LAND NAVIGATION

Map, Compass and GPS Techniques

Introduction

SAR personnel must know:

- Where they are
- Where they need to go
- How to get there effectively

- Clues and hazards may be discovered and their coordinates need to be recorded.
- Variety of techniques available to aid in backcountry navigation.
- You should not rely on just one technique.

Objectives

After this course you will be able to:

- Competently read maps
- Be able to plot coordinates on a map or report coordinates from a map
- Use maps in conjunction with a compass & GPS
- Use orienteering techniques to navigate across the terrain using contour lines and landmarks
- Competently use a compass in the field, on a map, and transition between the two.
- Competently use a GPS, including reporting your position and provide tracks.

Course Outline

Maps

Reading a 7.5 Minute Topo Map

Coordinate Systems

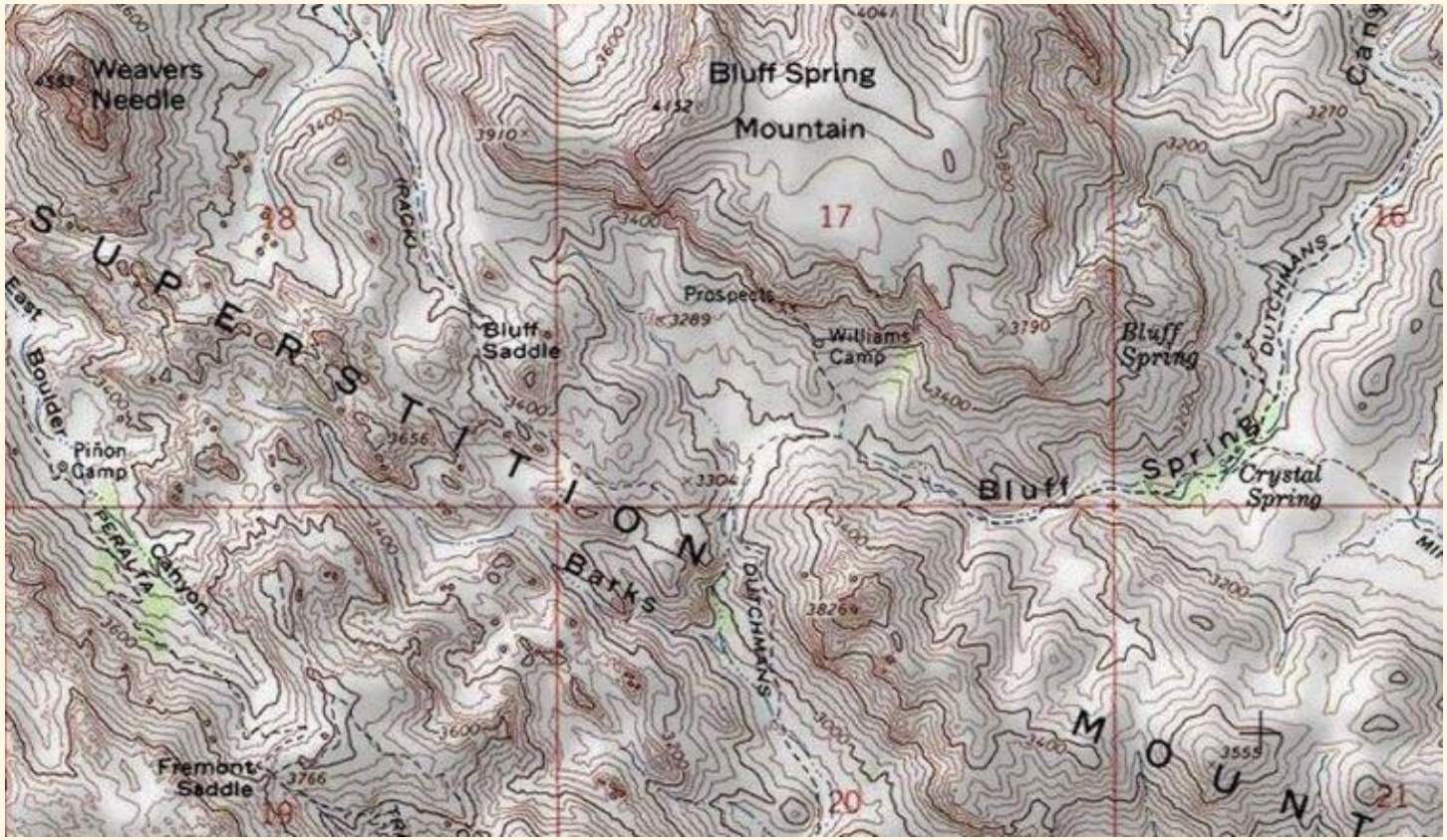
Pace Counting

Compass

GPS

Maps

If you have the choice between having a map, a compass, or a GPS as the only source of navigation, which do you choose?... choose the map

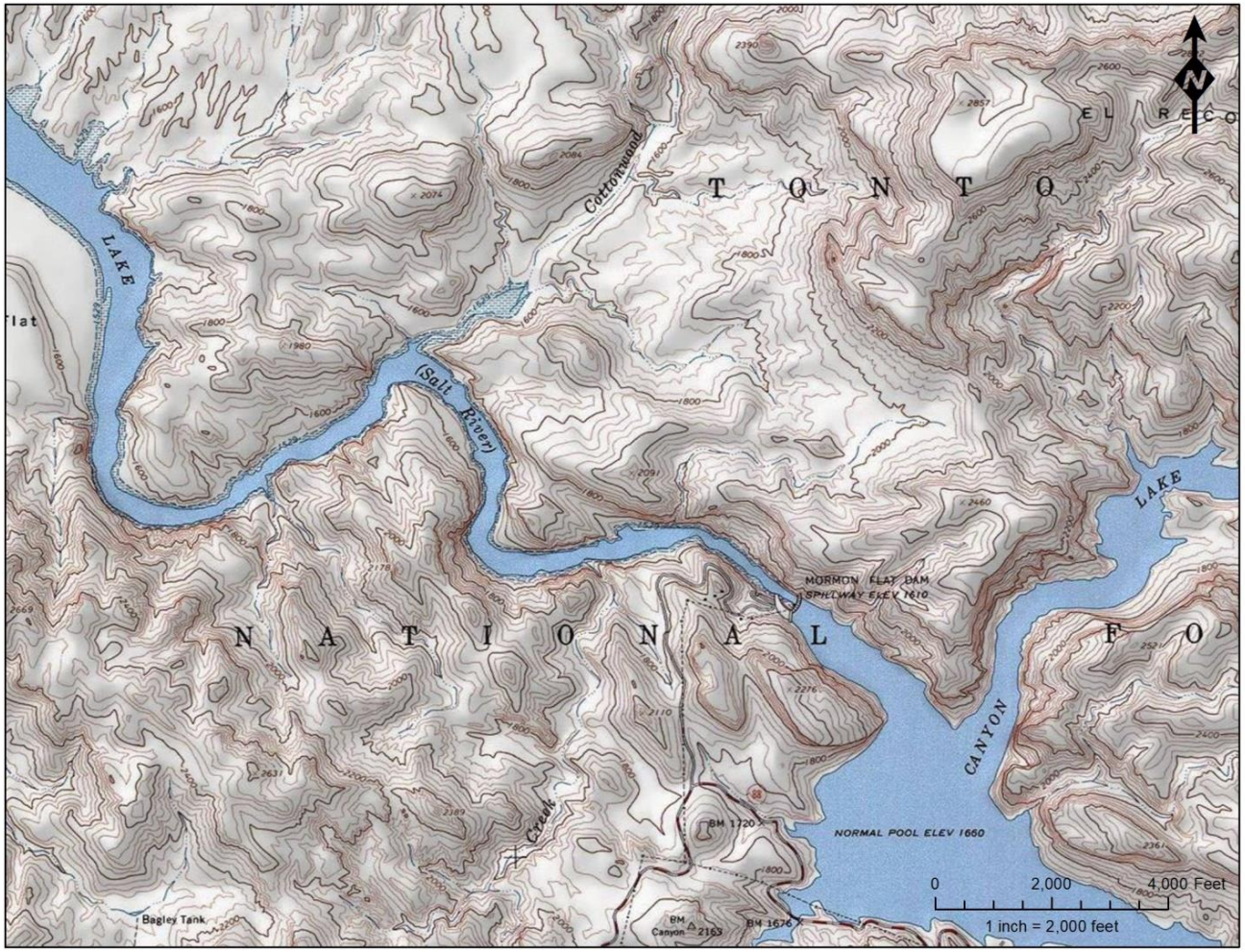


Map Scales

Small-scale map shows a large area and less detail.

