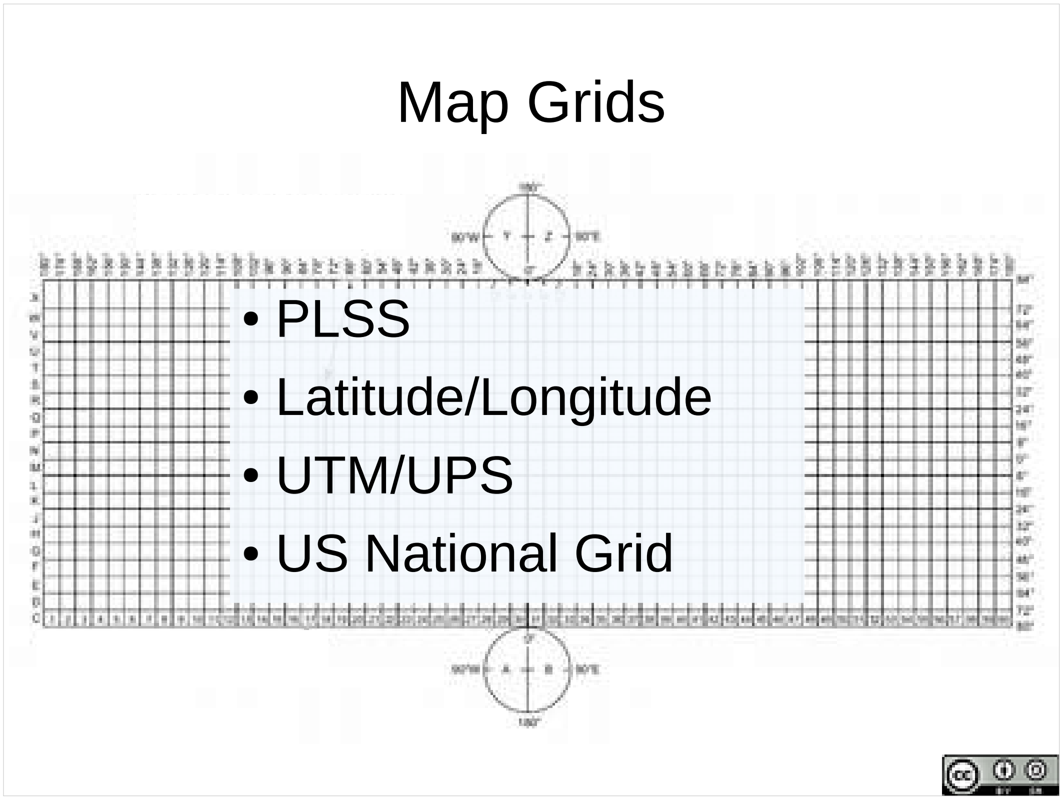
Latitude and Longitude can be expressed in three different ways:

Most common: Decimal Degrees (widely used by Geographic Information Systems (GIS), and by Google Earth and Google Maps).

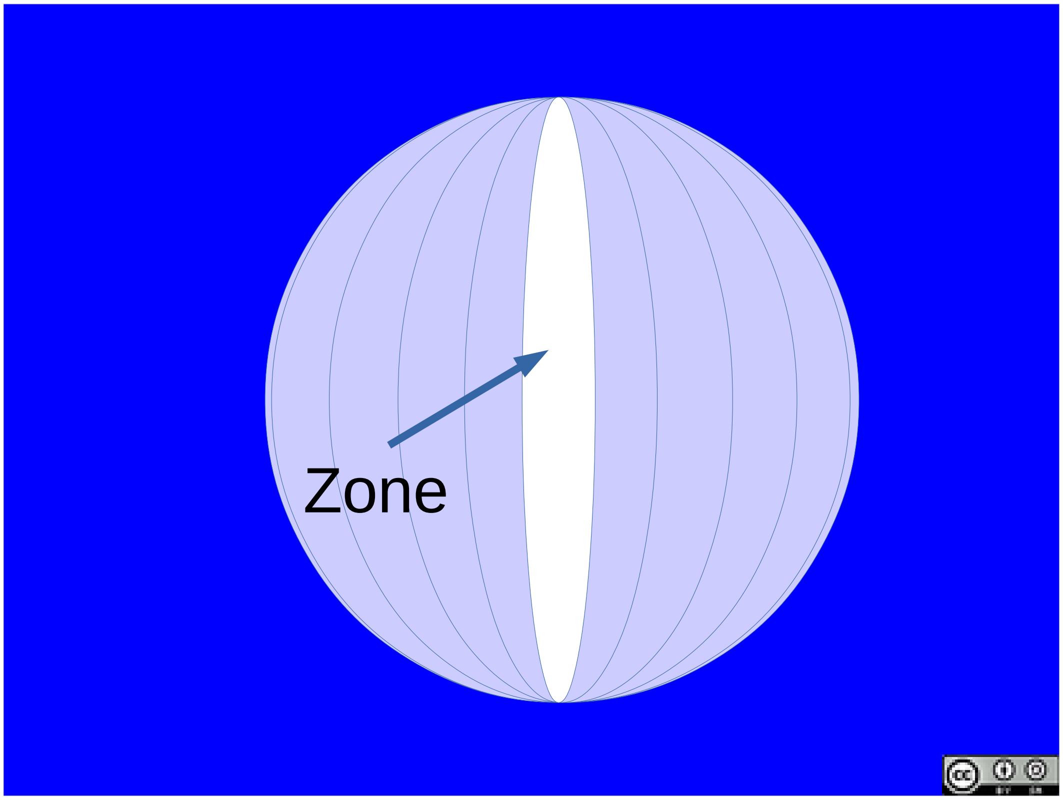
Decimal degrees are often represented with North and East positive, and South and West negative (you can type “40.1197, -75.2328” into Google maps (**4 decimal places is about 11 m precision in latitude**)).

Also used (and printed on USGS topographic maps) are: Degrees, Minutes, and Seconds (**one second of latitude is about 30 meters**, Lat/Long tics on the edge of the maps are typically 2’30” (or 4.6 km apart)).

Sometimes used: Degrees and decimal minutes.



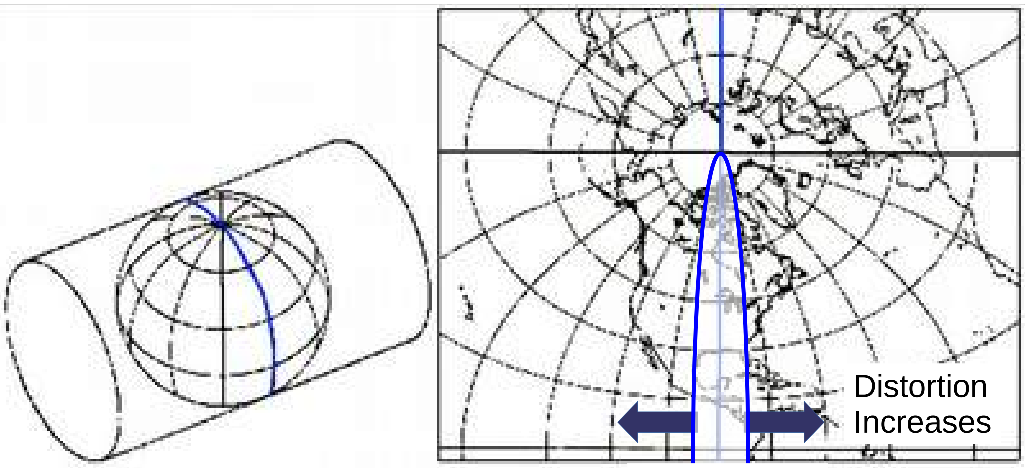
Next: UTM: Universal Transverse Mercator.



UTM starts by dividing the world up into 60 6 degree wide zones (60*6=360).

This doesn’t make a lot of sense until you look at how UTM uses this to minimize distortion when turning the spherical globe into a flat map.

Transverse Mercator Projection

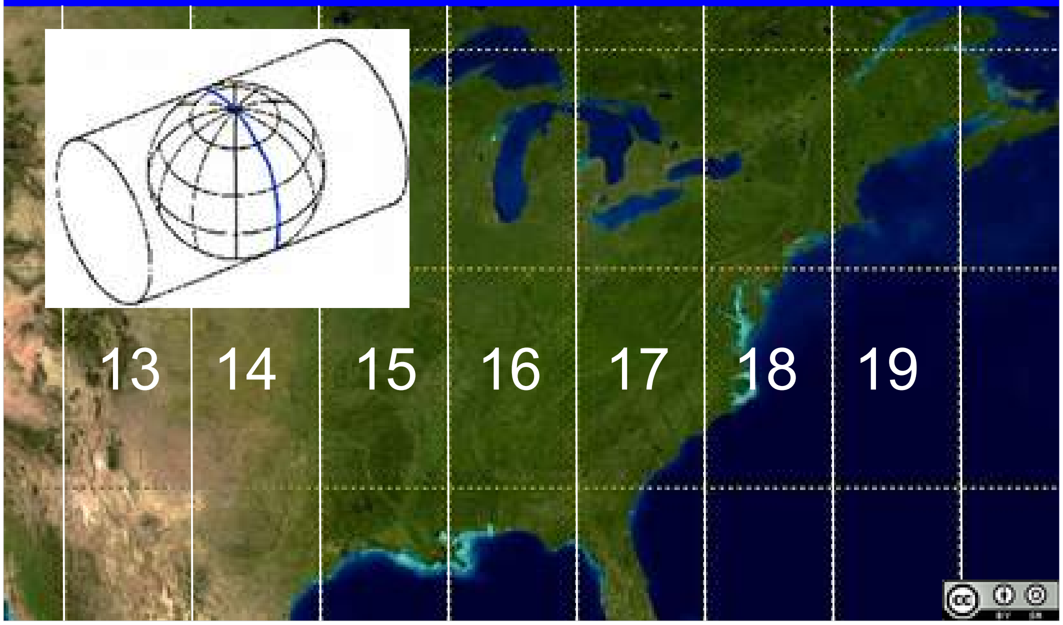


Project the globe onto a cylinder wrapped pole to pole. Unroll the cylinder into a flat map. The line where the cylinder touches the globe has the least distortion, the further you move East or West of that line, the greater the distortion. UTM: Repeat 60 times.

UTM is Universal Transverse Mercator. In UTM, each of the 60 6 degree wide zones is projected separately onto a cylinder touching the surface of the earth in the center of the zone (the cylinder is then unrolled into a flat map (and the 60 zones can be spliced together to make a map of the world)).

In the Mercator projection, the cylinder touches the Earth at the equator, and distortion increases towards the poles (Greenland looks much larger than it really is) It the transverse mercator projection, distortion increases away from the center of each zone. Since the zones are only 6 degrees wide, distortion on maps of small areas is minimized.

UTM Zones
6º wide, numbered 1 to 60



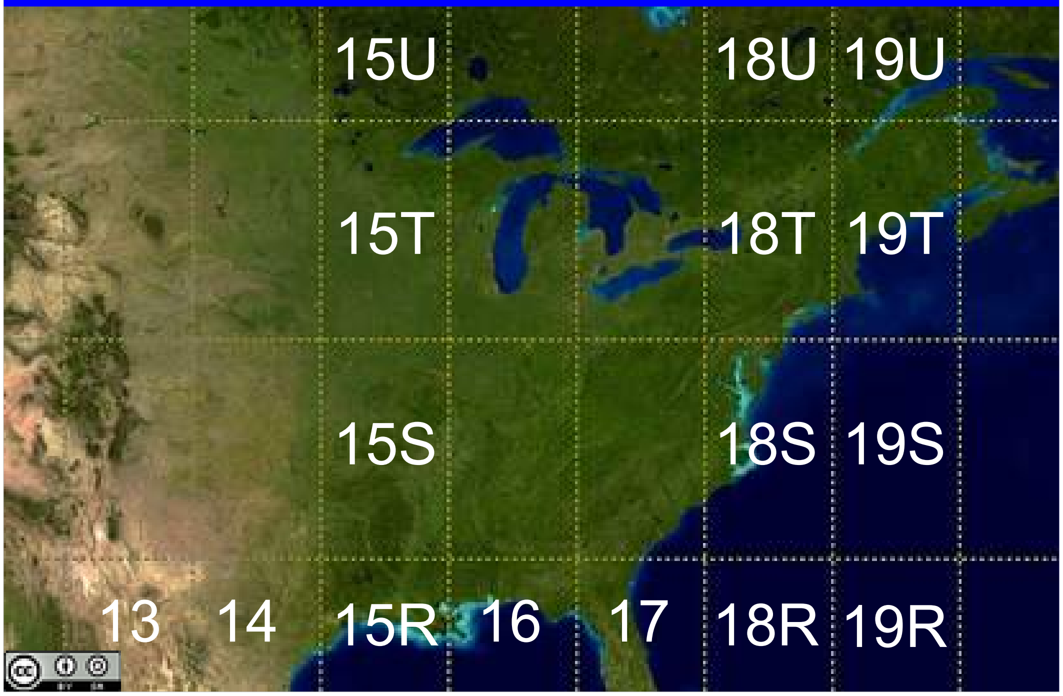
The Universal in UTM comes from repeating this transverse projection of a narrow slice of the globe onto a cylinder 60 times - onto 60 cylinders, one centered on each zone. When these 60 zones are stitched together, they give a flat map of the world.

Each zone is 6 degrees wide.

The 60 zones are numbered 1 though 60 (starting at 180 degrees West (the zone 30/31 boundary runs through the Greenwich meridian)).

New England falls into zones 18 and 19.

UTM Zone Letters (Latitude bands)



Zones are divided into 8 degree tall bands, each band is given a letter.

New England falls into the T band, thus into 18T and 19T.

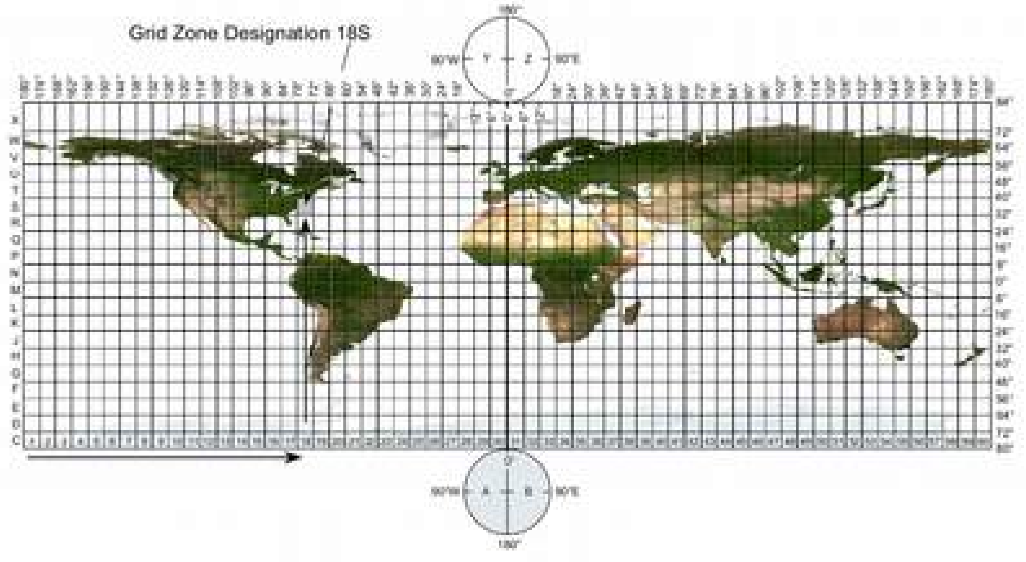
Latitude Band Letters

- 8 degree tall bands (except for X)
- Starts with C at 80 to 72 degrees south.
- C-M, southern hemisphere
- N-X, Northern Hemisphere
- (N is the first zone north of the equator)
- No O or I (can be confused with 0 and 1)
- A,B South of 80 degrees south (UPS).
- Y, Z, North of 84 degrees north (UPS).

Band lettering starts at 80 degrees south latitude with C.   N is the first band north of the equator. Not all letters are used, O and I are left out as they are too easy to confuse with numbers.

The poles are handled separately (we'll come back to that).

Grid Zone Designator



Here's a map showing the layout of the zones and bands.

