



Search and Rescue Land Navigation





Search and Rescue Land Navigation



This Course Consists Of:

- Compass and Map Basics
- Traveling to a Target
- Topo Map Basics
- Distance Calculations
- Finding Yourself
- UTM / USNG Coordinate System
- Using GPS with a Map
- Understanding And Adjusting For Declination



Search and Rescue Land Navigation



P.A.C.E.

System for Search and Rescue

- PRIMARY – GPS, Phone Apps
- ALTERNATE – Map and Compass
- CONTINGENCY – Terrain Association
- EMERGENCY - PLBs



Search and Rescue Land Navigation



Compass Types



Baseplate



Digital



Mirrored – Sighting
(Preferred)



Accessory



Lensatic



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Compass Needle – Red Points
To Magnetic North

Orienting Lines

Bearing Index (Read
Bearing Here)

Orienting Arrow

Declination Scale



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Boxing A Compass





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Map Orientation With Compass Adjusted For Declination

1) Adjust dial so "N" is at index line.

2) Align edge of compass with north / south reference line.

3) "Box" compass needle by rotating map.

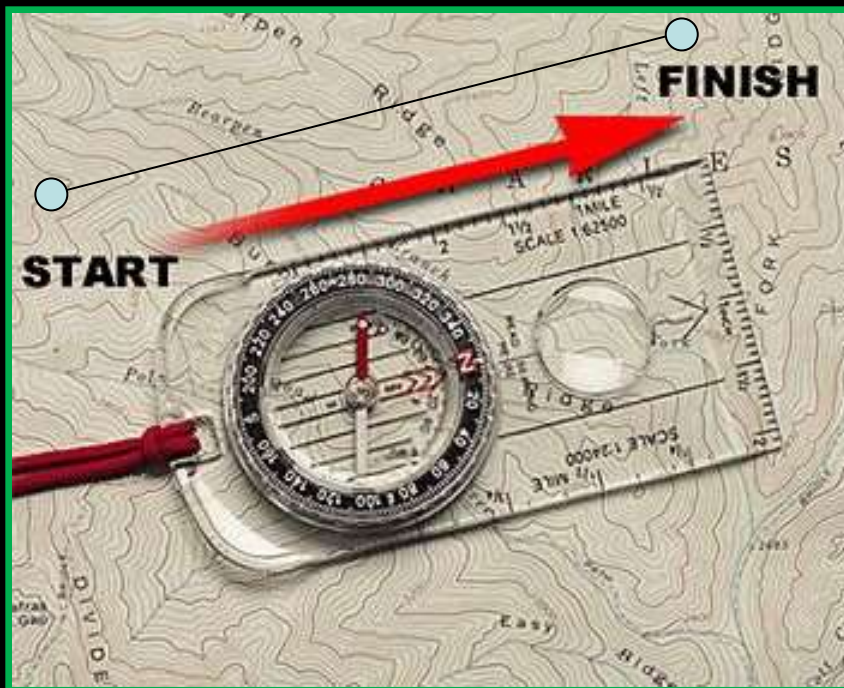




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Finding An Azimuth With Compass Without Grid Lines



Step 1

- 1) Draw a line on the map from your starting point to your finish point.
- 2) Orient the map to north.
- 3) Place the compass on the map with the edge of the compass on the line and the bearing arrow pointing at your destination



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Traveling To a Target On The Map



Step 2

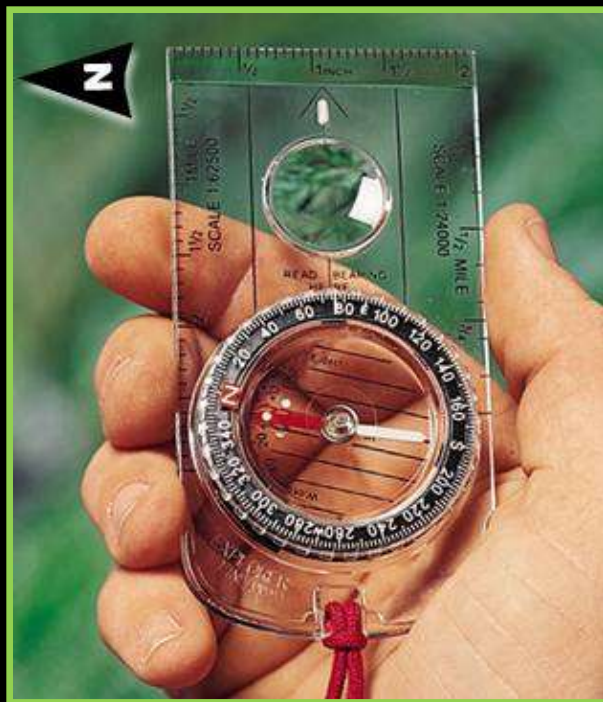
Set Compass Heading - Turn the dial on the compass until “N” outline arrow boxes the compass needle. Your direction to your target (in degrees) is read at the Index Line on the Dial.



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Traveling To a Target On The Map



Step 3

Follow Your Heading - Remove the compass from the map and hold it level, so the Magnetic Needle is free to turn. Turn your body until the red end of the Needle aligns with the Orienting Arrow (boxed) and "N" on the Dial. Using the Direction of Travel Arrow, sight a distant landmark and move to it. Repeat this process until you reach your destination.

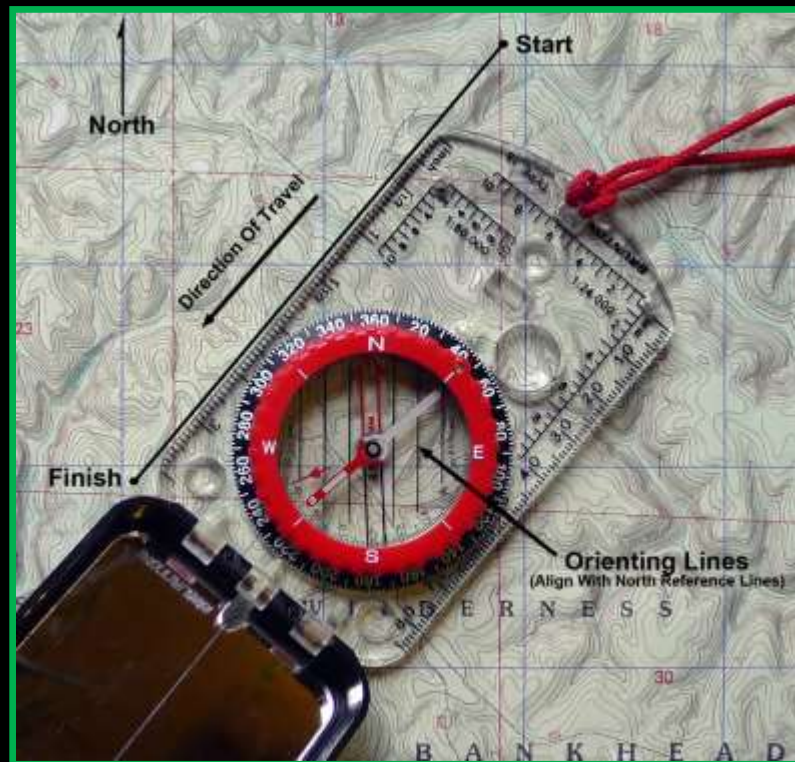


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Finding An Azimuth With Compass (Using Map Grid Lines)

- Draw a line from start to finish.
- Lay the edge of your compass on the line in the direction you are traveling.
- Rotate the compass bezel until the orienting lines align with your North Reference Lines (Make sure that North is pointing to North on the map).
- Pick up your compass, box, and travel to the destination.
- Note: The compass shown has already been adjusted for declination.



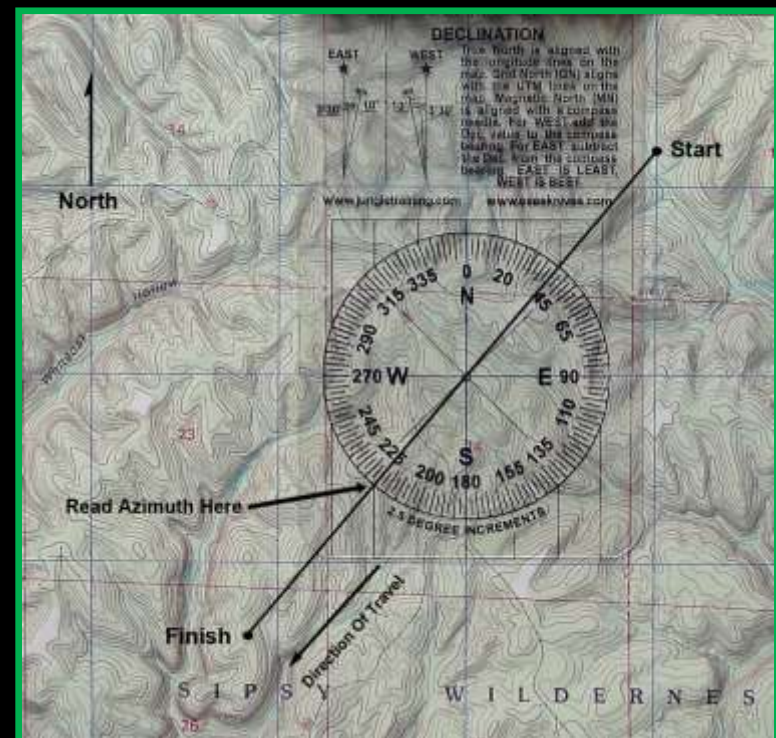


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Finding An Azimuth With Compass Card / Protractor (Using Grid Lines)

- Draw a line from start to finish.
- Lay the compass rose on the line so the line crosses through the center of the rose.
- Align N / S line or orienting lines on the compass rose with Reference Line.
- Read your azimuth on the “Finish” side of the compass rose.
- Note: you will have to add or subtract the declination value to the value.

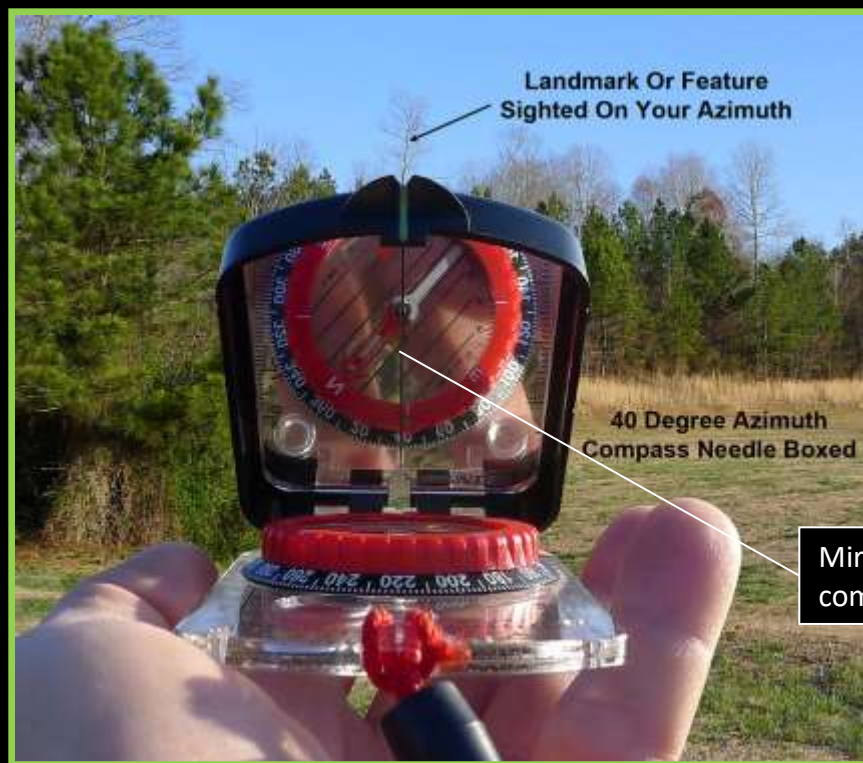




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Traveling To a Target With A Sighting Compass



- Use the mirror properly.
- Hold the compass at eye level.
- Use the mirror line to ensure the compass is aligned properly.
- Use the sighting notches to find a distant target.
- After a target is acquired, put the compass down and walk to your target. Do not try to walk and watch your compass.