Map Scales

Large-scale map shows a small area but MORE detail.

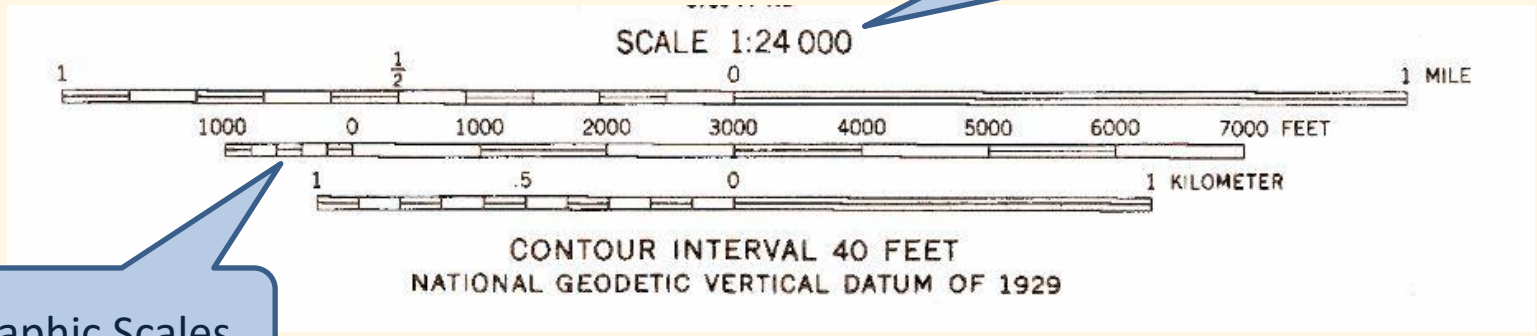


Map Scales

Methods of displaying the map scale:

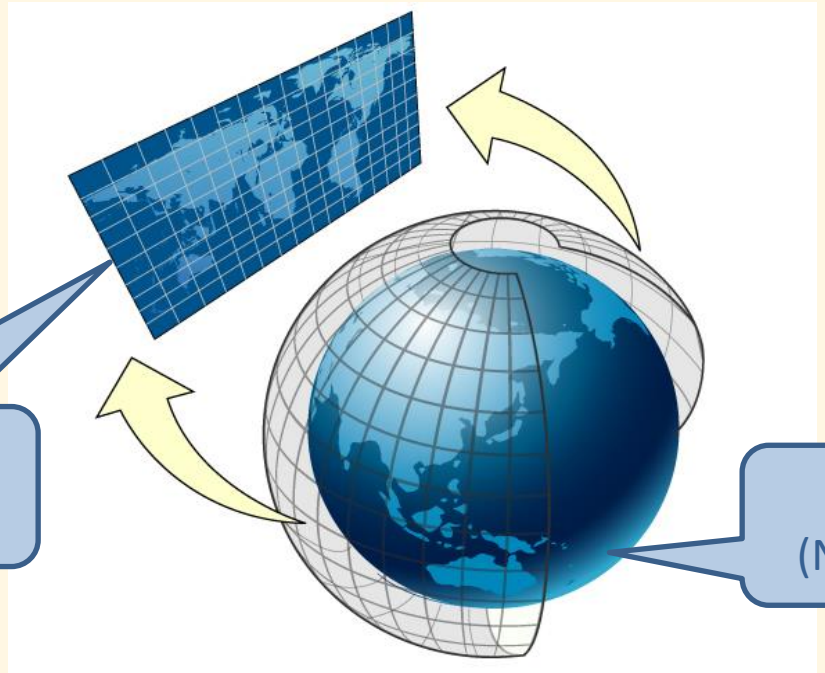
1. **Representative Fraction** - ratio of map distance to ground distance in similar units, such as 1:24000. One inch on the map equals 24,000 inches (2,000 feet) on the ground.