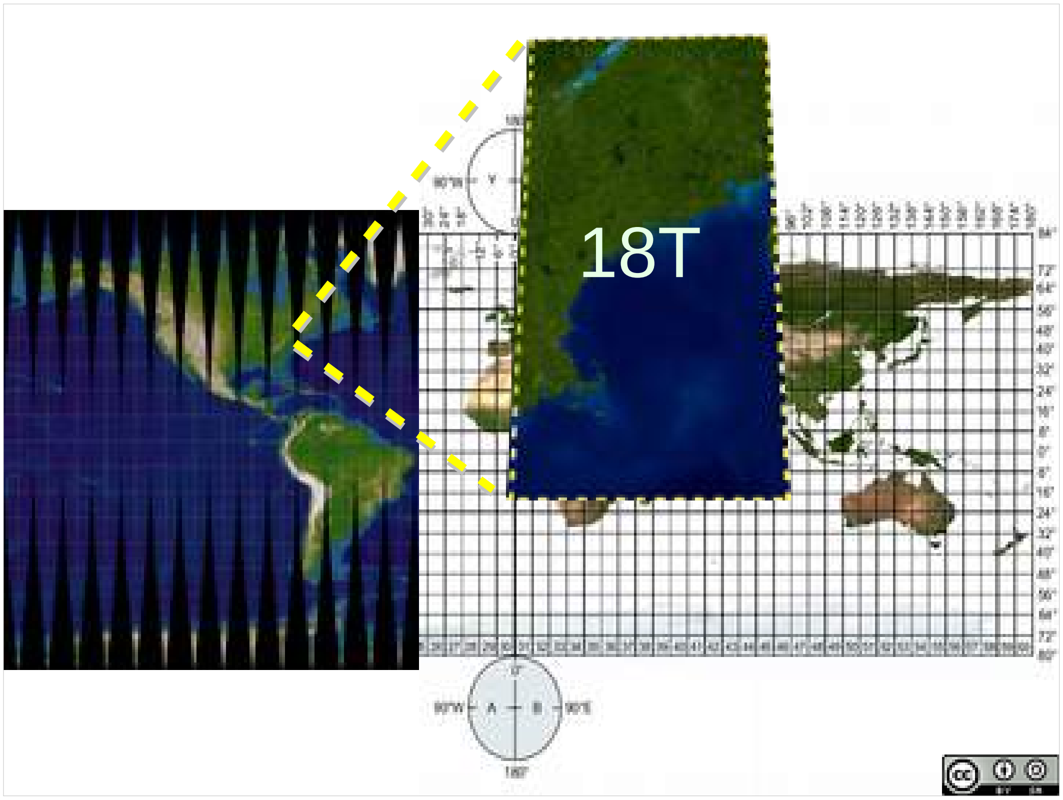
Zone 1 starts at 180 degrees west. The zone 30/31 boundary runs along the Grenwich meridian (at zero degrees Longitude).

(Band letters start with C at 80 degrees south latitude, N is the first band north of the equator. Poles are handled separately (bands A,B, Y and Z).

A Zone number and band letter provide a Grid Zone Designator (e.g. 18S, zone 18, band S)

Locations within each zone are described with a pair of numbers: an Easting, and a Northing.

The poles are handled separately.

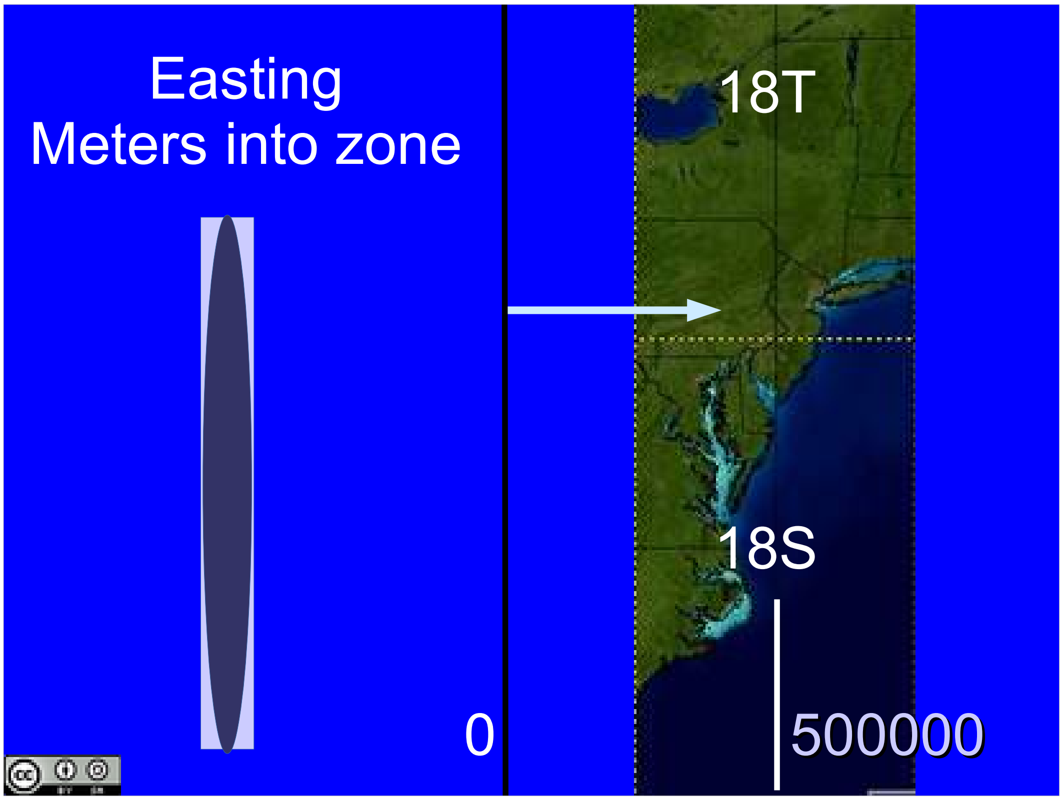


So we've got a Grid Zone Designator.

This describes an area on the surface of the Earth.

But the Earth isn't flat – zone 18 is a curved pie slice (left), not a neat rectangle (left, the distorted projection onto a flat surface), so 18T isn't a nice neat rectangle – it's a piece of a curved pie slice, it gets narrower as we go North.

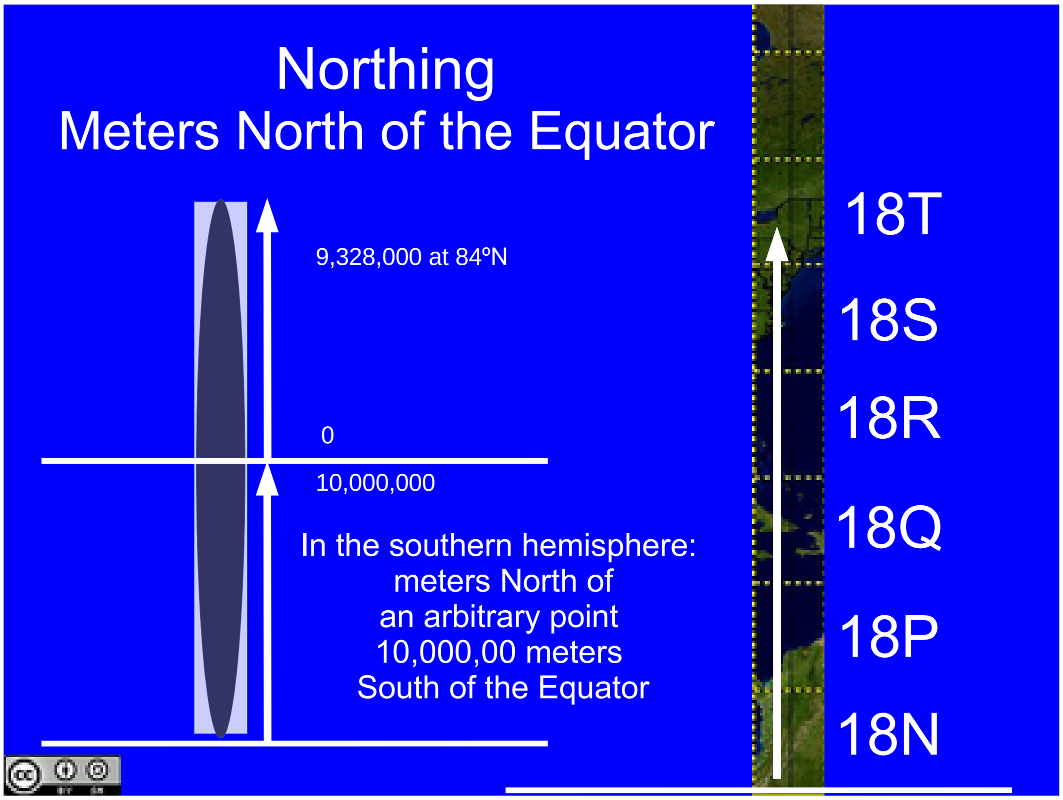
The problem becomes: how do we describe a position in this curved pie slice with a nice neat rectangular grid (where numbers in the grid represent distances on the ground (unlike latitude/longitude, where one degree of longitude varies in length depending on how close to the poles you are)).



UTM solves this problem with a grid of two distances in meters, the Easting, and the Northing.

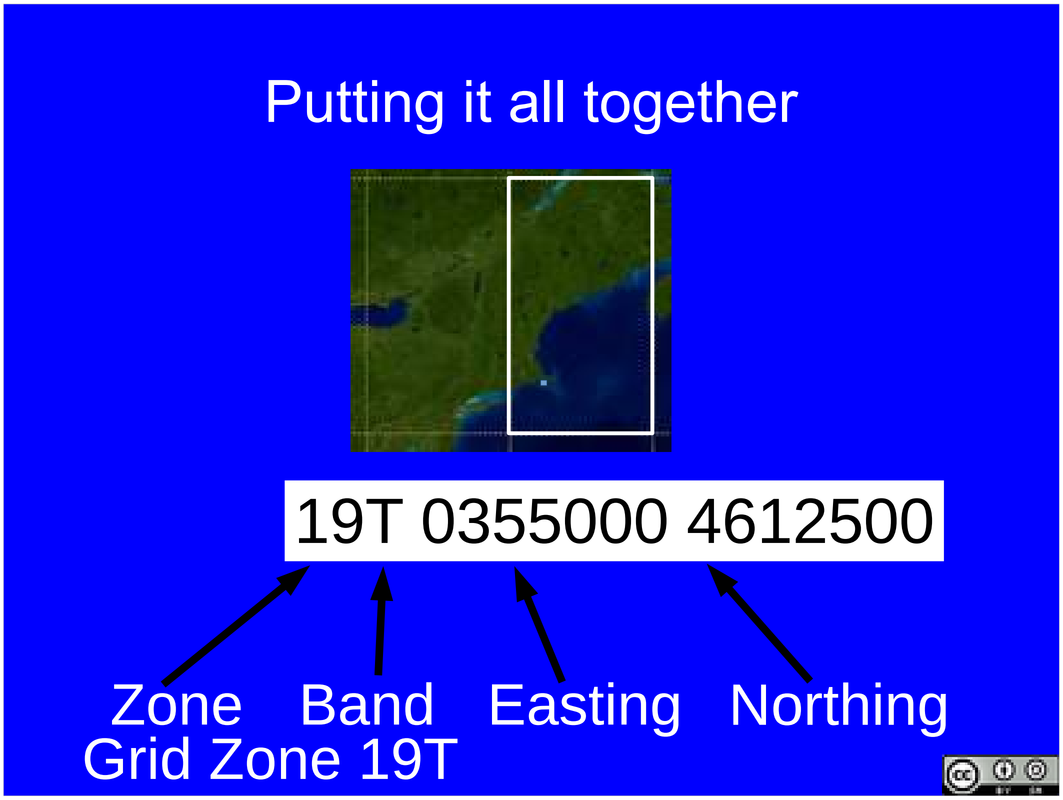
The Easting is the distance in meters into each zone from an imaginary base line for that zone, placed so that the 500,000 meter (500 km) Easting lies in the center of the zone.

At the equator, zones are 6 degrees (= 360 nautical miles = about 667 km) wide. They get narrower towards the poles.



Northing is measured as distance in meters north of the equator.

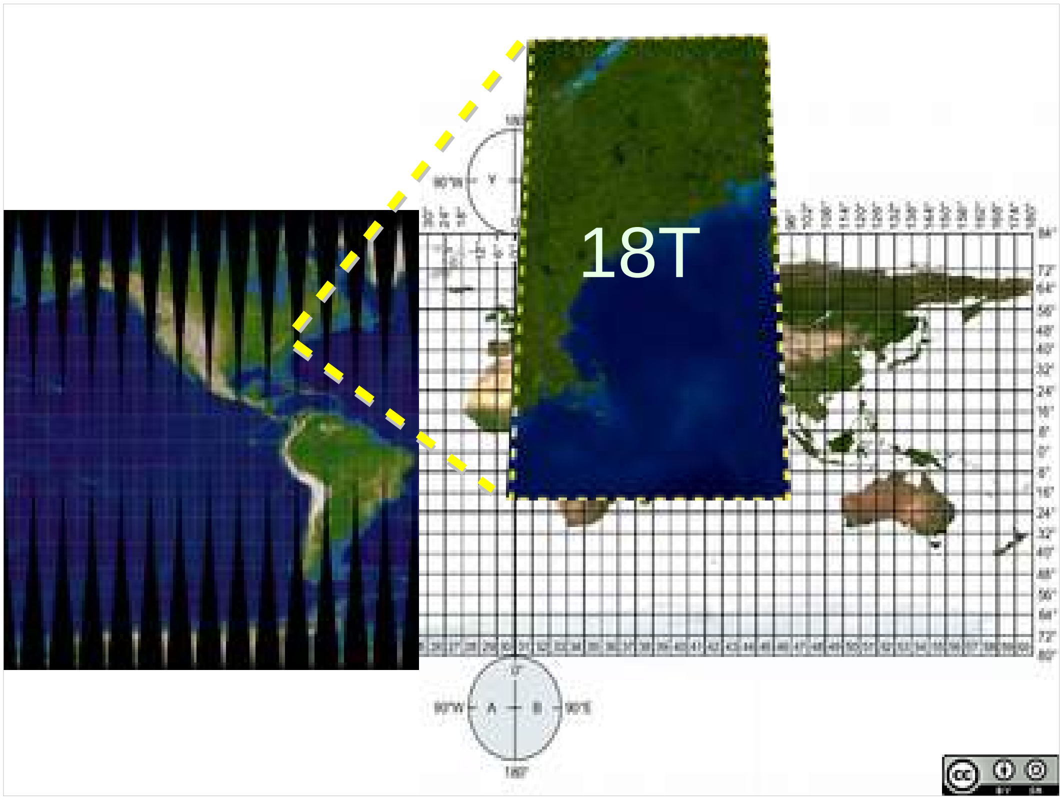
Or, in the southern hemisphere, meters north of an imaginary base line 10,000,000 meters South of the Equator.



Putting Zone, Band Easting, and Northing together let us describe a point on the surface of the Earth to a precision of 1 meter.

Here: 19T 0355000 461350

Zone 19, Band T, easting of 0355000 meters, northing of 461250 meters.

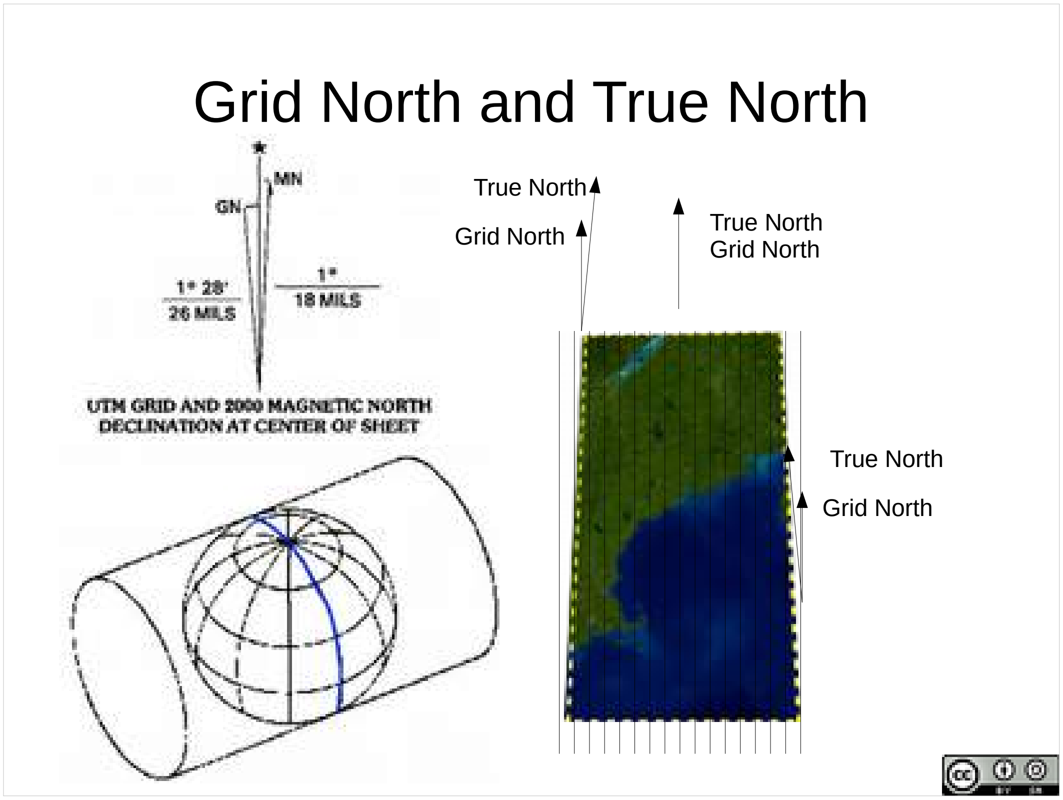


We've laid a nice neat rectangular grid on the curved pie slice.