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Posting Up

In addition to using natural landmarks as targets for your direction of travel, you can also post up a member of your team as a target.

Posting up is handy for working around thick areas or navigation at night.

Another option is the Back Azimuth.





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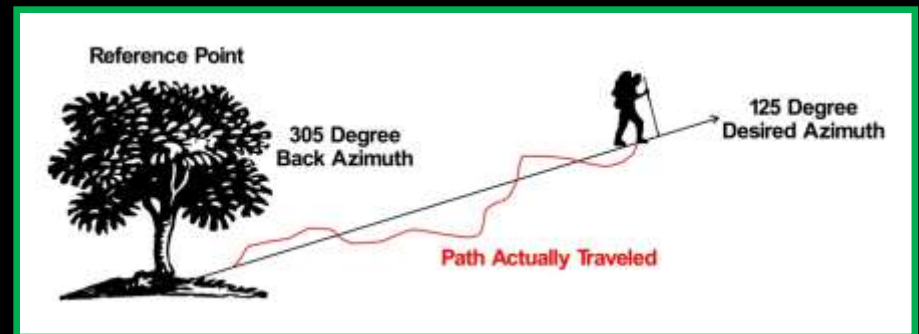
Back Azimuth

Use a Back Azimuth if you need to verify you are still on your desired direction of travel. This is especially handy when crossing rivers or boxing around objects.

Back Azimuth is 180 degrees from your target azimuth. If your target azimuth is more than 180 degrees, then subtract 180. If it is less than 180, then add 180.

Class Question:

If you travel 100 meters on a bearing of 40 degrees and then on a bearing of 60 degrees for 300 meters, can you get back to your starting point without a map and what route would you take.





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Boxing Around Objects

- Example direction of original travel is 45 degrees.
- Turn 90 degrees to a new azimuth of 135 (count your paces).
- Turn 90 degrees back to the original azimuth of 45 degrees until you are past obstacle.
- Turn 90 degrees to a new azimuth of 315 and pace the same amount as the first turn.
- Turn 90 degrees back to the original azimuth of 45 degrees and continue on.



Right – Add Left - Subtract



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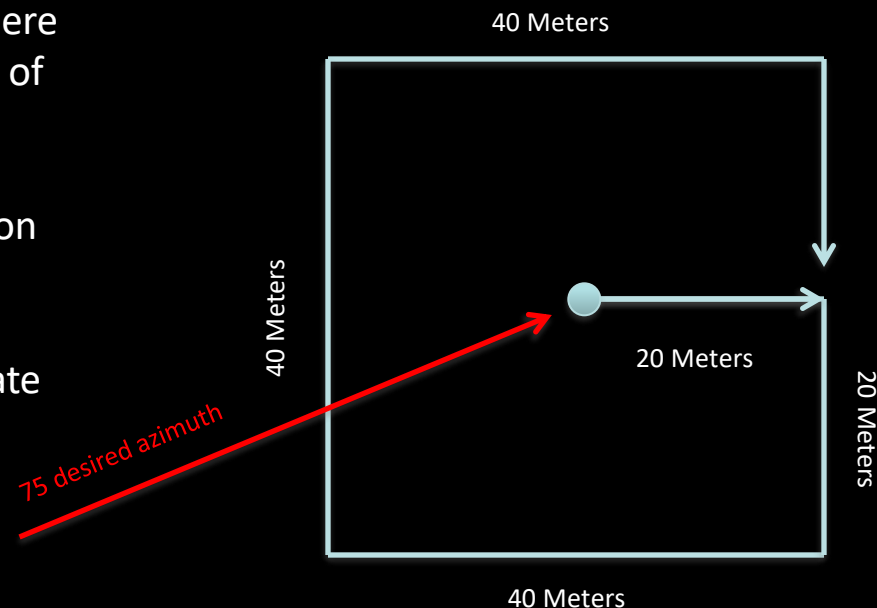
Lateral Drift

If you cannot find your target after walking your azimuth the correct distance, then mark the spot where you think it should be and begin a structured search of the area.

Make note of your azimuths, pace count, and direction changes.

Start your grid small then go larger if you cannot locate the target.

Alternate Methods: Skirmish line as you approach





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Gross Direction Navigation

As obvious from this simple road map, the lost hiker only needs to travel a westerly direction to cross a road and reach civilization.

Always know which general direction crosses a main artery!

When using a map and compass always have a "panic azimuth."

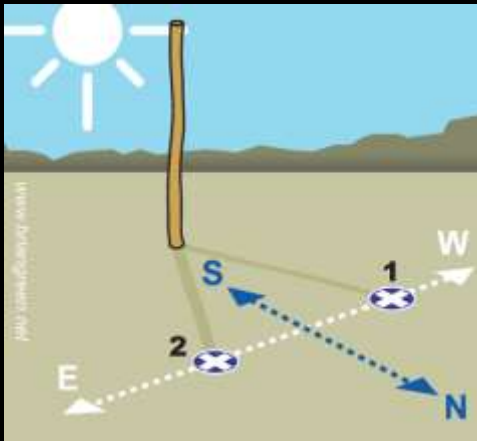




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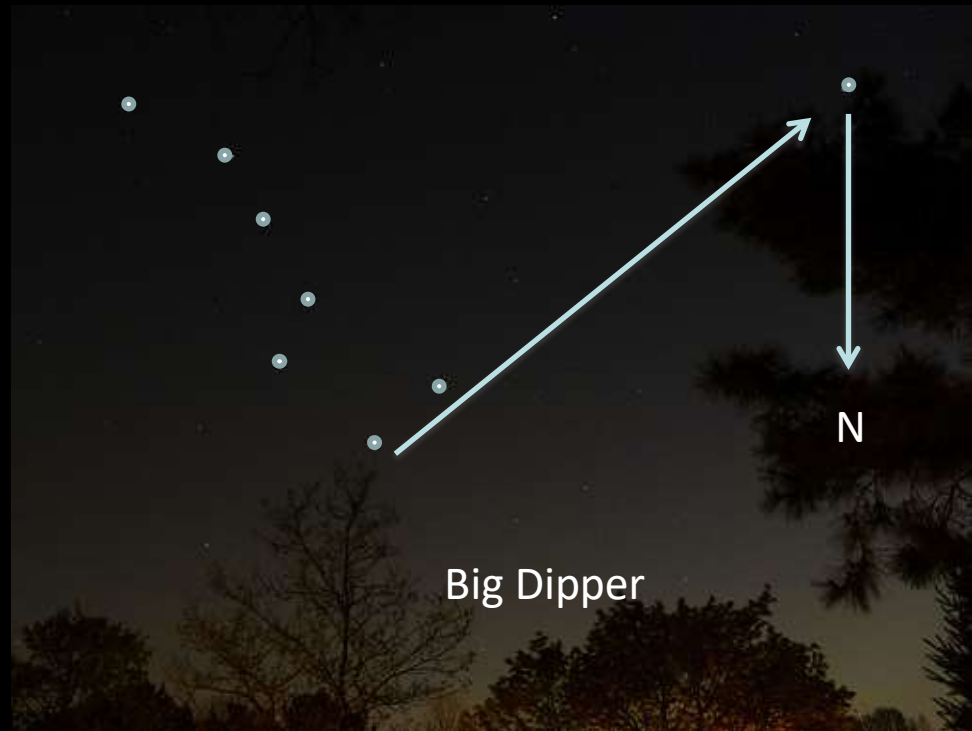
Gross Direction Navigation Aids



Shadow Stick



Quarter
Moon



Big Dipper



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Terrain Association Navigation

- This is the most widely used method of navigation.
- The navigator plans his route so that he moves from terrain feature to terrain feature.
- An automobile driver in a city uses this technique as he moves along a street or series of streets, guiding on intersections or features such as stores, parks or houses.
- Like the driver, the navigator selects routes or streets between key points or intersections. These key points can be lakes, mountains, roads or any other terrain feature readily recognized on a map.
- Before you hike a new area, familiarize yourself with the terrain by studying maps, satellite photos or other available information.



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Backstops, Handrails & Aiming Off

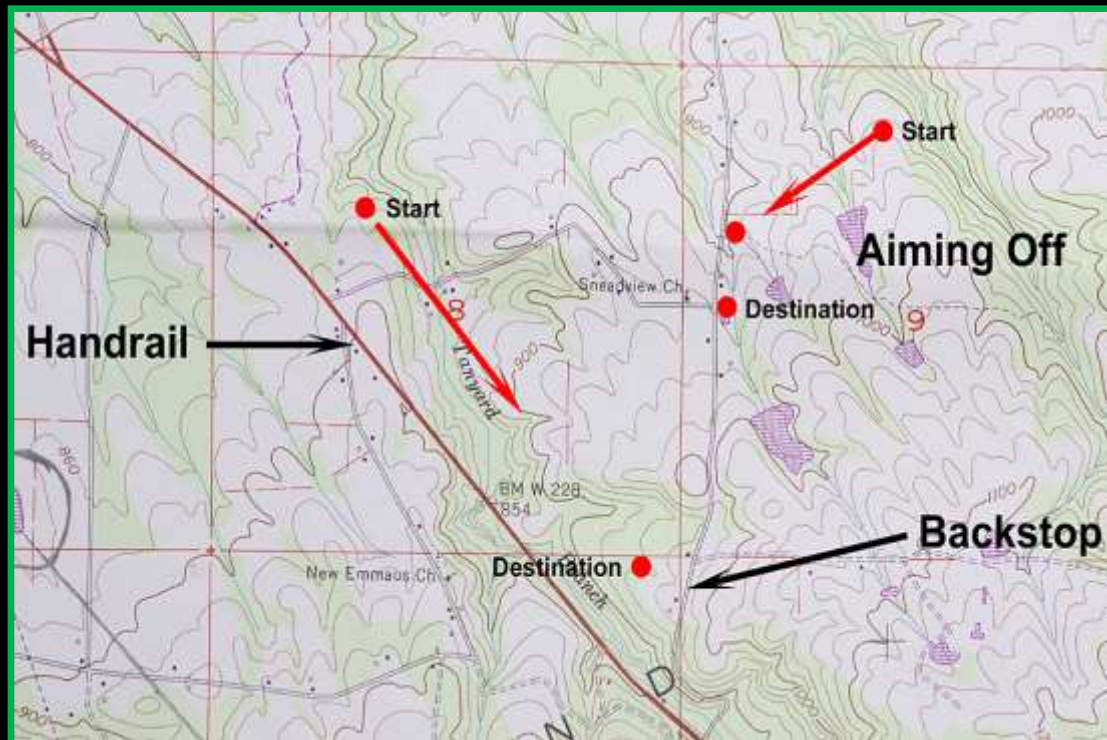
- BACKSTOPS are features that typically run perpendicular to your azimuth and located beyond your target point. If you run into your backstop then you know you have traveled too far and missed your target point. Backstops can be rivers, roads, mountains, railroad tracks or other useable features.
- HANDRAILS are features that run parallel to your azimuth. They can be rivers, roads, mountains, or other useable features that the navigator can use to continue traveling in the desired direction.
- AIMING OFF is a process of deliberately adding or subtracting to the desired azimuth so the navigator knows which way to go once they reach a feature (such as a trail or road) that leads to the target.