There are a few consequences of this.

First is the difference between True North and Grid North.

The 500,000 meter meridian runs right up the center of the zone, but the east and west edges of the zone converge on each other – while the grid lines run straight.



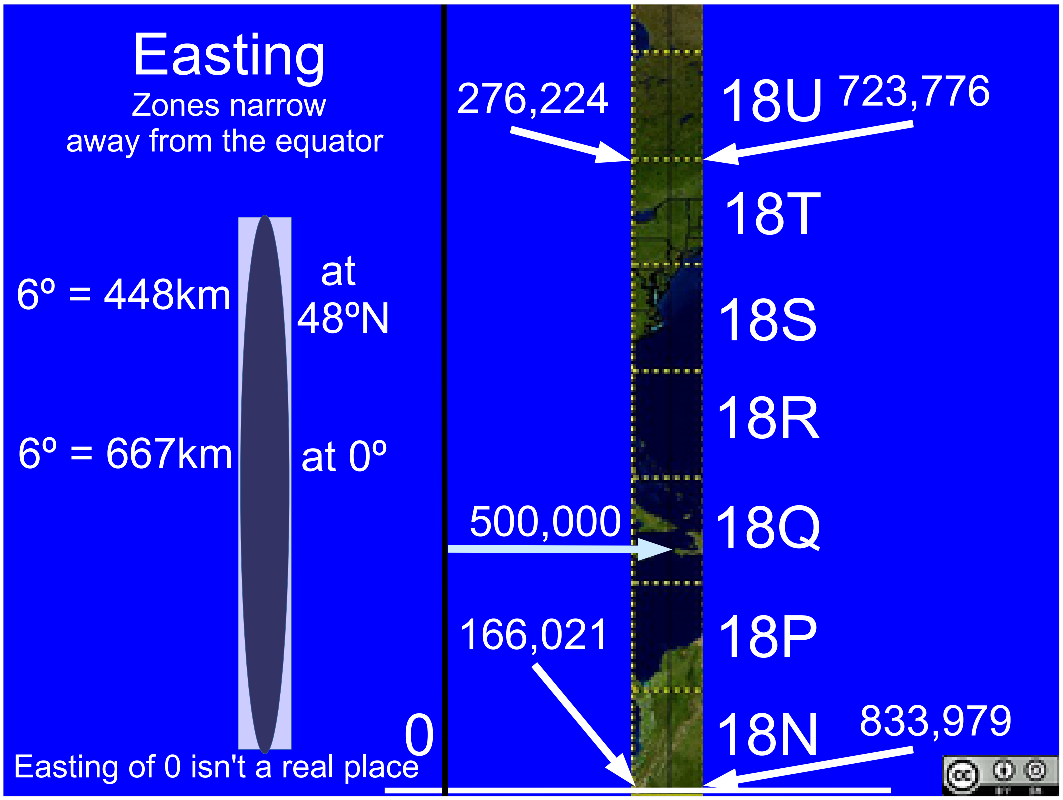
Thus, Grid North (the north of the UTM grid lines) is the same as true north at the 500,000 meter eastings. But Grid North is slightly off from True North near the Zone Boundaries.

Near the center of a zone (with Eastings about 500000), place your compass along the UTM grid lines and it will be aligned with True North.

Near the edge of a zone, place your compass along the UTM grid lines and it will be slightly off from True North.

USGS Topographic Maps and US National Map maps will have a description of how far off grid and magnetic north are off from True North. In mid-latitudes the difference between grid and true North will be relatively small. It is about 0 at the Equator and larger closer to the poles.

The difference between grid north and true north is a property of the Transverse Mercator Projection – the cylinder the map is projected onto touches the globe at the 500,000 m easting, the further East and West you go from that line, the more distortion there is. UTM is good at reducing distortion, but doesn't eliminate it.



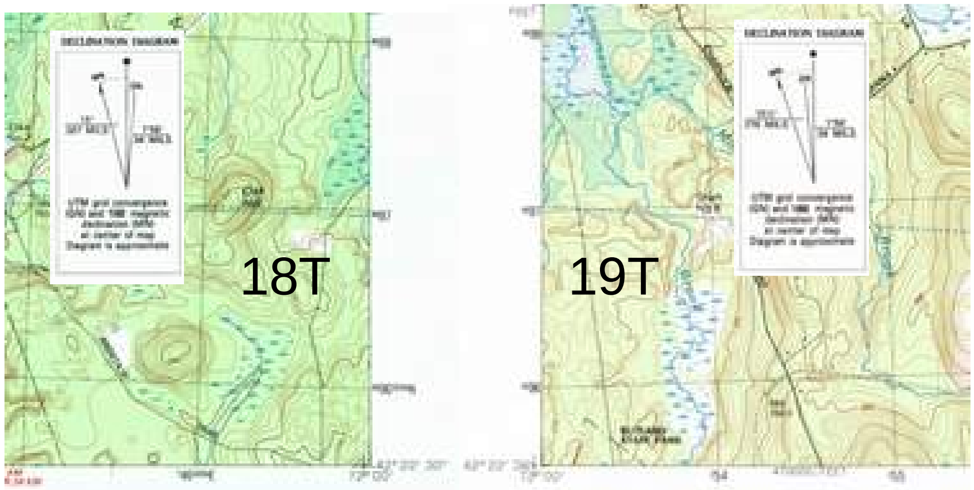
Second consequence of putting a flat grid on a curved pie slice: Since the zones are slices through a spherical globe, they are widest at the equator and narrow towards the poles. Since the UTM grid lines form a rectangular grid, the smallest Easting in a zone gets larger as you move North.

Thus the smallest Easting at the Equator is about 166,000 meters (and the largest Easting at the Equator about 833,000 meters), and each zone is about 667,000 meters (667 km) wide at the equator.

Moving north, the zone narrows, so the smallest Easting within the zone gets larger, and the largest gets smaller. At the north end of band T (48 degrees north) the 6 degree wide zone is down to a width of 448 km, with a smallest Easting of 276224 meters, instead of the smallest Easting of 166021 meters at the Equator.

The 500000 m Easting lies right down the middle of the zone (right on the 75 degree West Meridian for Zone 18).

Grids at a zone boundary



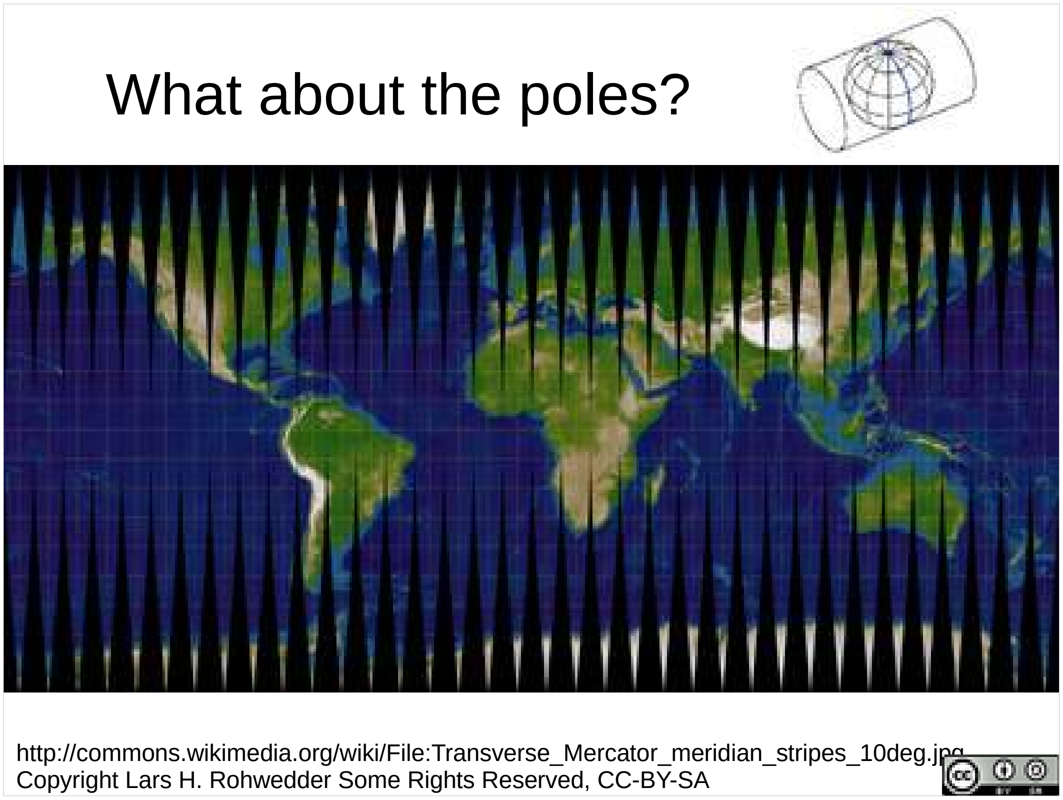
$^{07}46$ $^{02}54$

Grid North 1º56’ E Grid North 1º56’ W

Here’s the 18T/19T zone boundary (the 72 degree meridian) in Massachusetts (Barre quardrangle to the left, Sterling quadrangle to the right). Grid North in Sterling is 1 degree 56 minutes West of True North. Grid North in Barre is 1 degree 46 minutes East of True North, about 2 degrees.

Declination diagrams also note the difference in mills (1 mill is 1 meter at 1 km) difference at the edge of the Zone between grid north and true north is 34 mils, thus 34 meters in 1 km of travel, not particularly significant for navigation on foot. (Difference here between true north and magnetic north is about 15 degrees, 267 mils, 267 meters in 1 km of travel, much more significant.)

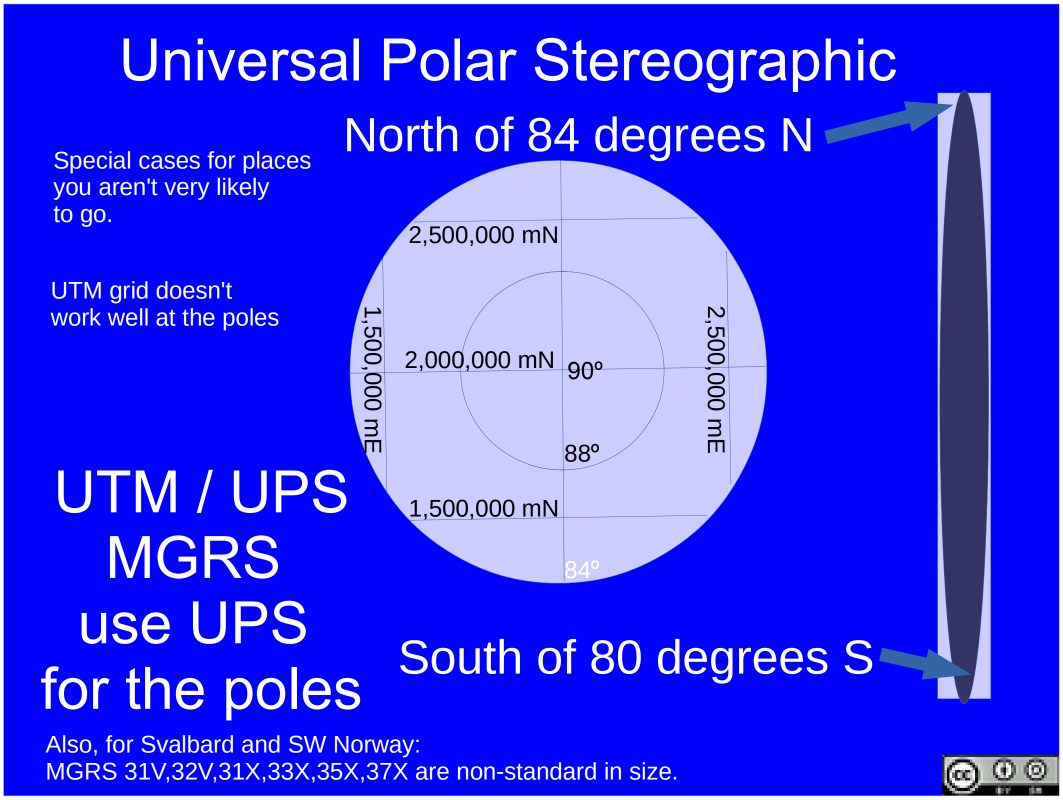
Easting of last gridline on the left is 0746000, on the right 0254000, largest and smallest of their zones at this northing.



Remember the 60 separate projections onto a cylinder, each 6 degrees wide?

UTM Zones keep getting narrower the closer and closer you get to the poles – short travel distances would move you between zones (at an extreme, near the North pole, a few steps could have you traversing tens of zones).

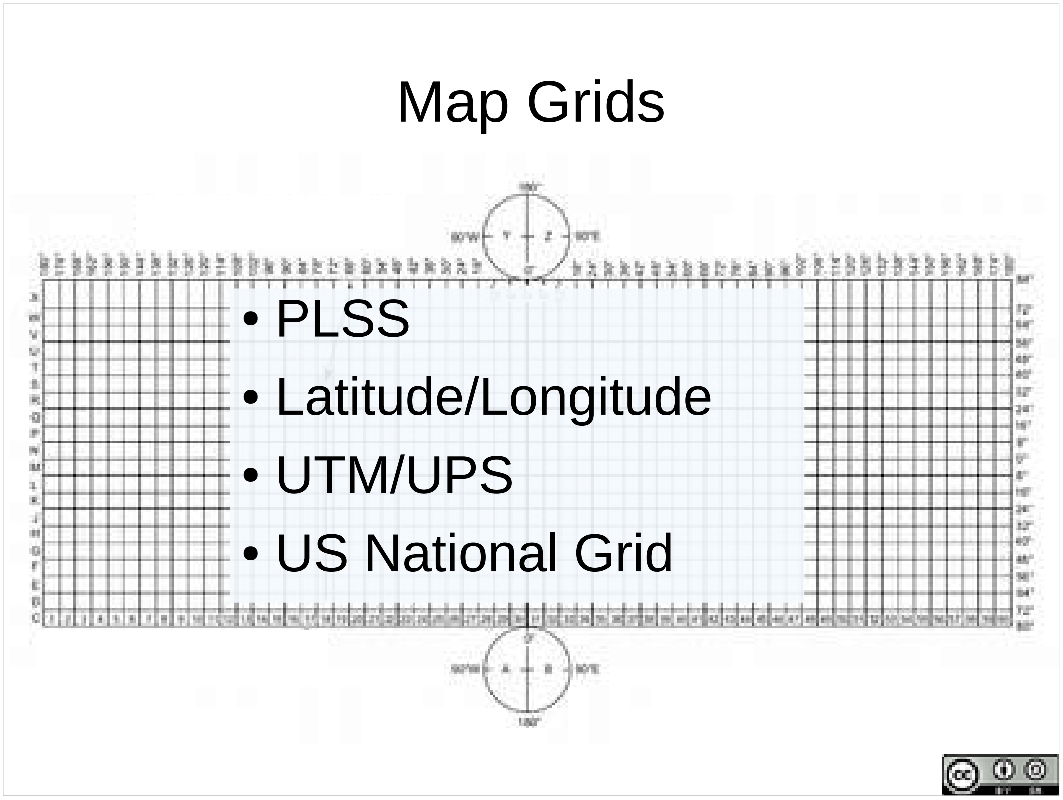
So, at some point North and South, UTM becomes an ineffective system.



Thus, North of 84 degrees North, and South of 80 degrees South, a different system, Universal Polar Stereographic is used.

In your GNSS, you will have an option for a coordinate system called UTM/UPS.

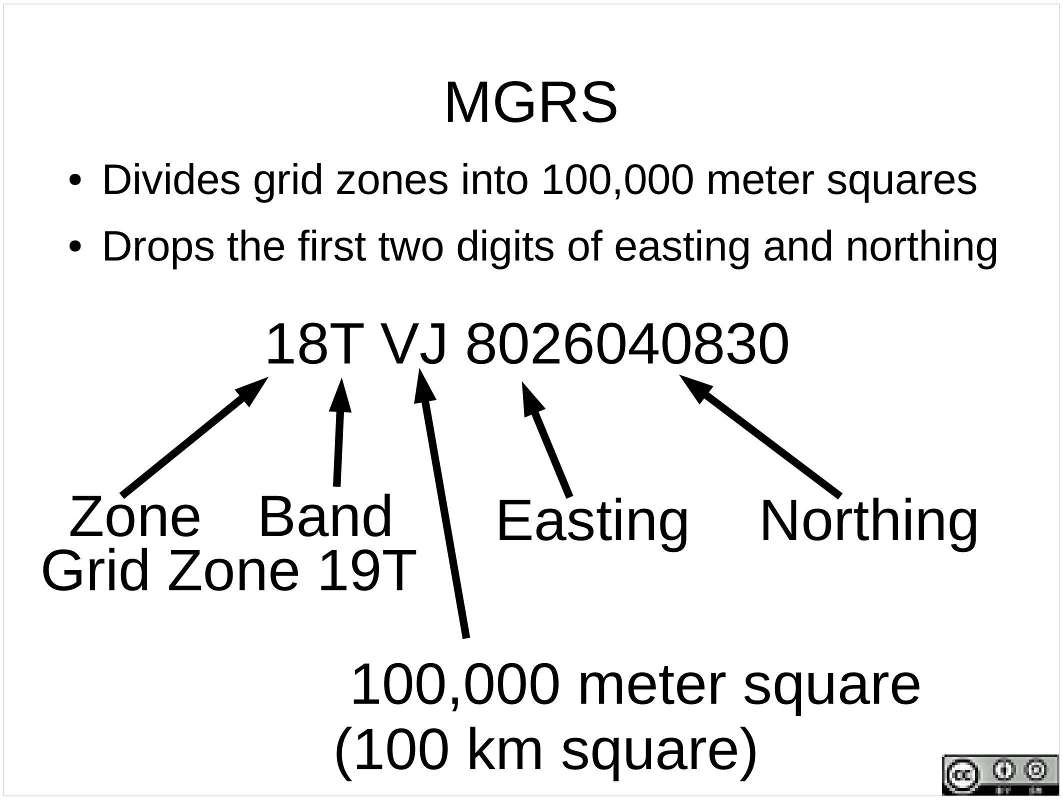
UPS is a similar sort of system to UTM, there are Bands (A,B,Y,Z), and Eastings and Northings are measured in meters off of imaginary base lines (with the poles set at 2,000,000 meters).



Next coordinate system: a variant of UTM: US National Grid.

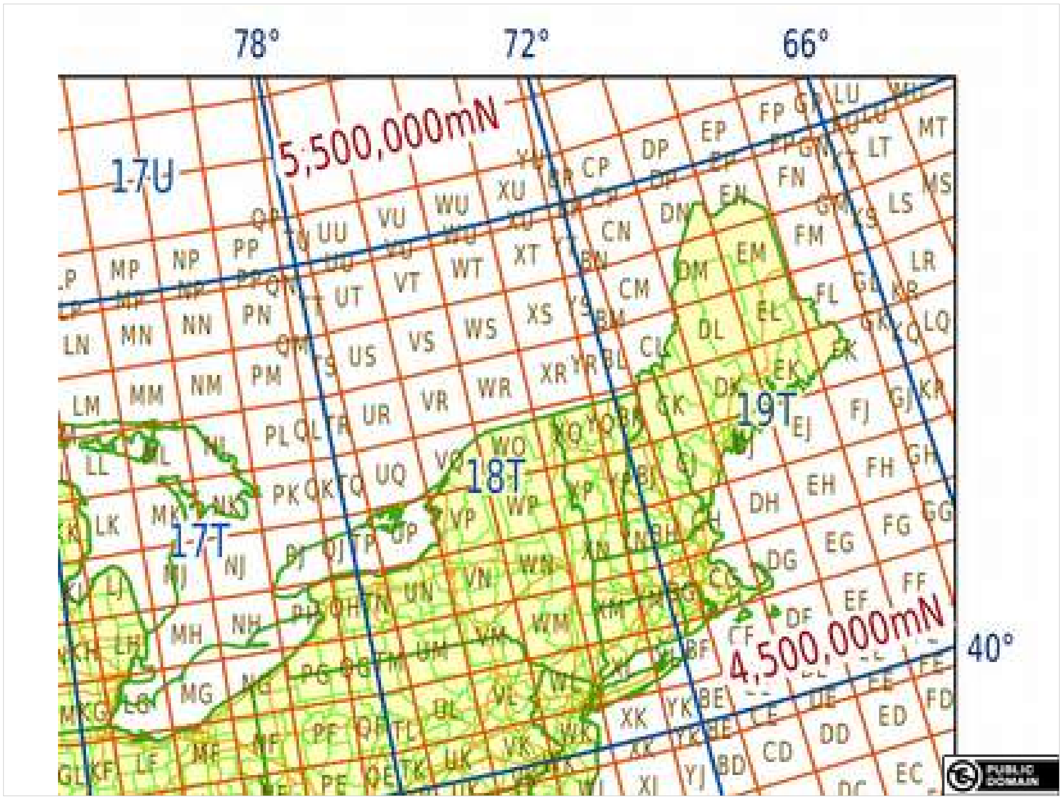
UTM allows us to describe a position on the surface of the earth: 19T 0355000 461350 Big long list of numbers.

US National Grid allows us to simplify this position to just communicate the minimum amount of information needed for the situation.



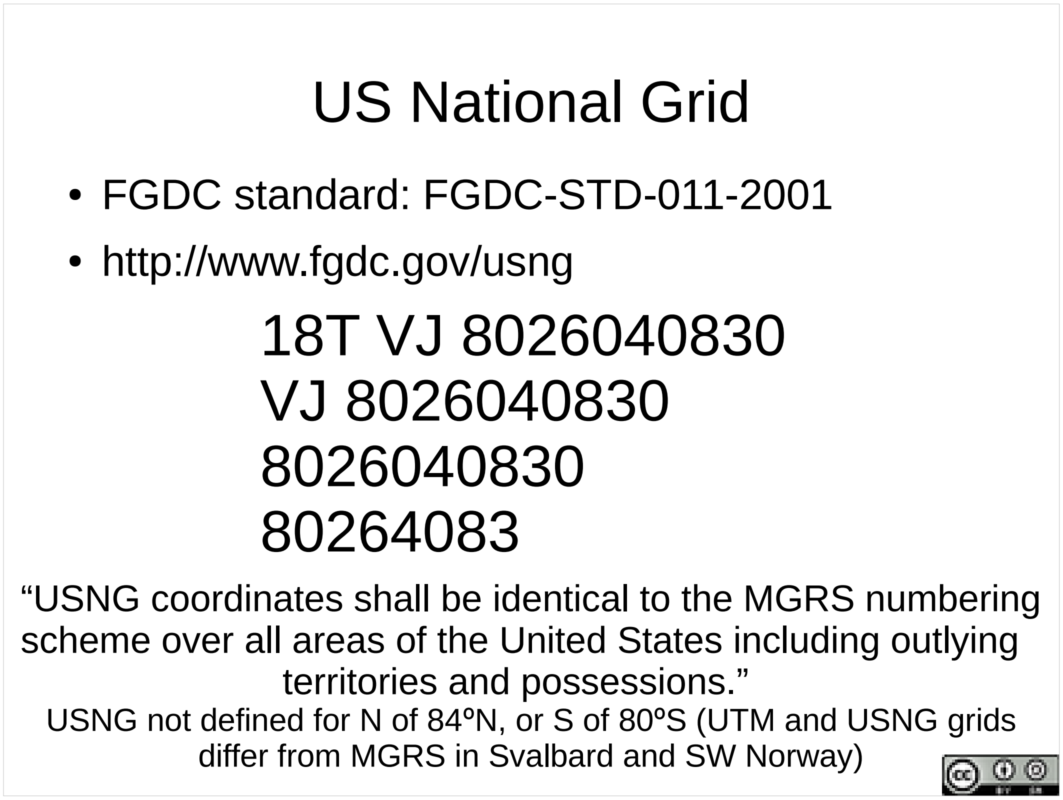
US National grid is based on Military Grid Reference System (MGRS). US National Grid coordinates (anywhere in the US) are same as the MGRS.

MGRS and USNG use UTM coordinates, but represent them slightly differently – key difference is that they divide the grid zones into 100,000 meter (100 km) squares, each defined by a letter (VJ in this example), and drop the first two digits of the Easting and the Northing, so that the Easting and Northing have 5 digits each instead of 7 at 1 meter resolution.



Here are the 100 km squares for Grid Zones 18T and 19T. Boston is within 19T CG, the Berkshires span 18T XM and 18T XN.

Note that 18T YN and 19T BH aren't square and are cut off by the 18/19 zone boundary (at 72 degrees (we saw the Barre/Sterling quad boundary earlier)). Note how the 100 km grid lines converge on the zone boundaries as you move North – the 100 km grid lines are Grid North, the 72 degree meridian is True North.



US National Grid coordinates are identical to MGRS in any US territory.

(USNG only differs from MGRS off the coast of Norway (where NATO expanded some of the grid zones so that operations off the coast of Norway wouldn’t continually change zones) and at the poles where USNG doesn’t formally adopt UPS.

USNG defines specific ways to leave out parts of the coordinate to limit how many numbers and letters need to be communicated to just those needed for the situation.

US National Grid: Simplifying

- 18T VJ 8026040830
- VJ 8026040830
  - Leave off grid zone
- 8026040830
  - Leave off grid zone and grid square
- 18T VJ 802408
  - Leave off some numbers (leave off 2 = 100 m square)
- 802408
  - Leave off grid zone, grid square, and some numbers

US National Grid: **Goal: Keep things as simple as possible.**

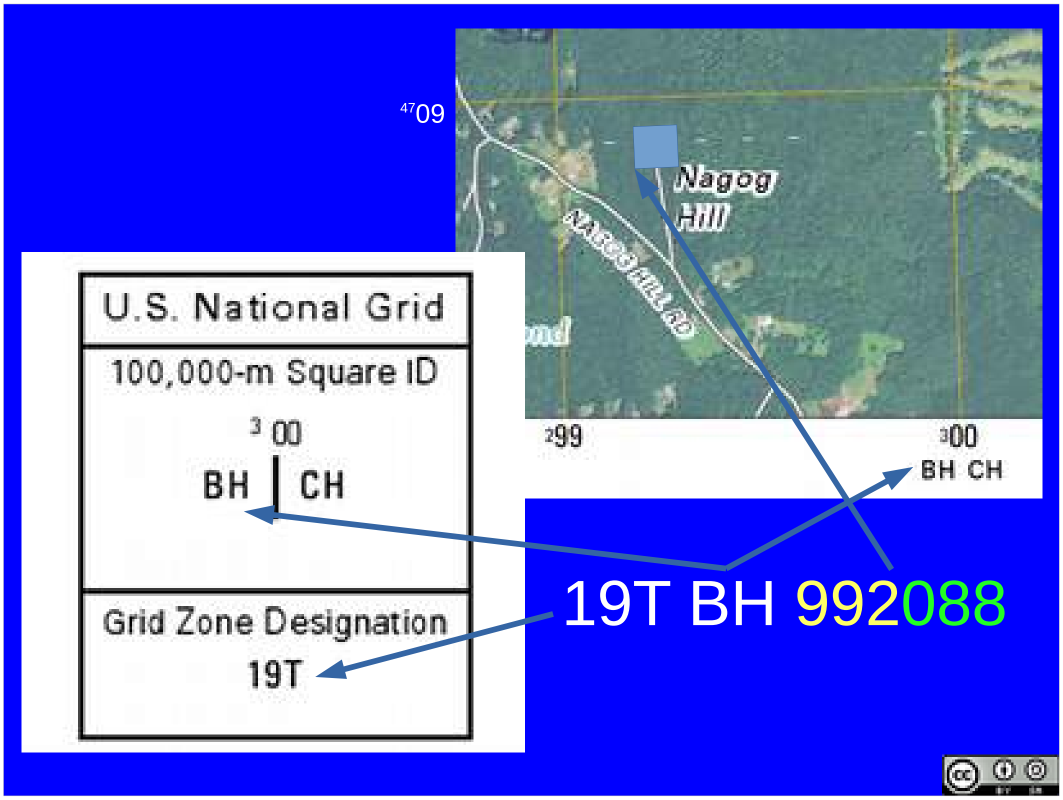
For global communication, the grid zone designator and grid square need to be included.
For regional communication, the grid zone designator may be left out.
For local communication, the grid square may be left out.

If you don’t need 1 meter precision, leave off some numbers.

8026 4083 – to 10 meters

802 408 – to 100 meters

80 40 – a 1km square

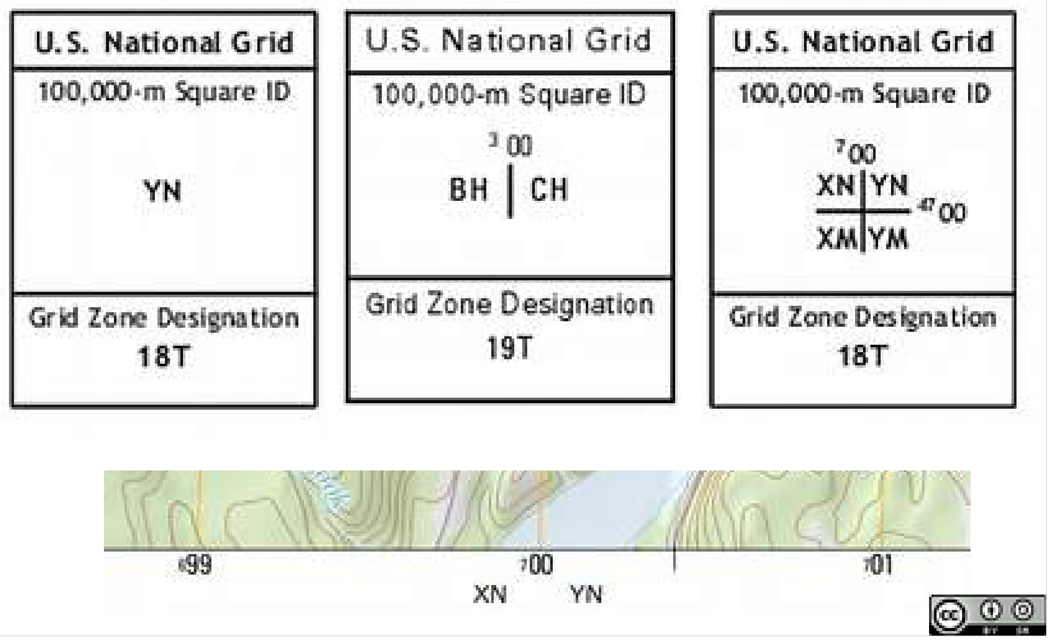


So, how do you work with USNG with maps? The US Topo Map series make things easy.

Border of the map has a box with the Grid Zone Designation and the 100,000 meter square. If (as in this case) the map spans more than one 100,000 meter square, both (or all) will be listed in the box, and shown on the border of the map.