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Backstops, Handrails & Aiming Off



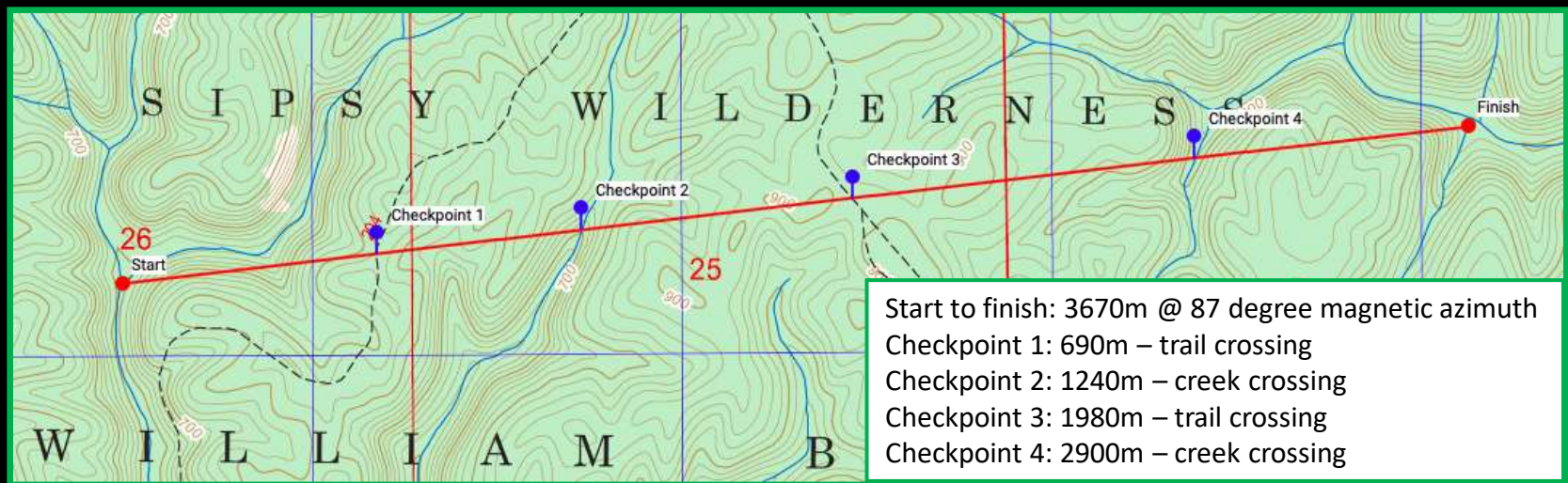


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Checkpoints

Checkpoints are features on the map that will be readily noticeable when navigating in the field, thus allowing you to verify your course and distance traveled. Checkpoints are established and noted before beginning field navigation.



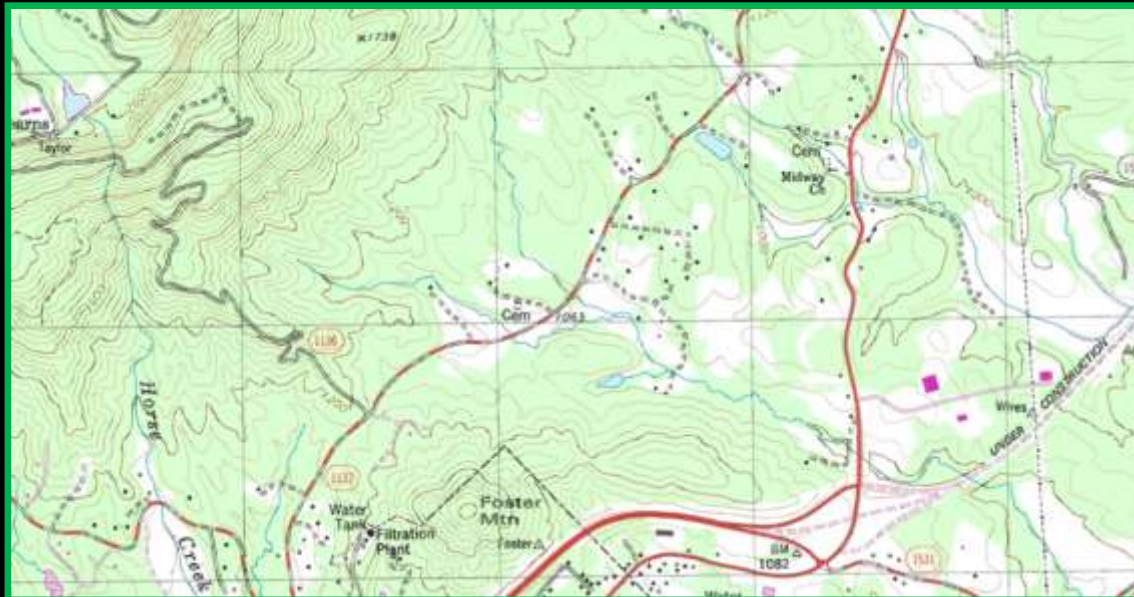


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TOPO MAP BASICS

Topographic Maps are maps which portray the shape and elevation of the terrain while showing a graphic representation of selected man-made and natural features.






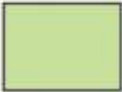


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Basic Symbols

The Map Legend is a side table or box on a map that shows the meaning of the symbols, shapes, and colors used on the map.

Most maps will also have a scale, declination value, UTM zone, the datum the map is printed in, and revision dates.

----- TRAIL		OPEN AREAS (CROPLAND PASTURE)
===== LIGHT-DUTY ROAD		WOODED AREAS / VEGETATION
..... UNIMPROVED ROAD		WATER
+ + + + + RAILROAD		PURPLE DENOTES NON-SURVEYED MAP REVISIONS
===== PRIMARY HIGHWAY		
----- SECTION LINE		
----- FENCE / FIELD LINE		
■		BUILDINGS (BLACK DENOTES MAN MADE OBJECTS SUCH AS HOUSES, SCHOOLS, CHURCHES, ETC.)





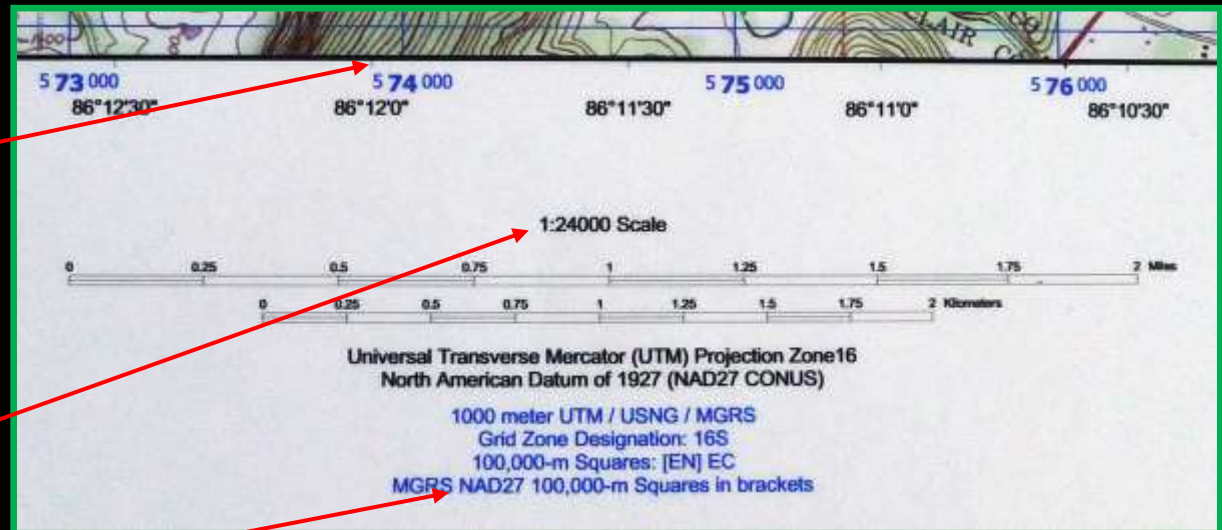
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Map Scale & Datum

Blue tick marks are UTM grid lines

- Use the proper scale card for measuring on a map.
- Set your GPS to the map datum shown on your map.



A 7.5 minute quadrangle topo map is scaled at 1:24,000. 1:24,000 scale means 1" on the map equals 24,000 inches in real terrain.



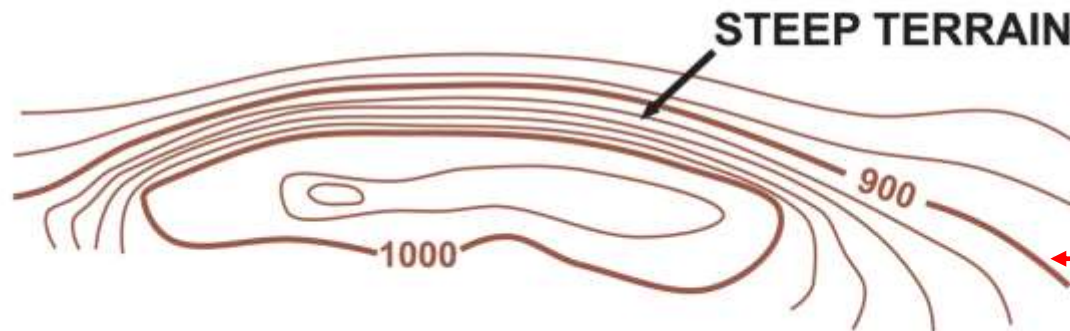
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Contour Lines

CONTOUR LINES

The closer the contour lines, the steeper the terrain. Check the map for the contour intervals. Contour lines will also have elevation markings.



Intermediate Line

Index Line

Example above shows a map with contour intervals of 20 feet.