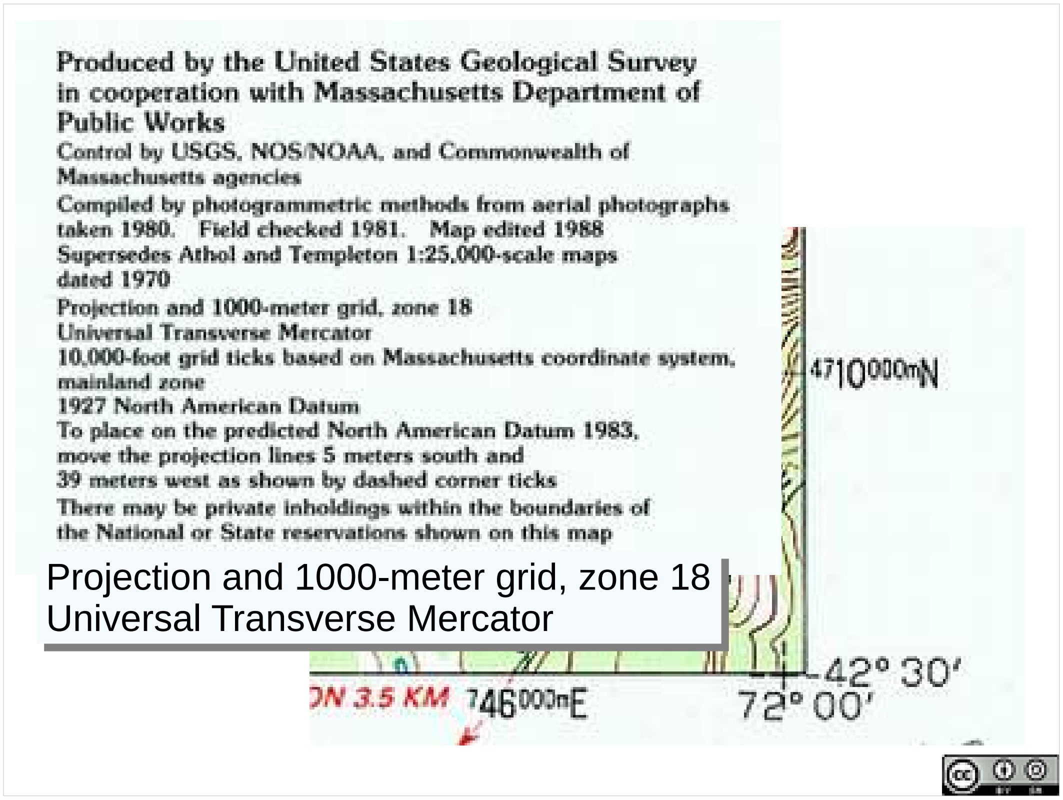
The map border has tic marks every kilometer, labeled with the Easting or Northing for that tick. The first two digits of the USNG position are in large font. Digits before them from the UTM coordinate that are replaced by the 100,000 meter square are in a small font (with leading zeros omitted). Thus the UTM Easting starting with 0399 is shown as ^{3}99, and would be BH 99... in USNG.

US Topo: Grid Zone and Square ID



On the border of USGS US Topo maps you can find a box with the US National Grid Grid Zone Designator and Square ID. If the map spans more than one 100,000 meter square, then the Square IDs can also be found at the square boundaries on the edge of the map.

Most maps will cover only a single square. Some will span 2 squares, a few will span 4 squares.



USNG is a bit harder on 1980s 1990s series USGS topographic quadrangles. On more recent maps the UTM grid is shown, and the UTM ticks are marked.

The metadata at the border of the map will contain the Zone Number, but not the band letter or the 100,000m grid square letters.

Easy to use with UTM or with USNG when just communicating local coordinates (e.g. 46830942).

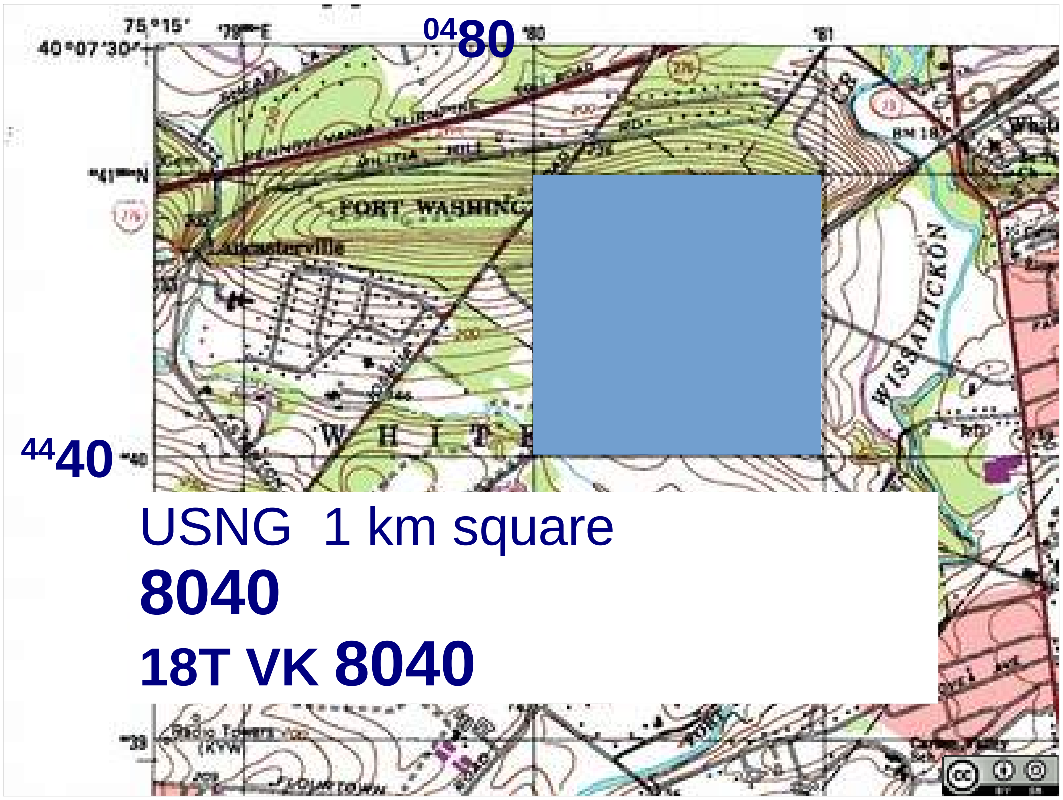
Historical USGS topographic quadrangles tend to not have grids printed on them, and tend to only be marked with latitude longitude (and sometimes other systems like state plane feet).

If we are just working on this map (or inside an area ov about 60 miles), we can describe the location of the 100 meter square North of Nagog Hill as 992089 (dropping the grid zone designation, the 100,000 meter square, and the 10m and 1m digits).

This is easy to read on the map. 992 is the Easting. Find the Easting of 99 (in big numbers), then go 2 tenths of the way to the next (00) grid line. 089 is the Northing. Find the Northing of 08, then go 9 tenths of the way to the next (09) grid line.

If we need to communicate outside about a 60 mile area, then add the 100,000 meter square "BH".

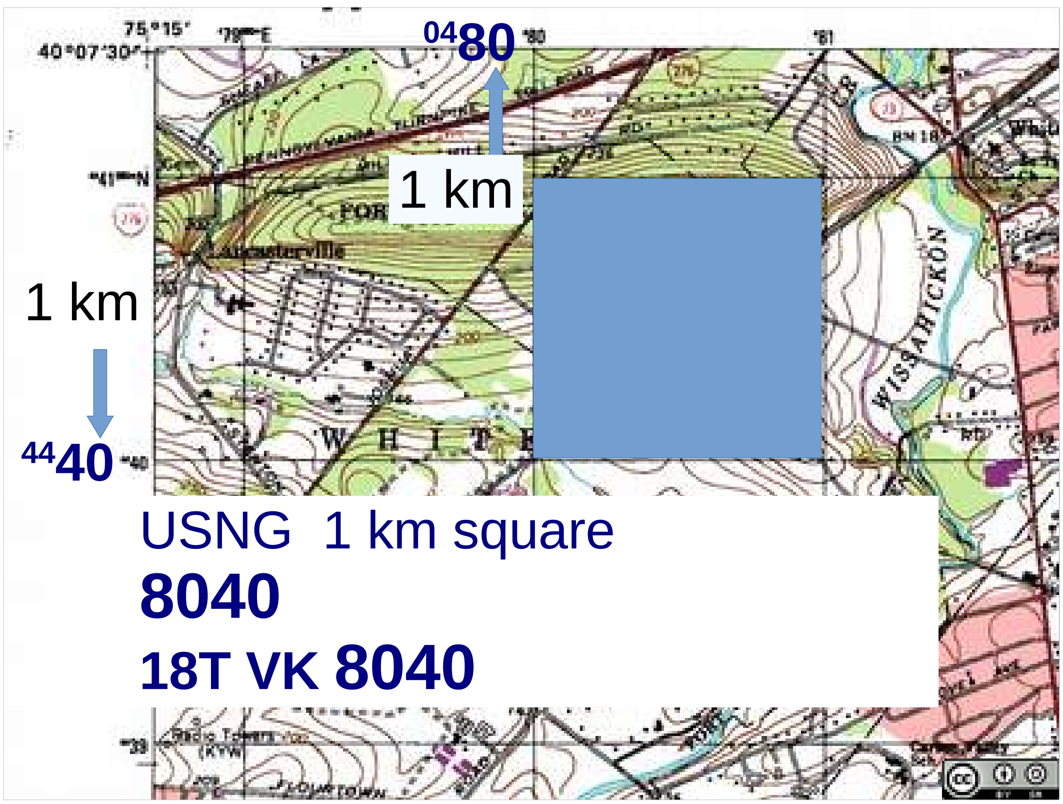
If we need to communicate globally, add the grid zone designation: 19T, thus: 19T BH 992089.



USNG lets us use the big numbers along the edge of the map to easily describe a 1 km square: 8040 (Easting of 80, Northing of 40, dropping the 100m, 10, m and 1 meter digits).

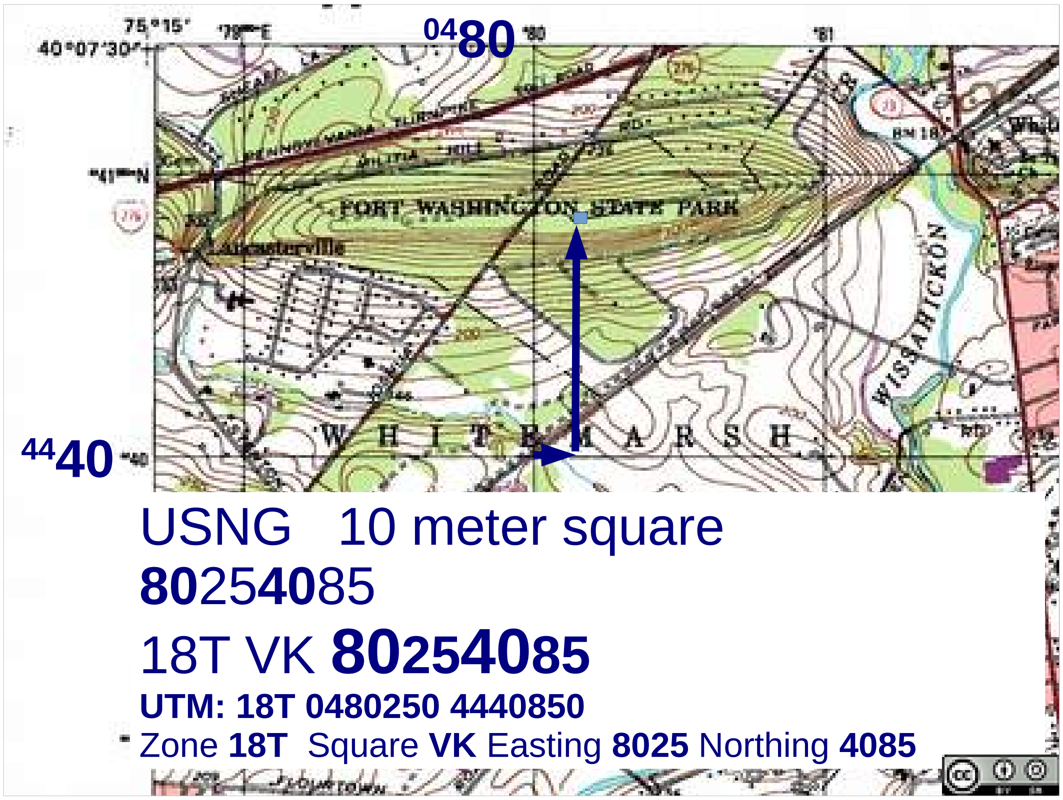
8040 is the point at the lower left of the square (leaving off the digits, USNG means an Easting of 80000 to 80999, and a Northing of 40000 to 40999).

USNG reads off the digits as a single string, so split 8040 into 80 for the Easting, and 40 for the Northing. USNG coordinates will always have an even number of digits.



The big numbers and the grid lines on the map mark 1 km intervals (1km=1000m, thus we’ve dropped off three digits from the Easting and three from the Northing in the USNG position 8040.

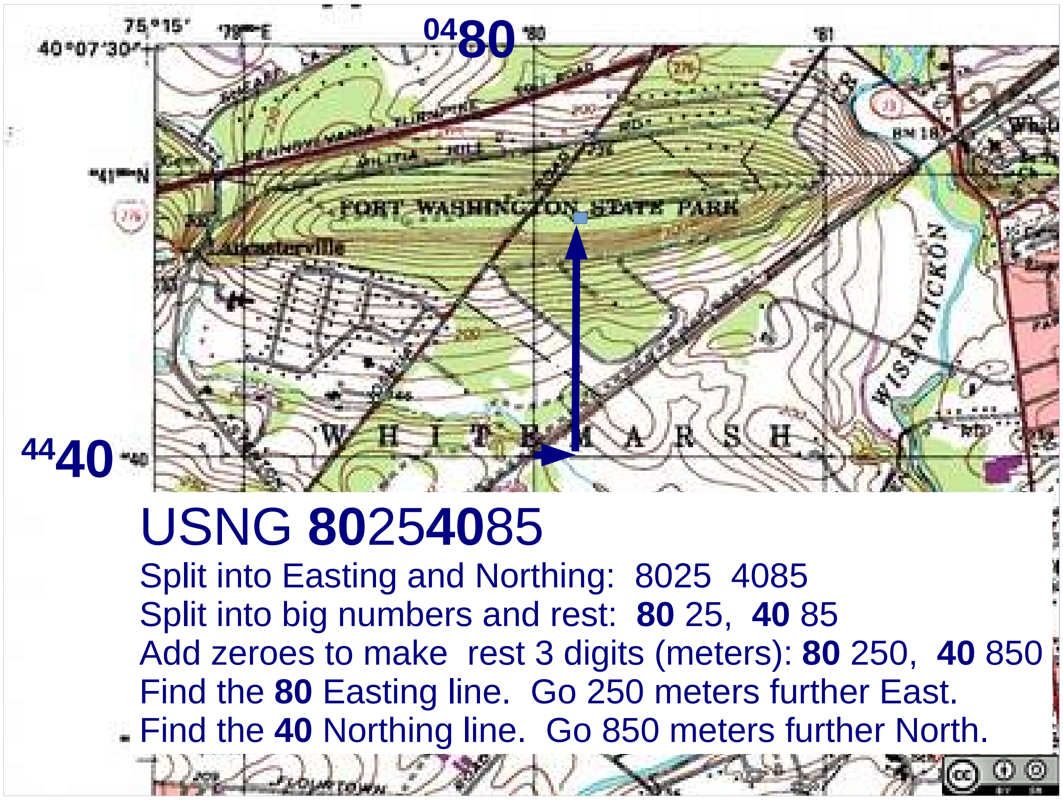
Knowing this makes it easy to find more precise locations.



A 1 km square isn't a particularly precise location for navigation for SAR purposes (get into the center of the square and you might be able to hear someone whistle).

A square 10 meters on a side is a nice precise location for most SAR purposes. It approximates the accuracy of modern GNSS receivers, and you should be able to spot a flagged clue within a 10 meter square.

USNG can describe a 10 meter square with just 8 digits: 80254085 describes the square shown on the map. Start on the 80 Easting grid line, go 250 meters further East. Then find the 40 Northing grid line, and go 850 meters further North. There's your square. To communicate globally, add in the grid zone designator and the 100,000 m square letters.



USNG can describe a 10 meter square with just 8 digits: 80254085 describes the square shown on the map. To find this location, first split the coordinate into Easting (8025) and Northing (4085).

Now split the big numbers off from the rest, starting with the Easting 80, 25. 80 represents a 1 km grid line, that means 3 digits should follow it (to get to meters), so add a trailing zero to the 25: 80 250.

Now we know to find the 80 Easting grid line and to go 250 meters further East.

Same thing with the Northing, split into 40, 85, 40 is in km, make the 85 into meters (add a trailing zero to make 850), so go 850 meters North from the 40 Northing grid line.

Or think 80 25: find the 80 Easting and go 25% of the way to the next grid line.

US National Grid
Describing a 10 meter square

Local: 99250895
Regional: BH 99250895
Global: 19T BH 99250895

For GPS: 19T BH 9925**0**0895**0**

So, a reasonable position to communicate in a simple ground search would be just the 8 digit USNG position for a 10 meter square: 99250895.