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Depression





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Continuous Water Flow





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Intermittent Water Flow





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Clear Areas / Fields



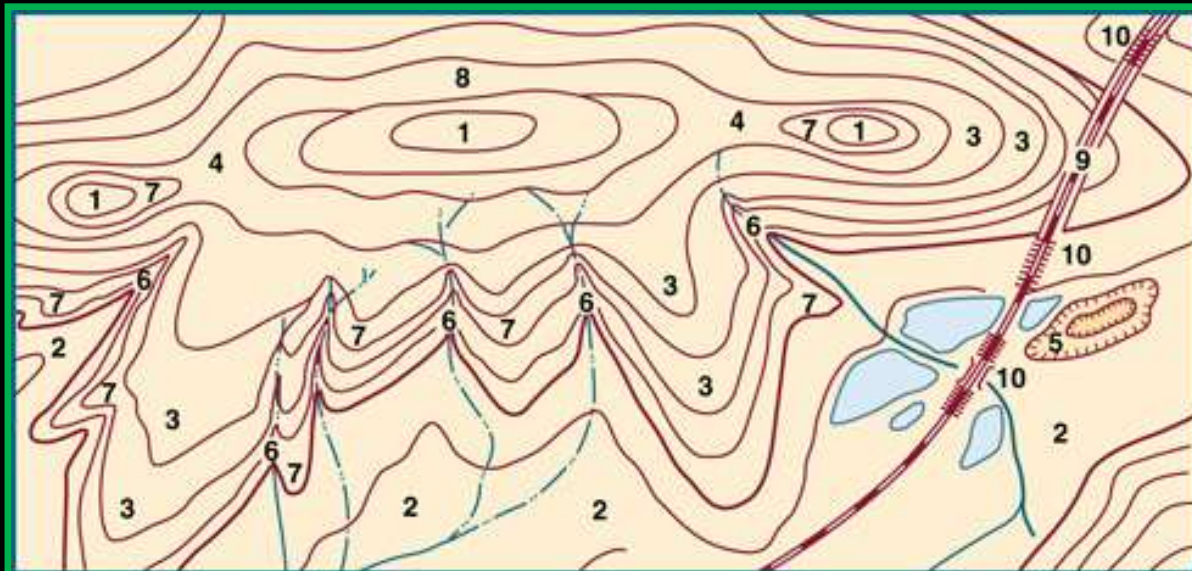
Wooded and clear areas may not be accurately represented depending on the last map revision.



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NASAR Graphic



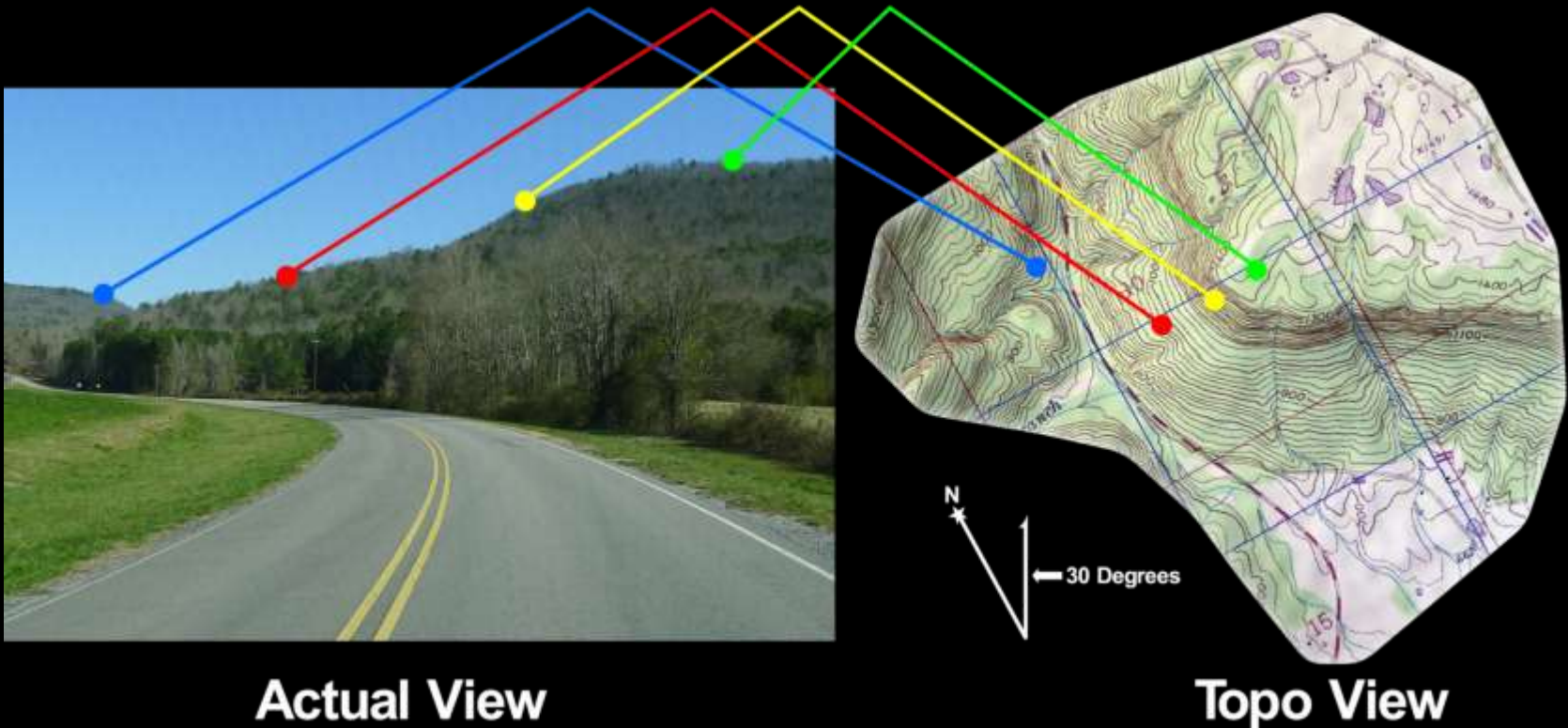
- | | | | | |
|-----------|-----------|---------------|----------|----------|
| 1. Hill | 3. Ridge | 5. Depression | 7. Spur | 9. Cut |
| 2. Valley | 4. Saddle | 6. Draw | 8. Cliff | 10. Fill |



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Interpreting A Topo Map





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Interpreting A Topo Map



Actual View



Topo View





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Determining Distance On Map



Use the correct scale card.



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Pace Count (Tally)

(Not a preferred method for overall navigation. Use checkpoints instead.)

Pace counting in varying terrain is an estimate at best. To be accurate, the navigator must practice pacing over different types of terrain. It's best use is for blocking around an area or object, or for short distance calculations such as measuring from backstops.

Averages

Flat easy terrain	100 meters	65 paces
Rougher terrain with some slope	100 meters	75 paces
Steep hill terrain	100 meters	95 paces

General Rule: You have never traveled as far as you think you have.



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Ranger Pace Count Beads





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0
meters



100
meters



200
meters



900
meters



1000 meters (1
kilometer)



1100 meters
(1km 100m)



5000 meters
(5 kilometers)





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Conditions That Affect Pace Count

- Slopes – Your pace lengthens on a downslope and shortens on an upgrade.
- Winds – A headwind shortens the pace and a tailwind increases it.
- Surfaces – Sand, gravel, mud, snow and similar surfaces tend to shorten your pace.
- Elements – Falling rain or snow causes the pace to be reduced in length.
- Clothing – Excess clothing or shoes with poor traction affect the pace length.
- Visibility – Poor visibility due to rain, snow, or fog will shorten your pace.

Your pace (or tally) should be determined by walking a variety of courses with your pack on.



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FINDING YOURSELF





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Baselines

Declination does not matter. All that is important is the ability to see your reference features.

- Find two prominent features.
- Take an azimuth to the first one and write it down.
- Take an azimuth to the second one and write it down.
- If you get lost, take an azimuth to the first feature and move until you get back on your first azimuth line.
- Take an azimuth to your second feature and move until you get back on your second azimuth line.



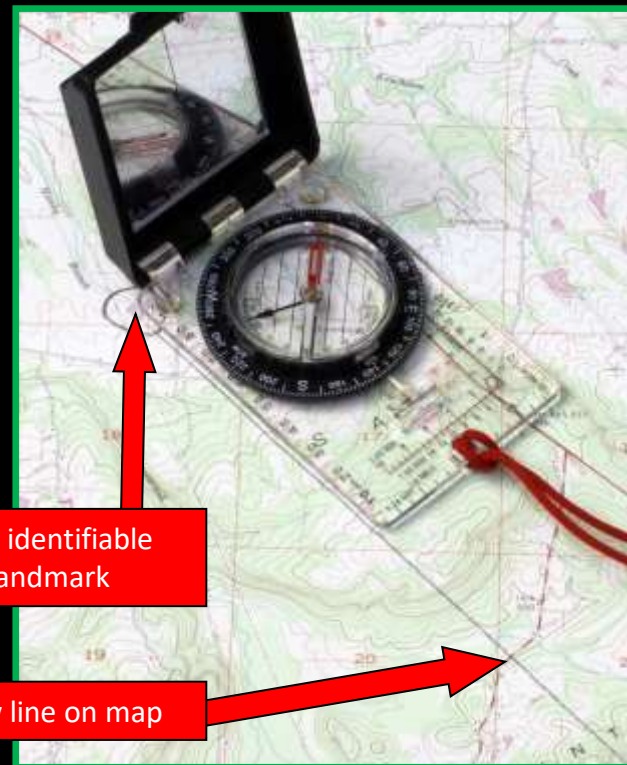


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Resection (without using grid lines)

- Orient your map and secure its position.
- Locate a landmark on the map that you can actually see in the landscape.
- Take a compass bearing to that landmark by sighting and then rotating compass dial until the needle is boxed.
- Once you have a bearing, do not move the compass dial. Lay the corner of the compass on the map landmark and rotate the whole compass (not the dial) until the needle is boxed.
- If done properly the corner of the compass will still be over your landmark. Draw a line along the edge of the compass base.



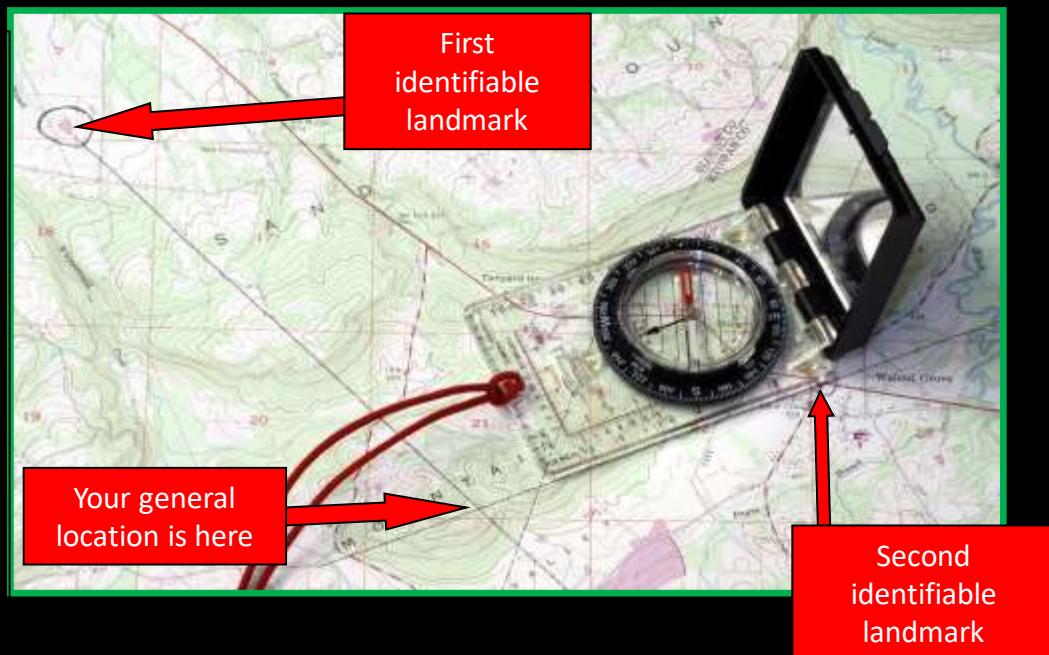


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Resection - Step 2

- Find a second identifiable landmark on the map and repeat the process from the previous slide.
- Where the two lines intersect is roughly where you are on the map.
- Finding a third point on the map and repeating the process is called “triangulation” and increases the accuracy of finding your location.