For regional communication, add in the 100,000 meter square, for global, add in the grid zone designator.

To enter the coordinate into a GPS, add in two zeroes (one at the end of the Easting, one at the end of the Northing) to bring the precision down to 1 meter.

US National Grid
Describing a 1 meter square

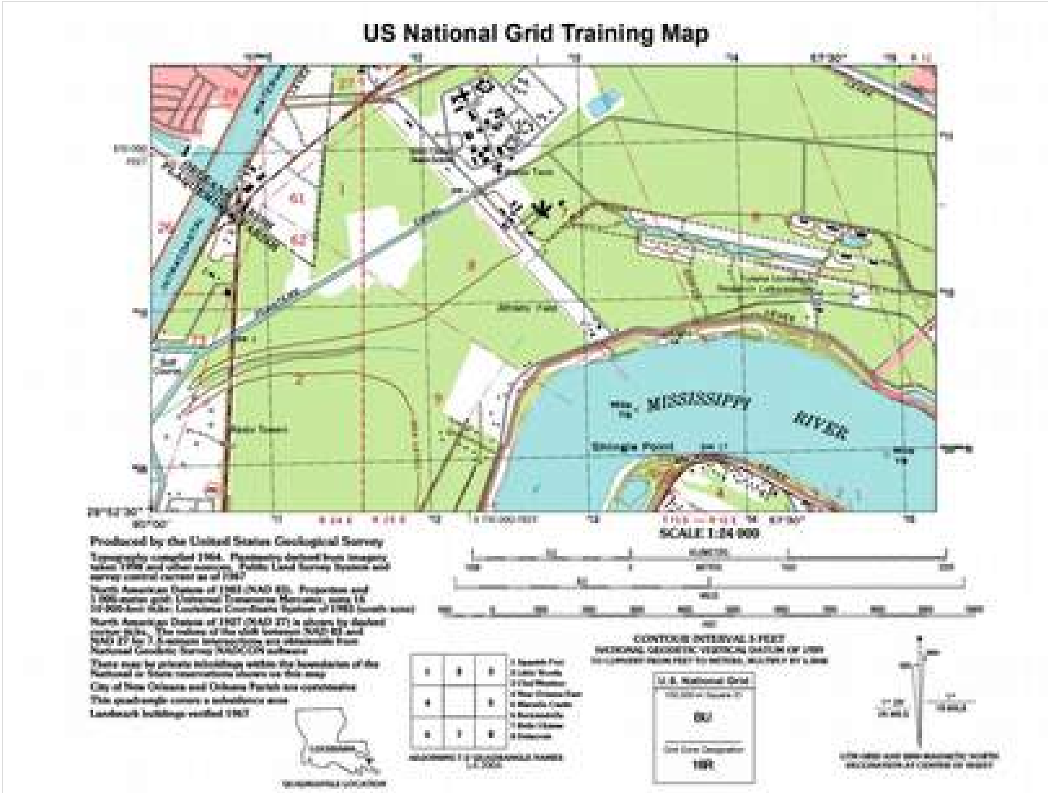
Local: 9925308956
Regional: BH 9925308956
Global: 19T BH 9925308956

For GPS: 19T BH 9925308956

If you want to describe a location to a precision of 1 meter in USNG, use 10 digits (5 for the Easting, 5 for the Northing).

Add the 100,000 meter square to communicate outside about a 60 mile local area (100,000 m = 100 km = about 60 miles, number alone is a unique position within that distance).

Add the grid zone designator to communicate globally, or to enter the position into a GPS.



Practical Evolution: (1) Determine USNG coordinates of points on a map.

(a) water tank near Planters canal

(b) + that marks Mile 78 on the Mississippi river.

Which Is Which?

(1) 19T 0355000 4612500
(2) T2S R4W S33 NW¼
(3) BH 99250895
(4) 40.1197N 75.2328W
(5) 19T BH 9925308956
(6) 40°07'11"N 75°13'58"W

Assess: Which coordinate systems are these?

How can you tell?

(1) UTM/UPS
(2) PLSS
(3) USNG (could also be MGRS)
(4) Geographic (latitude/longitude) decimal degrees.
(5) USNG (could also be MGRS)
(6) Geographic (latitude/longitude) d.m.s

Which one has the least precision? (2 – specifies 1/4 square mile).

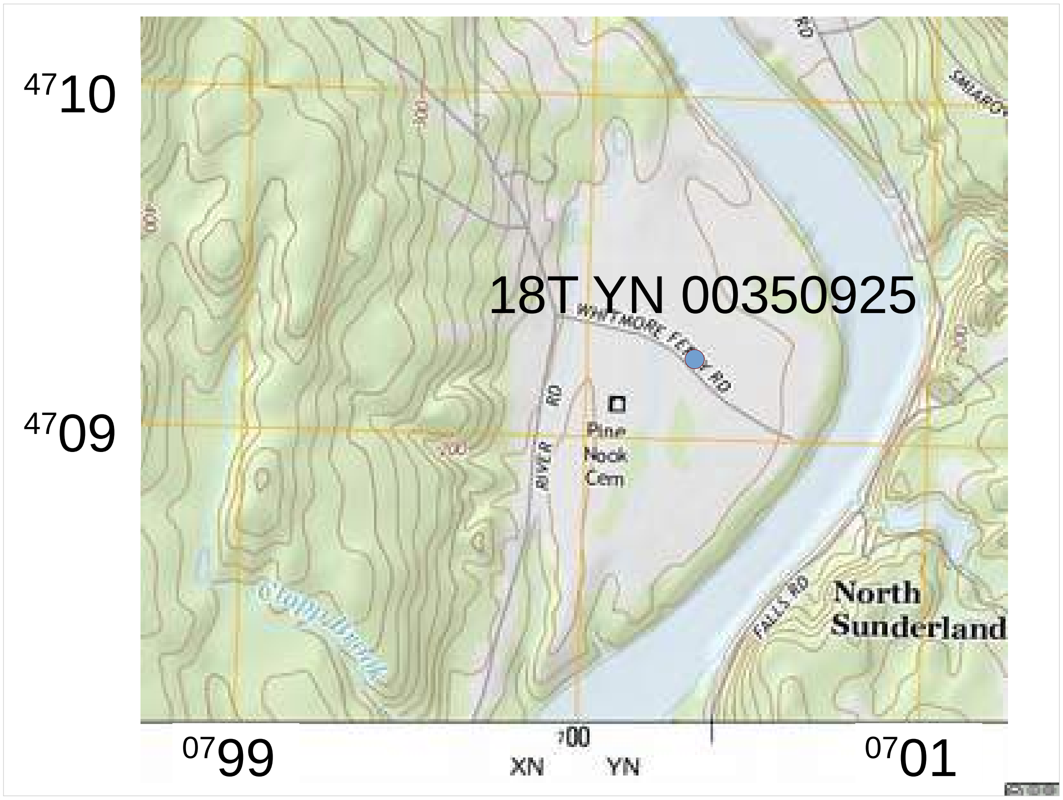
Which Coordinate System do I use?

- MA Land SAR: USNG with WGS84.
- NSARC Georeferencing Matrix:
  - Land SAR Responder
    - USNG Primary, Lat/Long Secondary
  - Land SAR coordination with Incident Command
    - USNG Primary, Lat/Long Secondary
  - Land SAR Responder with Aeronautical SAR
    - USNG Primary, Lat/Long Secondary

Which system to use?

Emerging MA SAR community standard: USNG with WGS84

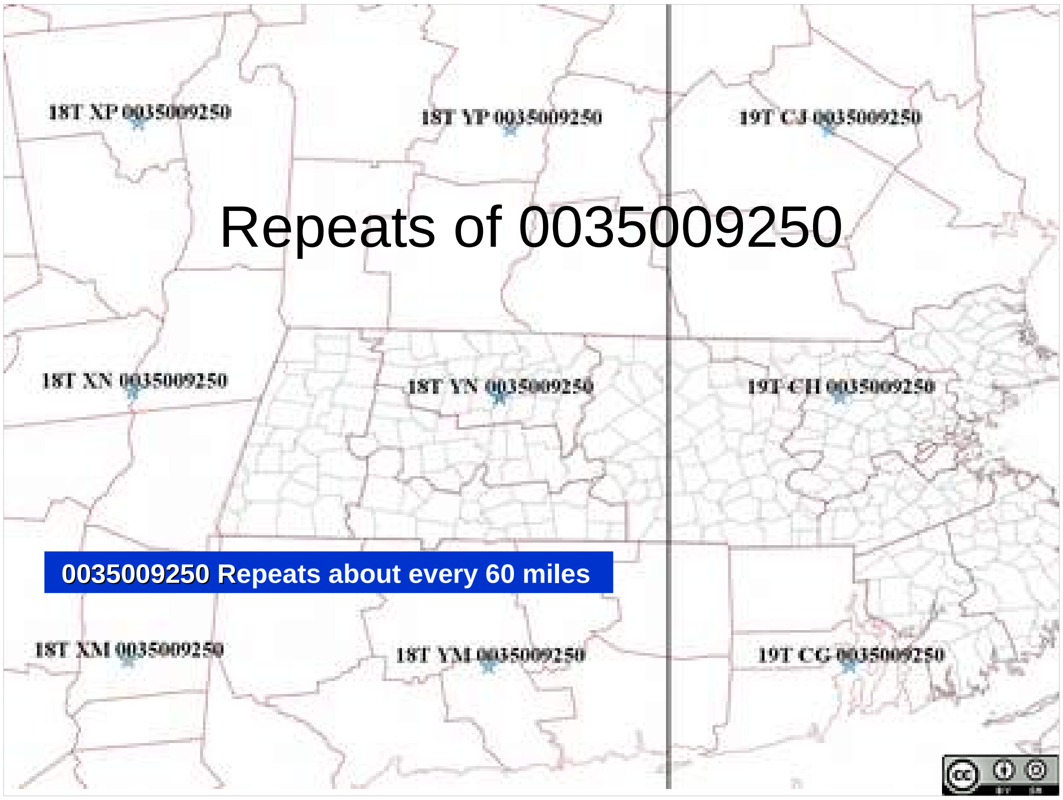
National SAR Council matrix:
Primary for Land SAR responders: USNG.



Let’s take a location: 18T YN 00340925

What are the pieces of this coordinate?

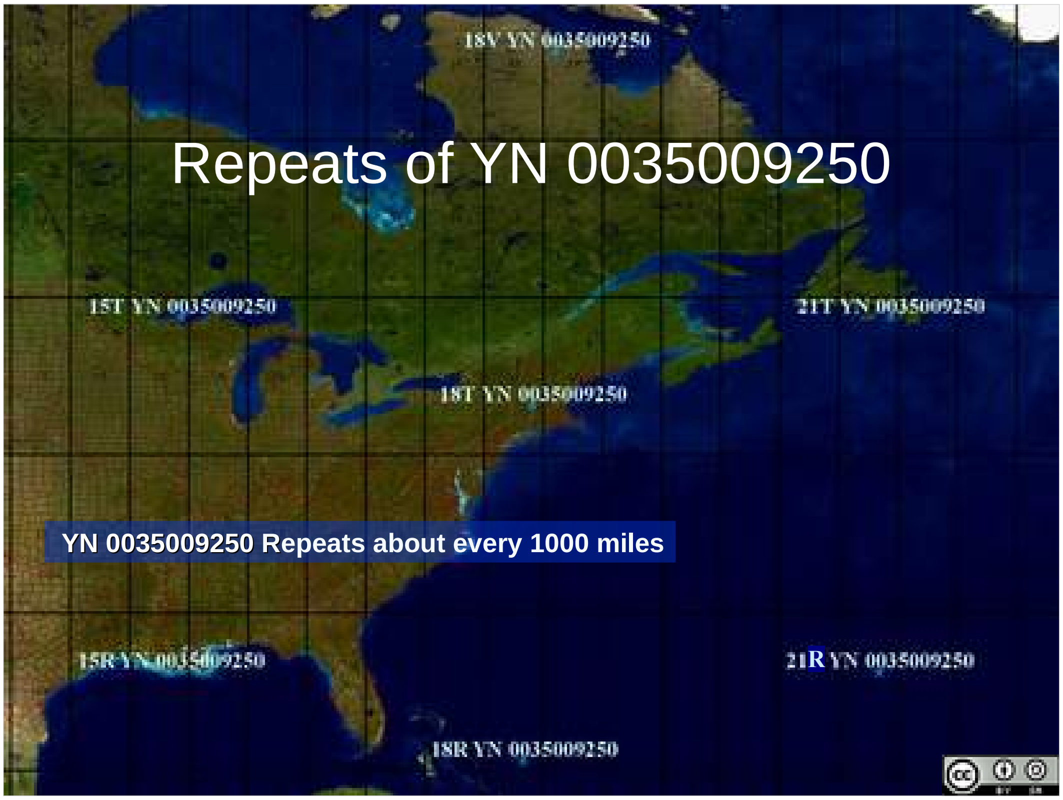
(Review what we are looking at:
Zone 18, Band T
100,000 meter square YN
Easting: 0035
Northing: 0952 (4 digits, thus 10 meter resolution)



If we just take the Easting and Northing: 003509250 (for local communication), this same local coordinate repeats in each 100,000 m grid square, thus about every 60 miles (100,000 m = 100 km = about 60 miles).

So, local coordinates mean local within a distance of a few tens of miles.

(Black vertical line is the zone 18-19 boundary, map shows outlines of counties and in MA the outlines of towns.)



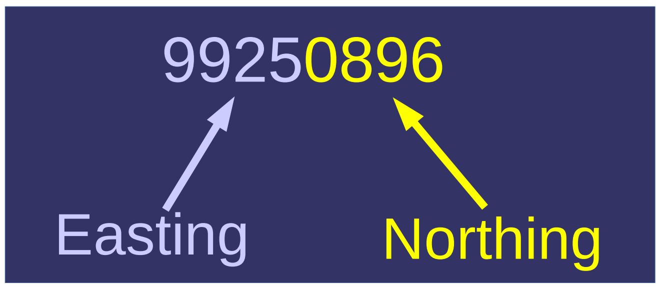
If we add the 100,000m grid square: YN 0035009250, then this location repeats in each zone where there is a YN grid, about once every 1000 miles.

So, including the 100,000 m grid square provides for regional communication, where regional means within a few hundred miles.

(Black vertical lines are UTM zone boundaries, black horizontal lines are bands, the A-Z lettering system for the 100,000 m grid repeats about every three zones, thus zone 16 and zone 17 don't have northern hemisphere YN 100,000 m grid squares).

US National Grid
Local coordinates

100 meter grid square: 992089
10 meter grid square: 99250896
1 meter grid square: 9925308966



So, to review: In USNG, local coordinates are always an even number of digits. Split in half to get the Easting and the Northing. The first two digits of Easting and Northing will be the big numbers for the 1 km grid on USGS maps.

6 digits, 100 meter square, first 3 Easting last 3 Northing (leaving off the 10 m and 1 meter digits). 992 will be 200 meters East of the 99 Easting line (2/10ths of the way to the next Easting line).

8 digits, 10 meter square, first 4 Easting, last 4 Northing (leaving off the 1 meter digits). 9925 will be 250 meters East of the 99 Easting line.

10 digits, 1 meter square, first 5 Easting, last 5 Northing. 99253 will be 253 meters East of the 99 Easting line.

Ready to copy location?

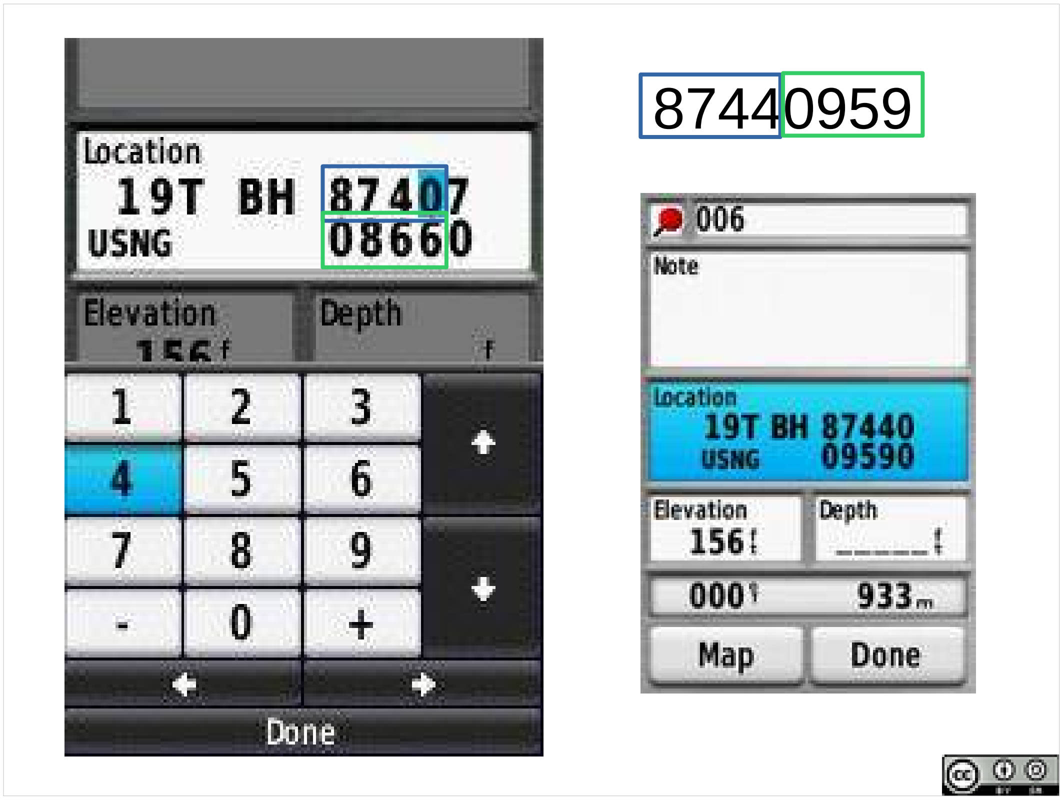
19Tango Bravo Hotel 8744609591

Or (much simpler):

87440959

What did I just give you? (local coordinate, just the easting and northing)

How do you enter this (local) position into your GPS?

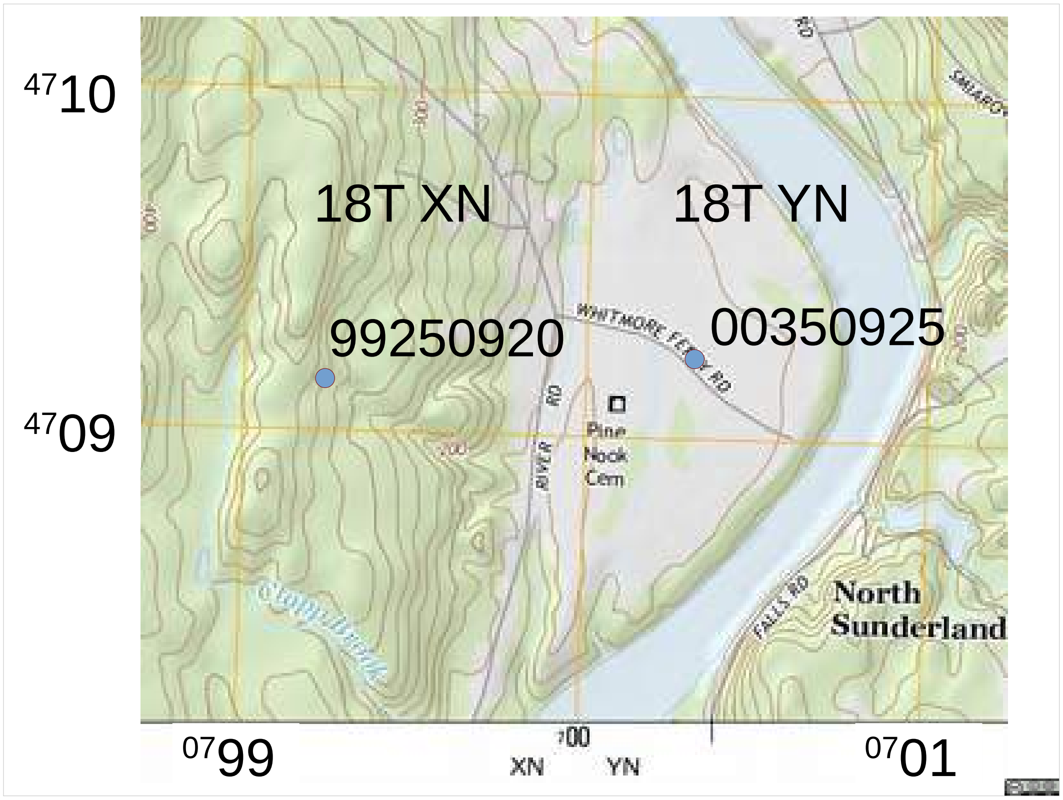


Position transmitted as: 87440959 What do we have?

USNG, Easting 8744[0] Northing 0959[0] (10 meter)
(split the position in half, first half is Easting, second half is Northing).

Create a waypoint in your GNSS. Edit to match. If you are working nearby in the same grid square, then the zone, zone letter, and grid square will be the same (USNG has 5 digits after the grid square to get to 1 meter resolution, so start at the leftmost digit and fill in zeroes after you run out of numbers).

If you are working near the edge of a grid square you may need the grid square as well. Working with a map it should be obvious, working with a GPS you may get a location some 60 miles away.

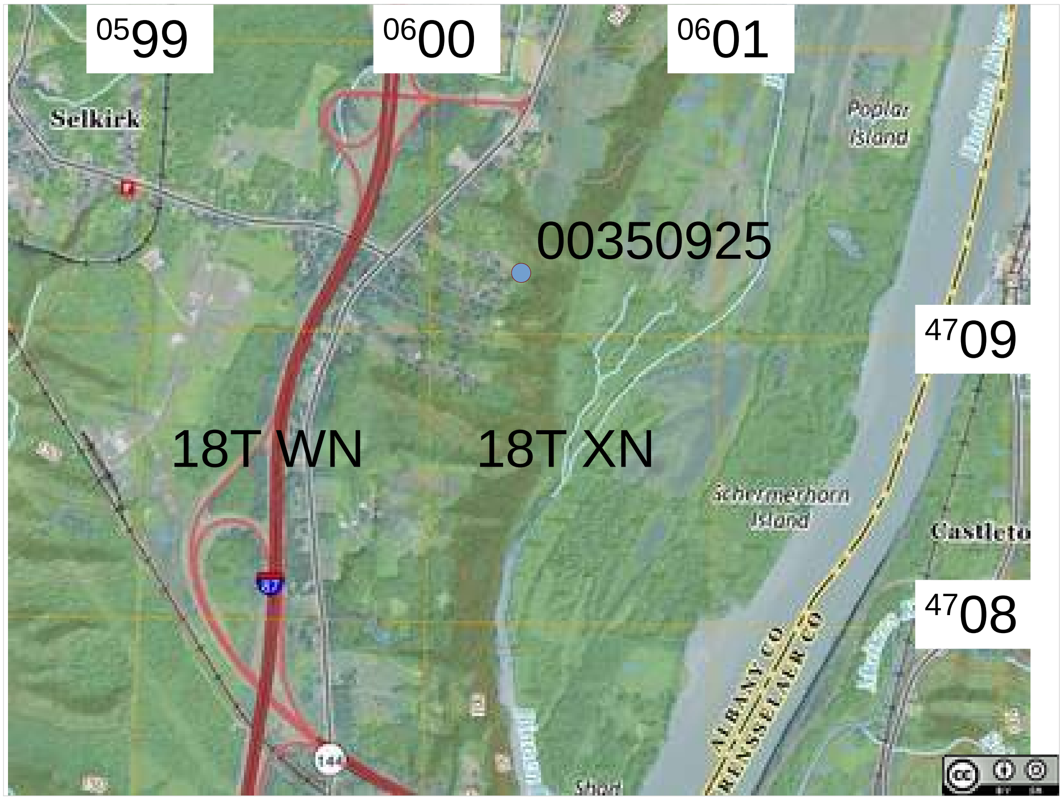


These two points should be about 1 km apart.

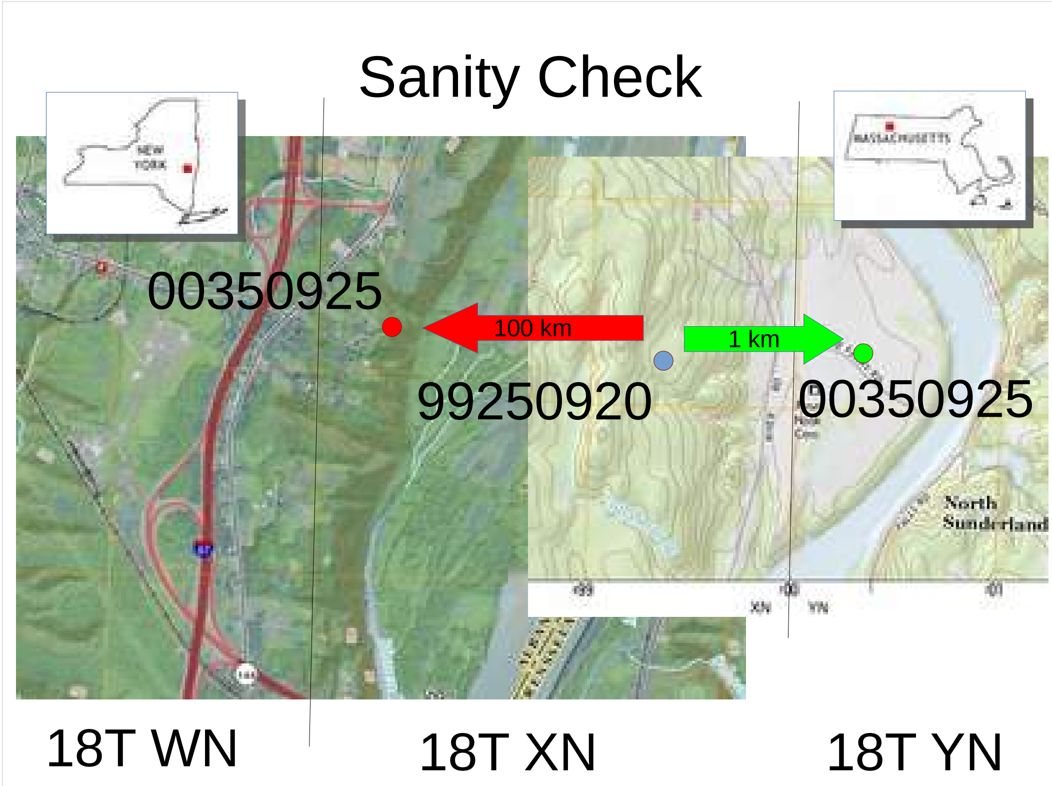
Communicate without the XN and YN, and you might end up with 18 T XN 00350925, about 100 km away.

You are in 18T XN. You receive the local coordinate 00350925. You create a waypoint in your GNSS reciever. You edit that waypoint so that the coordinate is 18T XN 00350925. You ask your GNSS to go there, and it says the distance to that waypoint is about 100 km away. That's a point about 100 km away at the far Western edge of Square XN.

When a search area spans a 100,000 m square boundary, you need to be aware of the which grid square a coordinate is in. Working with a map, this is simple. Working with just a GNSS, you may need the full USNG coordinate transmitted to you.



Here’s 18T XN 00350925 – about 60 miles away from the search area, across the Hudson river, in New York.



Working near a 100,000 meter Square boundary, sanity check coordinates you enter into a GNSS receiver (that is, how far away is the new point from your current location)

A local coordinate should be in the search area, not about 100 km away.

When working near 100,000 meter Square boundaries, it may be appropriate to include the Square ID in coordinate transmissions – particularly when transmitting to a resource that will be entering the location into a GNSS reciever.

UTM
Conventionally:

19 Tango
0287367
Break
4709474

Communicating **UTM** coordinates, conventionally break (say Break, then release the mike and listen briefly) between the Easting and the Northing. Words Easting and Northing usually aren't included.

Common errors: Reading UTM as part of the coordinate. Only reading the Grid Zone Designator and the Easting,

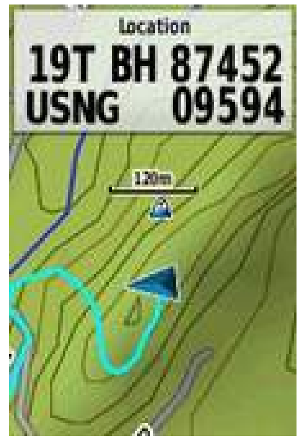
Save a waypoint, or write down the location before you transmit. The meters digit will probably change while you are standing in one place reading off the numbers.

USNG as:

19 Tango
Bravo Hotel
8736709474

or

87450959



UTM is conventionally read with the Easting and Northing as a single string of numbers, instead of separate parts (no pause and no break in the transmission).

42 Degrees
30 Minutes
30 decimal 7
Seconds
North

71 Degrees
35 Minutes
16 decimal 2
Seconds
West

Latitude and Longitude.

Transmitting the degrees/Minutes/Seconds format takes lots of words.

Decimal Degrees format is less wordy.

Practical Evolution: (2) Communicate USNG coordinates of points on map via radio

(3) Lat/Long, (4) UTM, (5) describing features on the map.

Advantages and Disadvantages

Each system has advantages and disadvantages:

Latitude/Longitude:

Single grid for anywhere in the world.

Coordinates are angles and don't readily translate to distances on the ground.

Longitude lines on a map always run true North/South (grid north is true north).

UTM

60 separate grids (one for each zone).

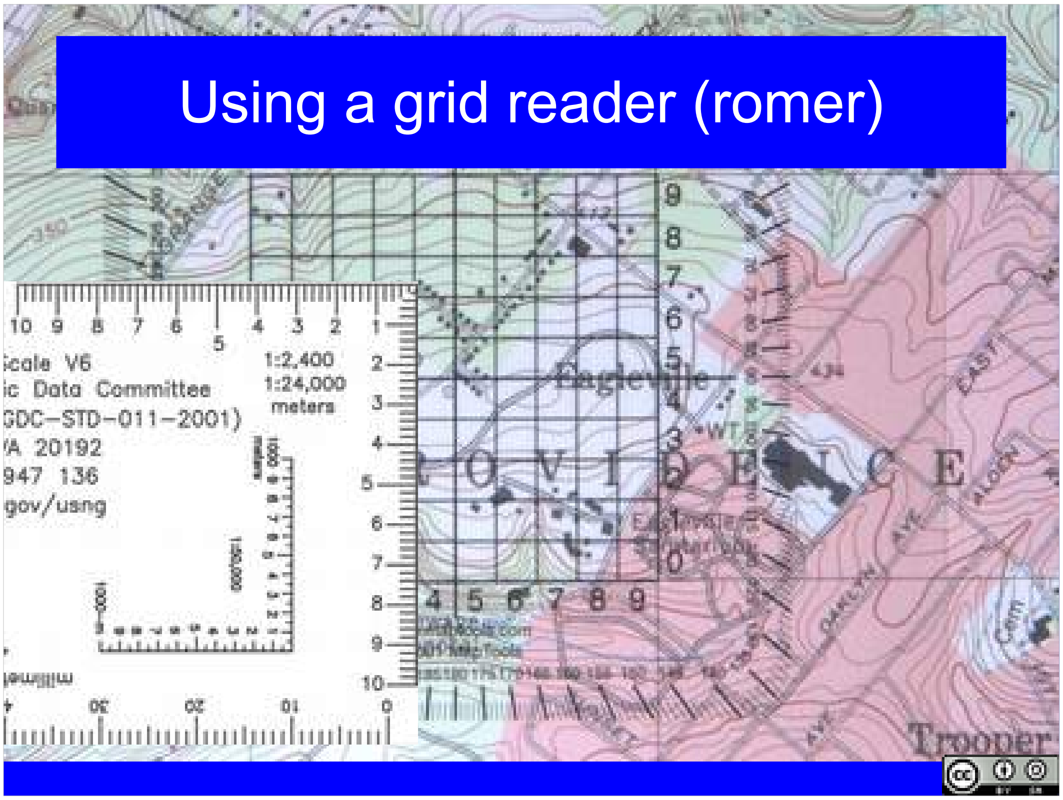
Coordinates are distances in meters. Easy to understand distances between two points in the same zone (but not across zones).

Grid North is slightly off from True North near zone boundaries.

USNG

Defined way for simplifying the coordinate for the situation.