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Resection / Intersection

If you are already on a known location (such as a road, river or mountain ridge) but not sure exactly where you are on this feature, you may only need to shoot one azimuth to determine your exact position on the map.

INTERSECTION is the reverse of RESECTION. An example of intersection is seeing smoke from a forest fire and determining where the fire is located on a map.





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COORDINATE SYSTEMS





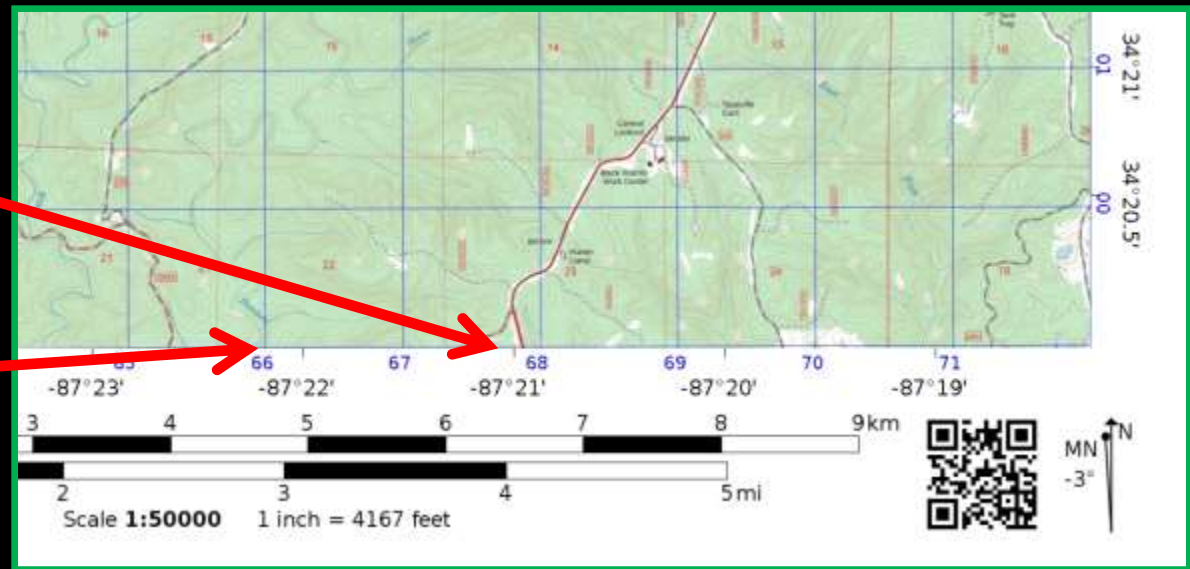
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Map Grids

Longitude: True North
Reference(Black)

UTM / MGRS / Etc.:
Grid North Reference (Blue)



When using a GPS with a map, set your GPS to the grid system you are using on the map.



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Universal Transverse Mercator (UTM)

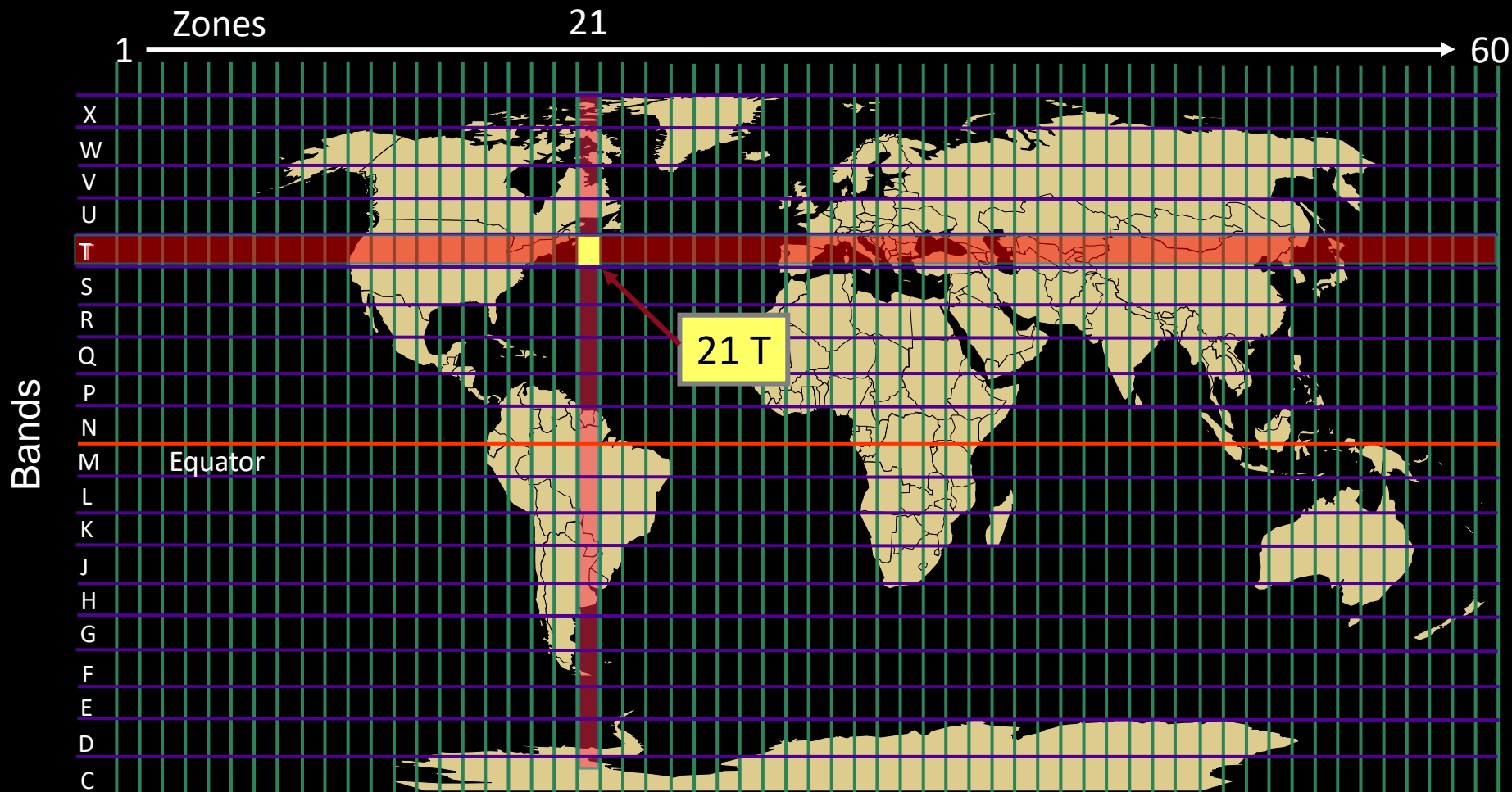
- A rectangular coordinate system based on the latitude and longitude (geographic) coordinate system.
- The earth is divided into 60 zones that allows it to be projected onto maps with minimal distortion.
- All coordinates are expressed in meters.
- The UTM/USNG grid system is the easiest method of relaying your position to others, finding yourself on a map after getting a location fix with a GPS unit, or navigating to a position on a map using a GPS unit.



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UTM: 60 Zones and 20 Latitude Bands