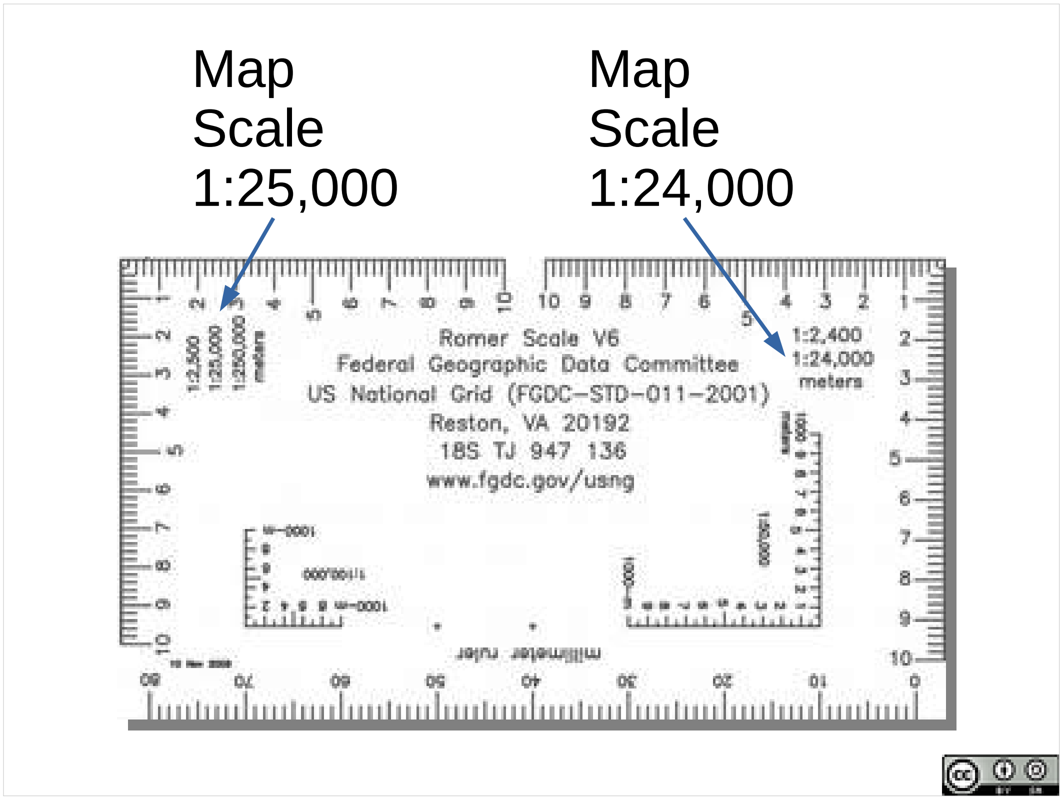
Distances within the same 100 km square are easy to see from the coordinate (but not across squares or zones) (coordinate on the right is about 150 m NE of the two on the left).



If you have a map printed out at a standard scale (true for the printed USGS topo quads, and US Topo maps, not true for print on demand maps), you can use a grid reader to find locations within 1 km grid squares.

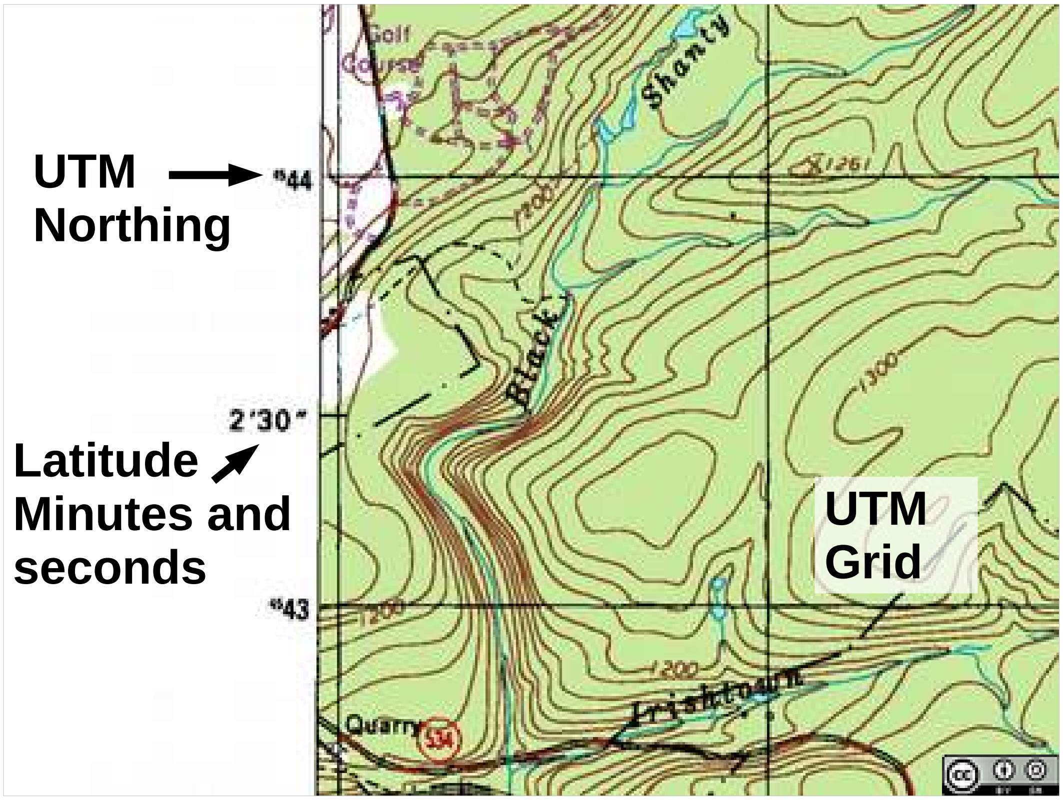
Two different grid readers shown: one transparent 1 km square, with 100 m grid lines; other L shaped, printed with 100m and 10 m tic marks.

Grid reader must match the scale of the map (which is why the work well for maps printed at standard scales, but not for print on demand maps, which can be arbitrarily rescaled for printing).

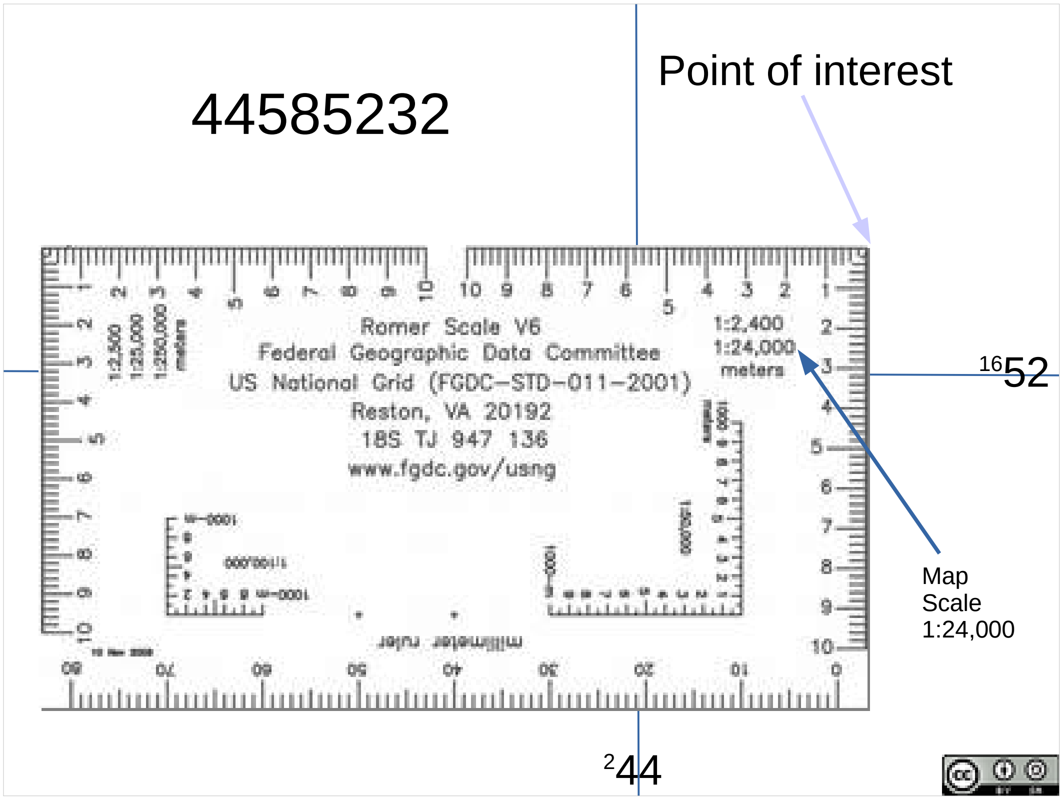


This is the FGDC (Federal Geographic Data Committee) romer (available from www.fgdc.gov/usng). When printed at the correct size, one corner is for use with 1:24,000 scale maps (the distance from the corner to 10 on the scale is 1 km, matching the 1 km UTM grid). The other corner is for use with 1:25,000 scale maps.

The numbered scales running into the corners are numbered at 100 meter intervals, and have small ticks at 10 meter intervals (for the 1:24,000 and 1:25,000 scales).



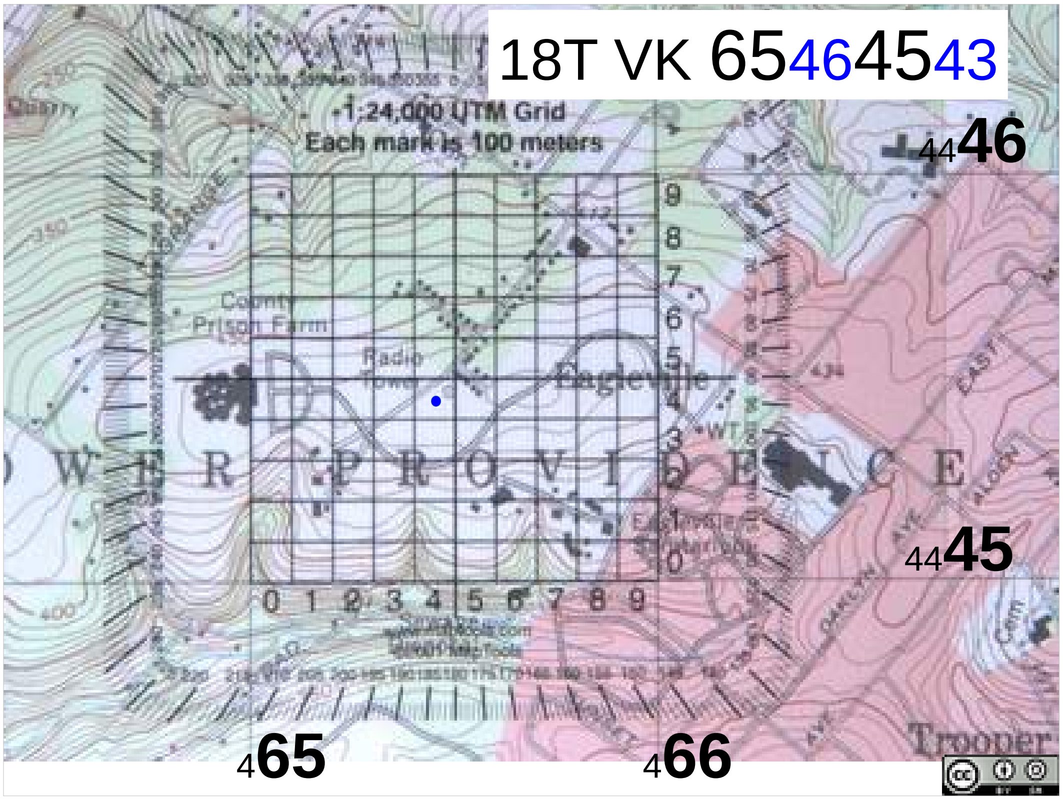
The romer works with the 1 km UTM grid printed on the USGS topo quad and US Topo maps.



To use the romer, first confirm that when the corner is placed on one grid line, the 10 on the scale is on the next grid line. If that is true, then the romer and the map are at the same scale and you can use that romer on that map.

Then place the corner of the romer on the point of interest, identify the grid line for the easting (here 44 (using USNG so we ignore the small 2)), and read off the number where the roamer crosses that easting line (here 5 and 8 small ticks). Put the numbers together for the easting: 4458 (down to a 10 meter square). Repeat with the northing: find the northing line (52), and read tens of meters off the scale (32) for a northing of 5232. If desired, estimate meters in the distance between the ticks (to go to 5 digits for easting and northing 4458052320),

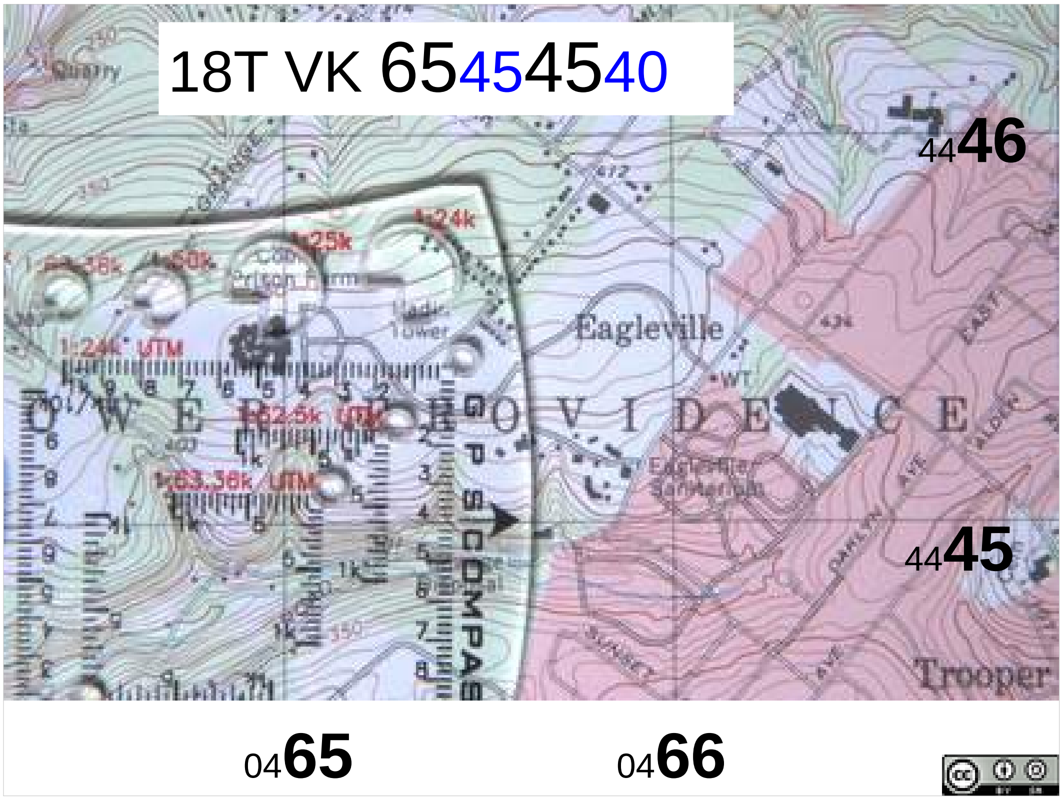
This works in reverse, given a coordinate, you can use the scale on the romer and the UTM grid to put a point on a map.



Other grid readers can be a transparent grid 1 km square at the scale of the map.

Use by placing the grid reader on a 1 km grid square, find the number for the Easting line (65), then find which square the point of interest lies in, and read off the 100 m easting digit from the edge of the grid (here 4). Then you can estimate the 10 meter easting digit (6), for an easting of 6546. Repeat with the northing, grid line (45), 100m square (4) and estimate 10s of meters (3) for a northing of 4543, thus USNG local coordinate of 65464543.

Where do we get the 18T VK from?



Some compasses have grid readers printed on the base plate – often with a hole at the corner of an L. Place the hole on the point of interest and read off the easting and northing 100m and 10m digits, or given a coordinate, find the easting line and northing lines for the 1km grid square of interest, line up the compass with the easting line and, move the easting scale to match the rest of the coordinates, repeat with the northing to put the hole over the point (then you can mark the map with a pencil or pen through the hole).

SDMRT coordinates

- Everyone has identical maps.
- Communicate points on the map from measurements in inches on the map from the edge of the map (read in like Easting, read up like Northing, but in inches measured on the printed map.
- Maps must be exactly identical (they can't be copied in different resolutions or positions).

San Diego Mountain Rescue Team coordinates.

Make a set of absolutely identical copies of a map (can be any arbitrary map, including local trail maps or street maps). Everyone communicating location needs an absolutely identicalcopy of the map (same scale, same position on photocopier, same enlargement, etc).

Mark a point on the map. Measure the distance from the left edge of the map in inches to the point. Measure the distance from the bottom of the map to the point. Communicate these two distances.

If the maps at the receiving and sending ends are identical in every way, then the point on the map can be communicated successfully. Any difference, and the wrong location will be received.