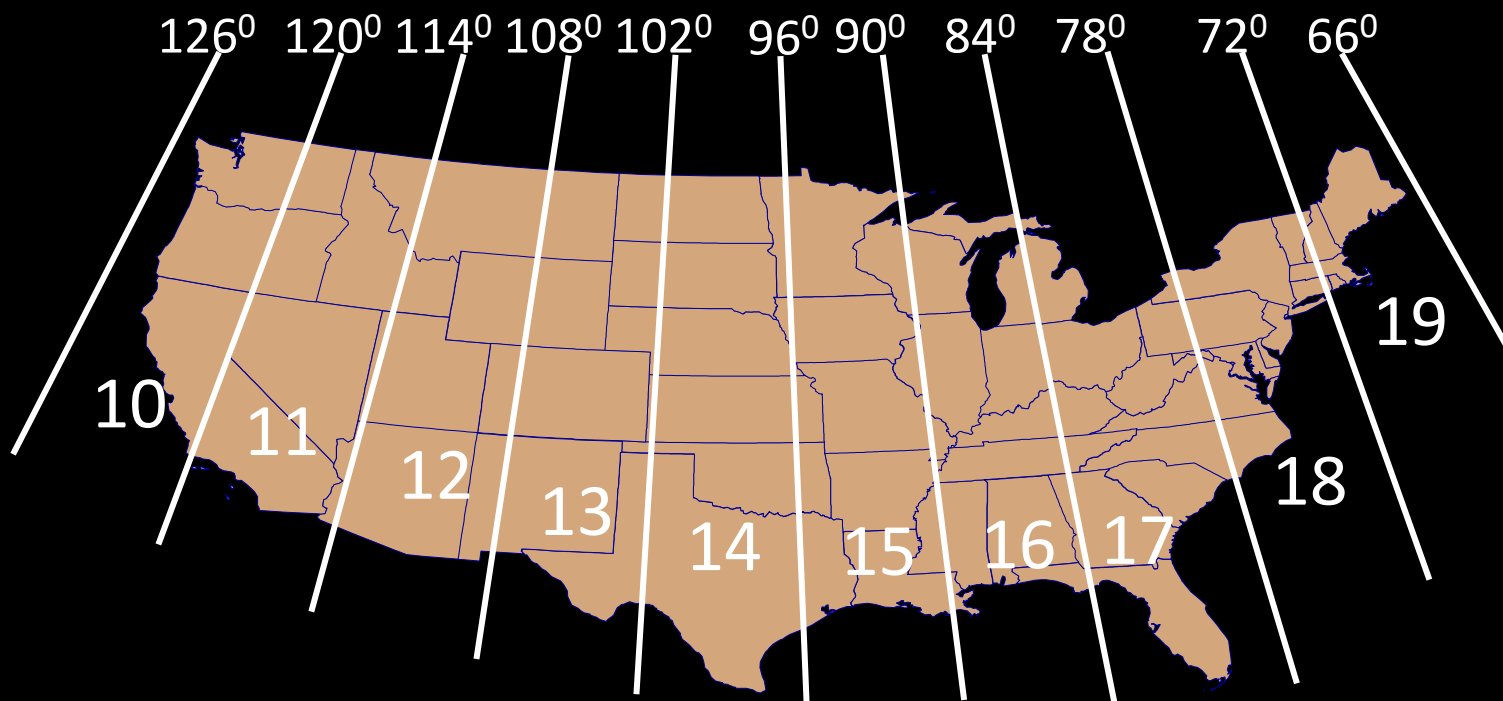




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UTM Zones



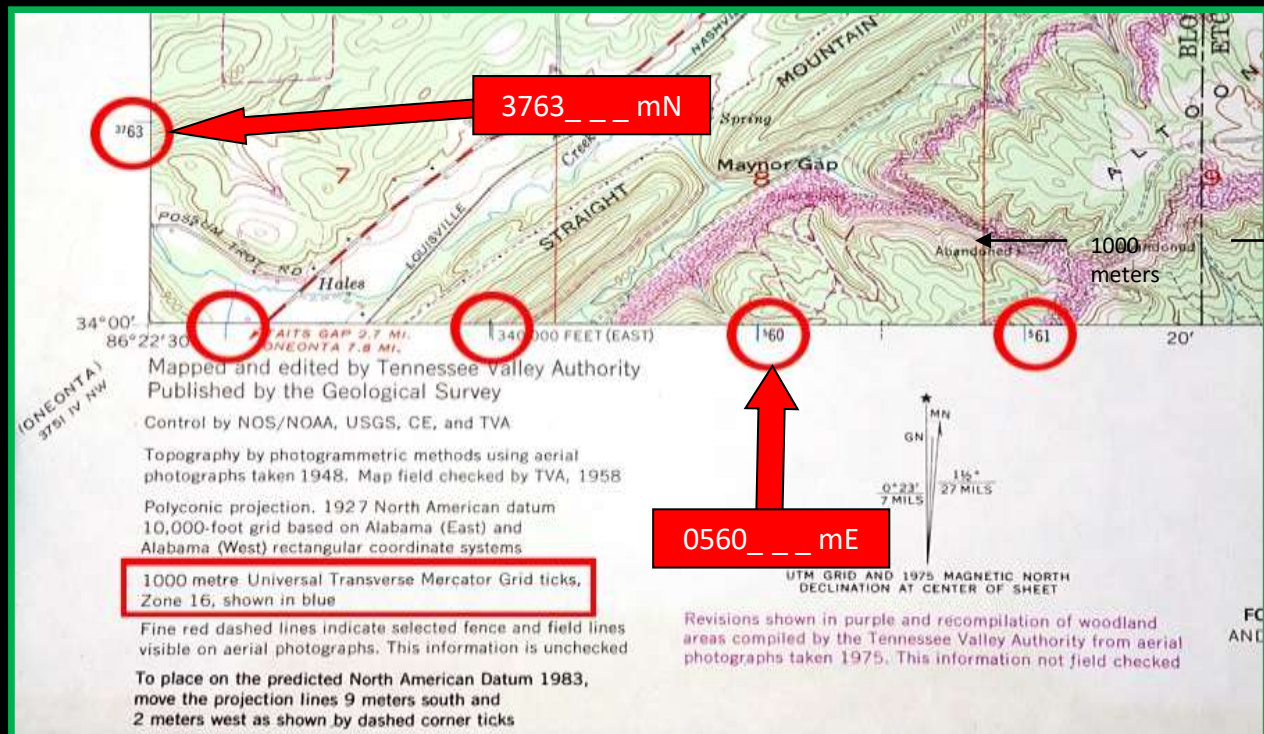


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Universal Transverse Mercator (UTM)

1000 meter increments already printed on the map. The navigator only has to plot the distance between the 1000 meter increments.





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Easting / Northing

Easting: A designation of the EAST/WEST position in the grid. Read this direction first. Read from left to right.

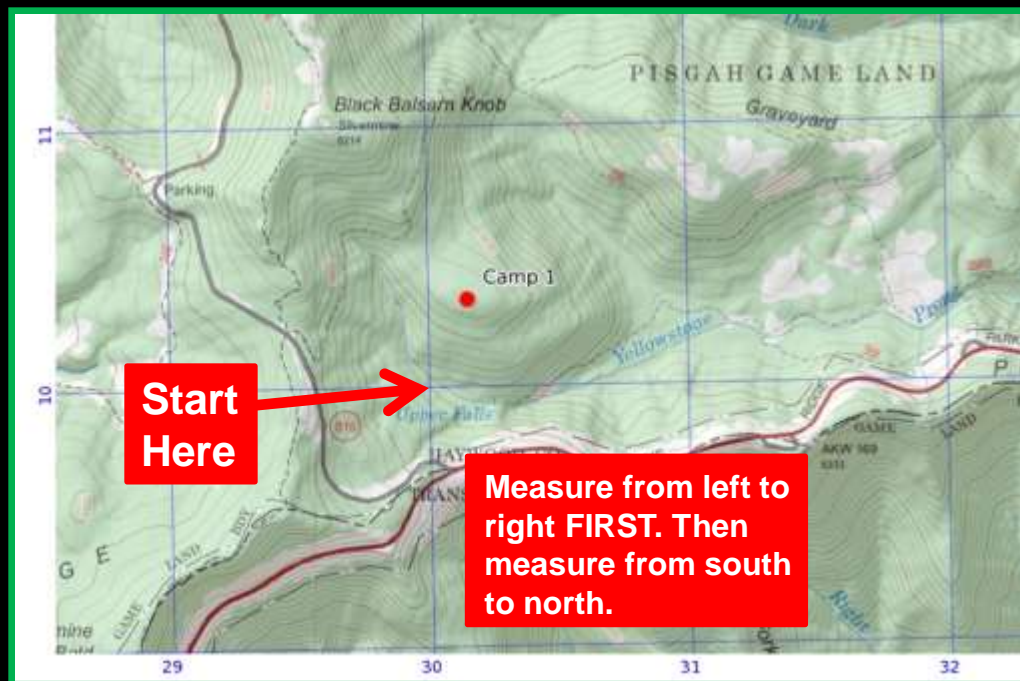
Northing: a designation of how many meters you are north or south of the equator. Read this direction after reading easting. Read from south to north.

Always start your measurement in the southwest corner of the 1000 meter square grid your desired target is located.

Location of Camp 1:

30 _ _ _
10 _ _ _

1st - Easting →



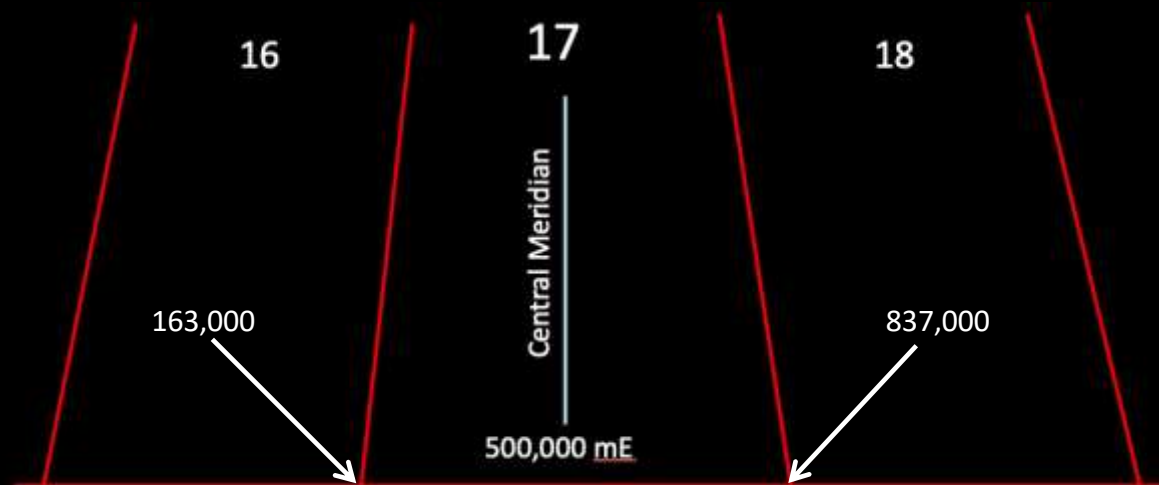
↑
2nd - Northing



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Easting



- Easting values are based on a Central Meridian of the zone.
- All Central Meridians are designated 500,000 meters east.
- At the Equator the widest zone is 674,000 meters. The zone would start at 163,000 meters on the left and end at 837,000 meters on the right.
- Due to working from a Central Meridian, there will be no "0" Easting values.



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Northing

The Northing values on the map are the number of meters north or south of the Equator.

To avoid negative numbers, Northing values start at 10,000,000 M at the Equator (when going south) and count down.

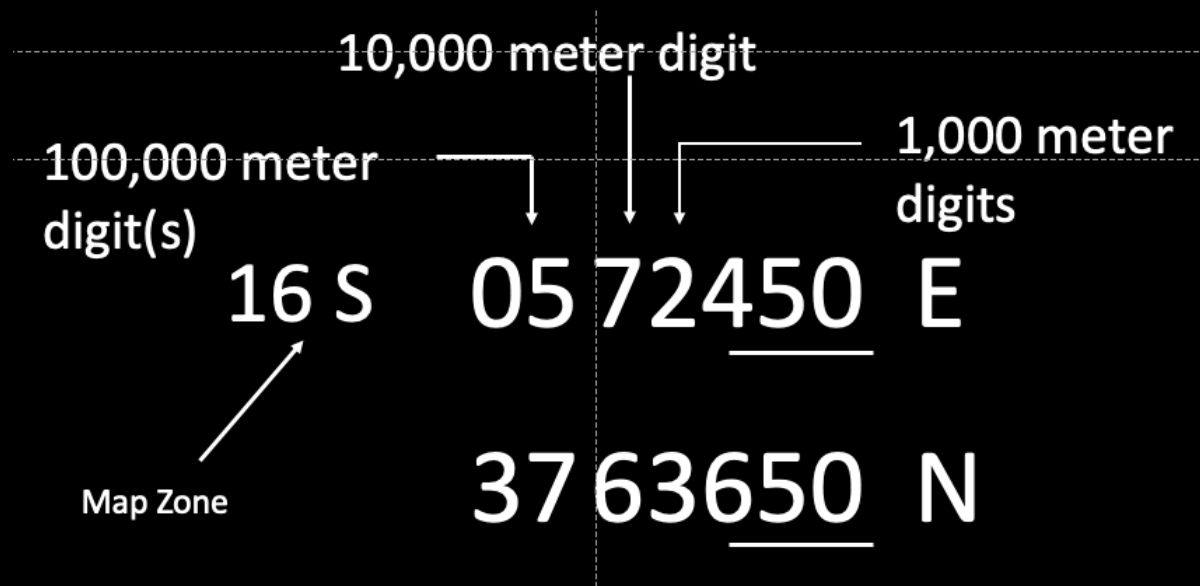
North of the Equator, the numbers on the map are the actual number of meters above the Equator.



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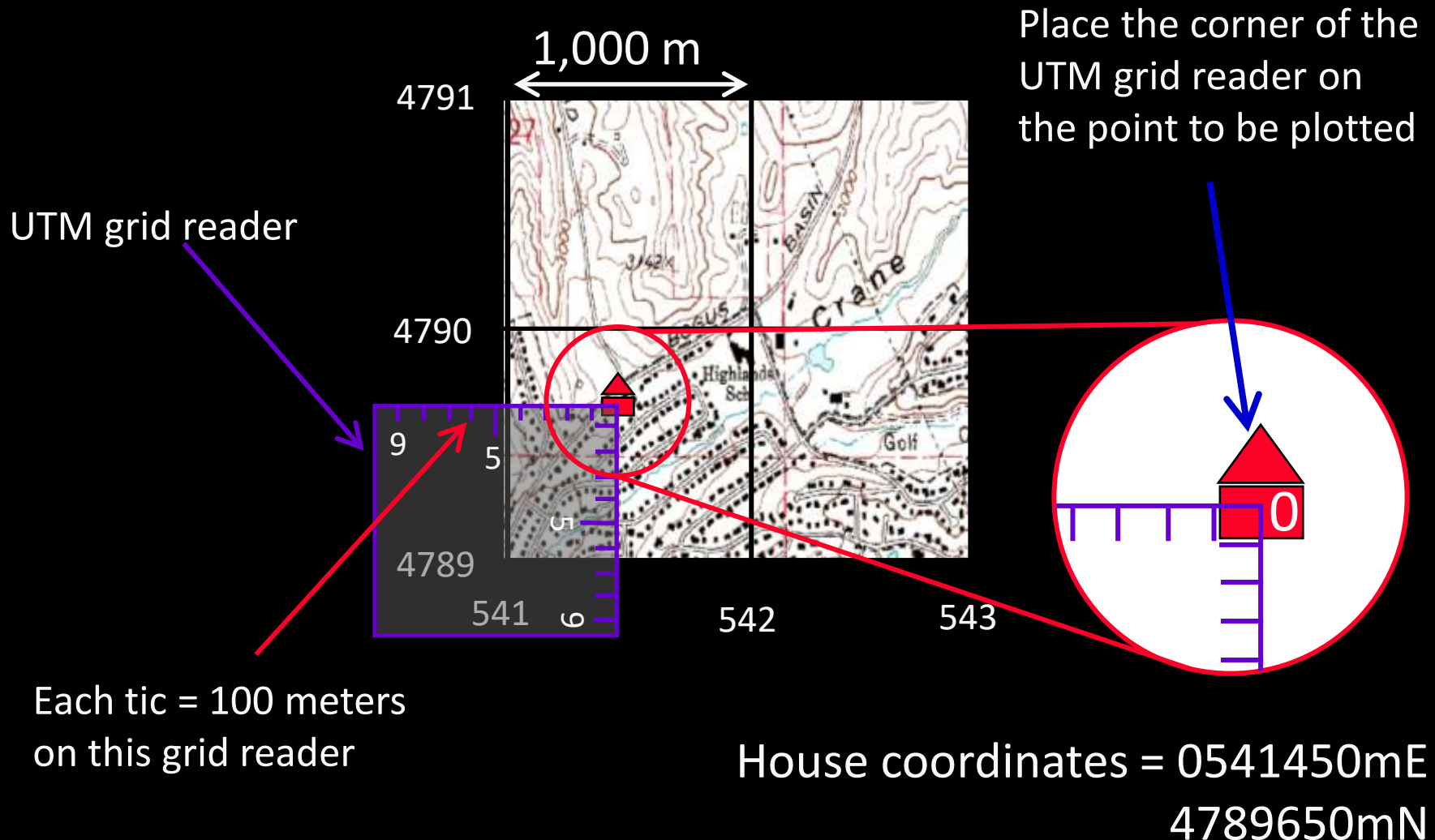
Plotting Coordinates



You only have to plot the last 3 numbers. The rest of the coordinate values are provided on the map.



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U.S. National Grid (USNG)

- Nationally consistent alpha-numeric georeferencing system.
- Uses a grid zone designation, a 100,000-meter square designation, and grid coordinates.
- Each 6-by-8-degree GZD (grid zone designator) is then covered by a specific scheme of 100,000-meter squares where a two-letter pair identifies each square.
- A point within the 100,000-meter square can further be defined using the UTM grid coordinates.

Difference between using USNG and UTM systems (differences shown in red):

USNG
16S DD 67713
DD 01518

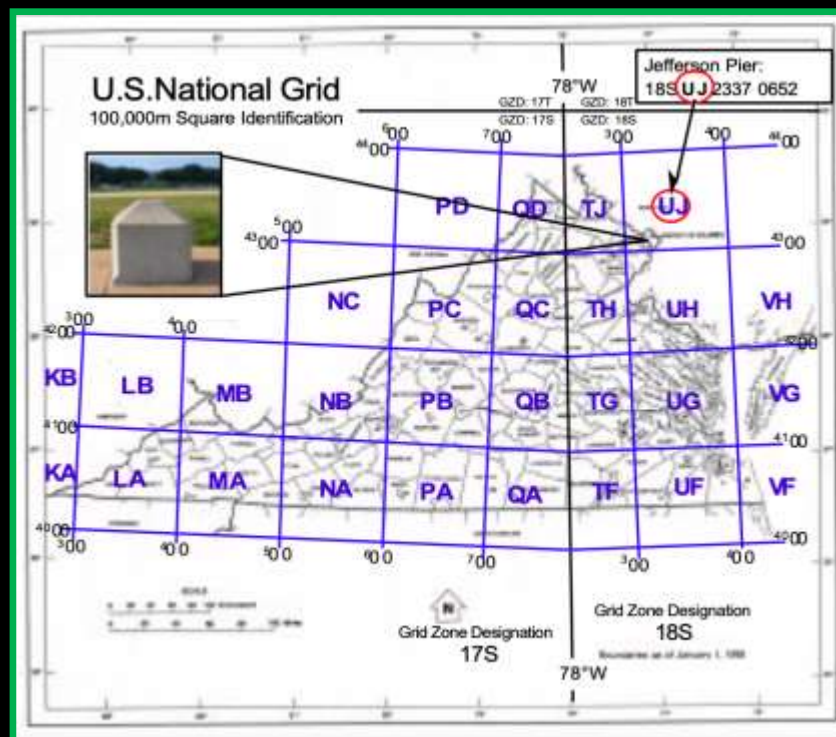
UTM
16S 0467713
3801518



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U.S. National Grid (USNG)

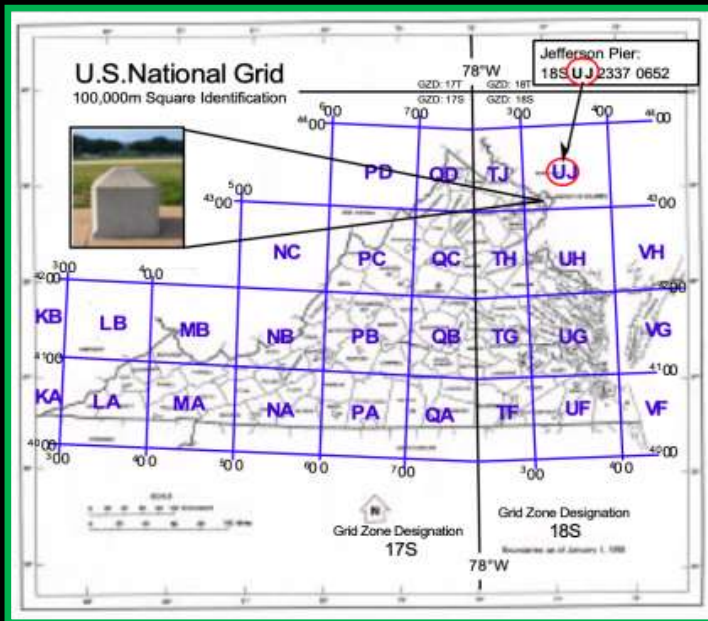




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U.S. National Grid (USNG)



A 4/4 grid will put you within 10 meters. It is communicated by dropping the last digit in a 5-digit grid and rounding up or down. For example, if your full 5-digit grid is 23371 / 06519, a 4/4 grid will be called out as 2337 / 0652

Four digits:	23 06	Locating a point within a 1,000-m square.
Six digits:	233 065	Locating a point within a 100-m square.
Eight digits:	2337 0651	Locating a point within a 10-m square.
Ten digits:	23371 06519	Locating a point within a 1-m square.



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Using GPS with Map/Compass



Plotting GPS to Map

- 1) Find current location with GPS.
- 2) Use scale card to plot current location on the map.

Plotting Map to GPS

- 1) Plot location on map of where you want to go with a scale card.
- 2) Enter plotted coordinates into the GPS as a new waypoint.



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GPS Setup

GPS units vary on how to set them up, but the following items should be setup on any unit prior to use. Settings should match the format and datum being used.



Distance



Position Format



Map Datum



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Communicating Location

If you are lost and can communicate with search personnel, try to give them the following info:

- General location (big picture)
- Type of navigation grid used
- Grid location (Easting Then Northing)
- Direction of travel if moving

Note:

A 4/4 (8-digit) grid will put you within 10 meters. It is communicated by dropping the last digit in a 5-digit grid and rounding up or down. For example, if your full 5-digit grid is 74356 / 63982, a 4/4 grid will be called out as 7436 / 6398.



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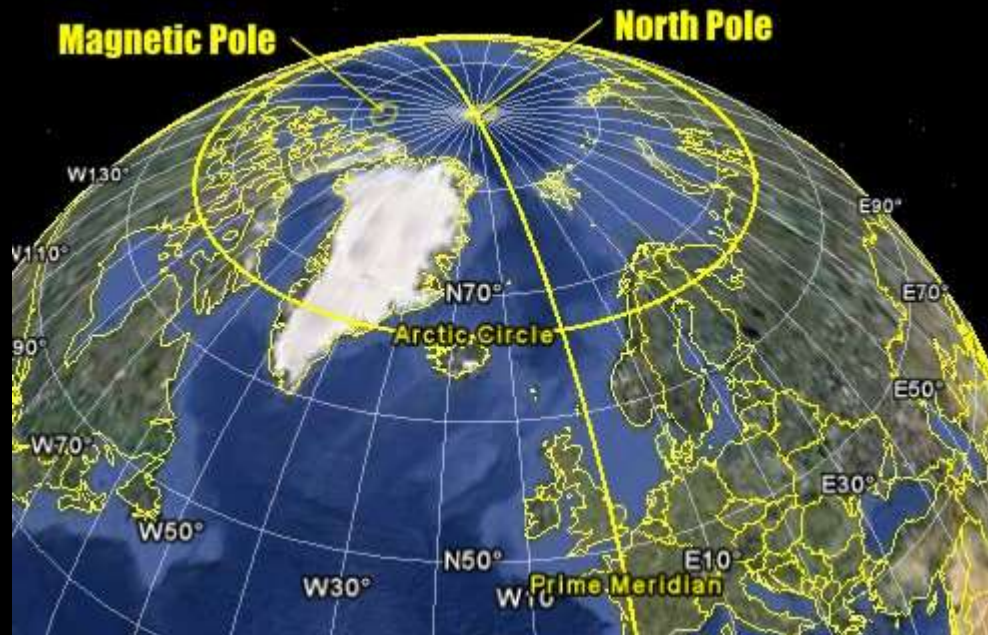


DECLINATION

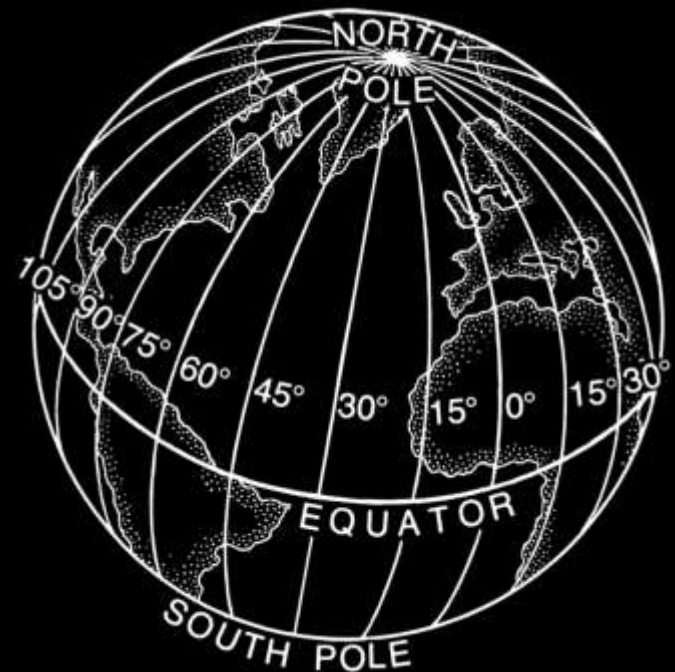
- Magnetic Declination is the difference between True North (Longitude Line) and Magnetic North (where the compass needle points).
- A compass needle ALWAYS points to Magnetic North.
- Grid Declination is the difference between Grid North (Grid Reference Line) and Magnetic North (where the compass needle points).
- When going from map to the field, you will add westerly declination. When going from the field back to map you will subtract westerly declination.
- Easterly declination will be the opposite.



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Difference in True North
And Magnetic North



Longitude Lines
(True North)

Magnetic North is moving approximately 35 miles per year.



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Magnetic Declination



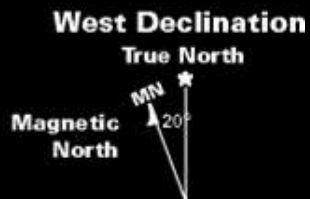
If you do not have a compass that adjusts for declination remember to add or subtract declination to your azimuth.



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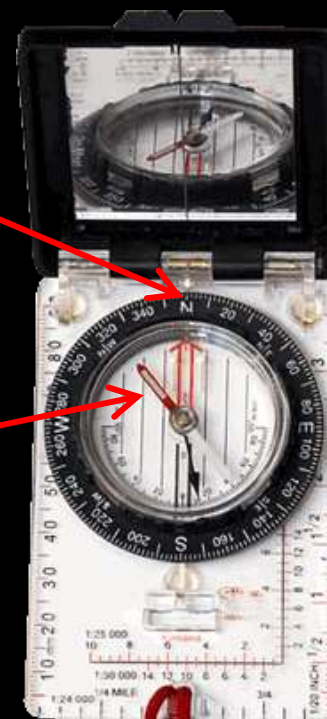
Exaggerated Example Of Magnetic Declination



Bearing indicator set to north

Magnetic needle pulling
west of true north

North Star
(True North)





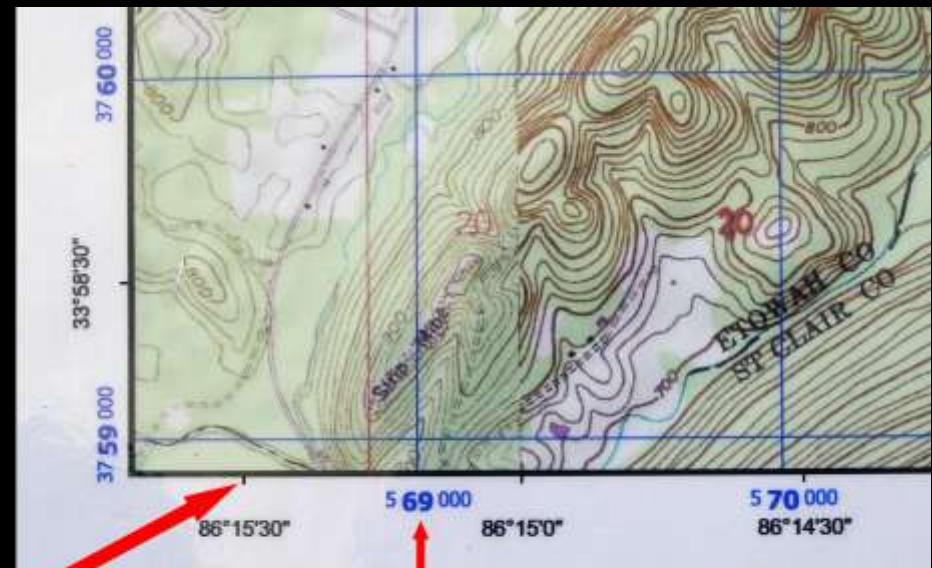
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Reference Lines

Depending on your map, it may be printed with True North Reference lines or Grid North Reference lines (or both).

The reference system you use to measure the azimuth on the map is the declination system you will use.



True North
(Longitude)

Grid
North
(UTM Or Other Grid)



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Adjusting For Declination For Map Use

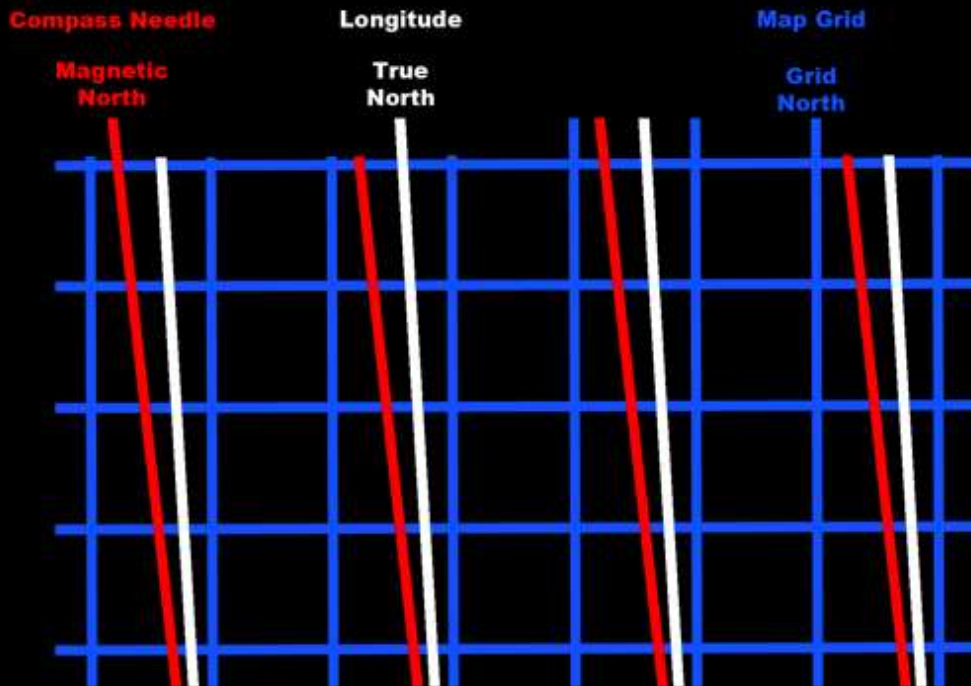
- Magnetic Declination is the difference between true north and magnetic north when using the longitude lines as north reference for measuring your bearing.
- Grid Declination is the difference between grid north and magnetic north when using the UTM grid lines as north reference.
- If the MN line is left of the reference line you are using to measure your azimuth, then it will be West Declination.
- If the MN line is right of the reference line it will be East Declination.
- If you are using a compass that is not adjusted for declination, add the amount for west declination when going from map to the field, subtract the amount for east declination (when going from map to field).
- When going from field back to map it will be opposite: Subtract for West and add for East.
- If your compass is adjustable for declination, set it for the north reference declination value you are using. No further addition or subtraction is required – set it and forget it.



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True North / Magnetic North / Grid North





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Grid Azimuth / Magnetic Azimuth

GRID AZIMUTH: Measurement taken on the map using a grid line as a reference.

MAGNETIC AZIMUTH: Measurement taken in the field using the compass needle as the reference.

West Declination: Add when going from grid to magnetic. Subtract when going from magnetic to grid.

East Declination: Subtract when going from grid to magnetic. Add when going from magnetic to grid.



Search and Rescue Land Navigation



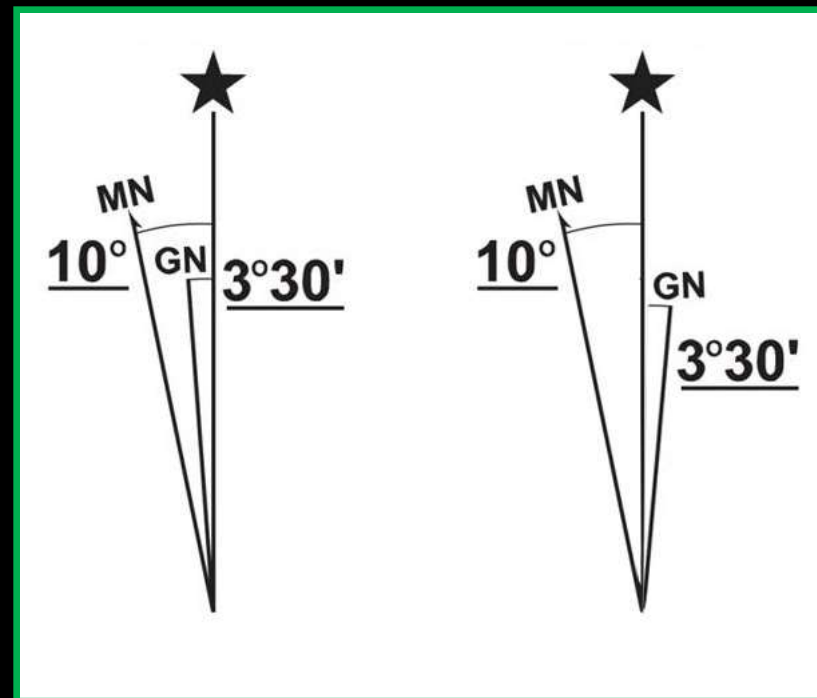
Declination Question

What is the declination value for each of the diagrams using Grid North Reference?

Degrees?

East or West?

If we want to walk a 30 degree grid azimuth in the field, what would we set the compass on?





Search and Rescue Land Navigation



Land Nav Checklist

- Verify Coordinates
 - Pace / Distance
 - Azimuth / Declination
- Checkpoint / Terrain Association
 - Backstops, Handrails, etc.

Write it all down!



Search and Rescue Land Navigation



REVIEW





Search and Rescue Land Navigation



8-Digit Grid

- A 4/4 (8-digit) grid will put you within 10 meters. It is communicated by dropping the last digit in a 5-digit grid and rounding up or down.
- Example: if your full 5-digit grid is 74356 / 63982, a 4/4 grid will be called out as 7436 / 6398.
- Remember: read easting first (left to right), then read northing (south to north).



Search and Rescue Land Navigation



Review

For westerly declination always add when going from map to compass, and subtract when going from compass to map. It is the opposite if it is easterly declination.

How do you know if it is westerly or easterly declination?



Search and Rescue Land Navigation



Classroom Exercise

You will be given a map and asked the following types of questions:

- Describe the terrain feature located at xxxx/xxxx
- Determine the distance in meters from xxxx/xxxx to xxxx/xxxx
- Determine the magnetic bearing from xxxx/xxxx to xxxx/xxxx