2. **Graphic Scale** - compares map distance to ground distance in different units of measure.



Map Datums

- A map datum is a model of size and shape of earth.
- There are many models and not all map datums match each other.
- Projections are a flat representation of the earth.



Map Datums

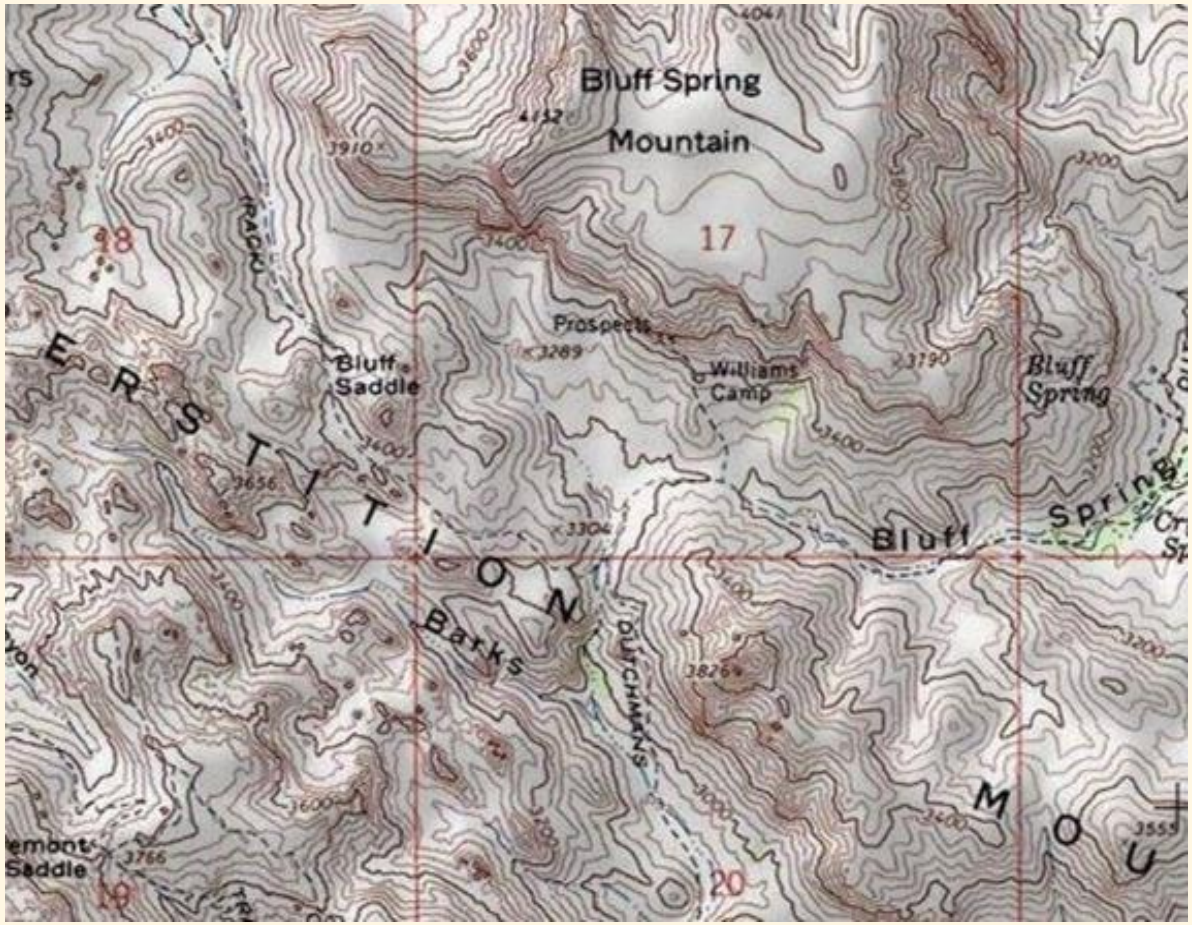
- It's important to know the map datum for a map. Adjust the GPS datum to match the map's datum.
- If the datums do not match there could be a shift in the location.
- Most common map datums in U.S. are NAD83, WGS84, NAD27(retired)
  - NAD27 coordinates will differ greatly from NAD83 & WGS84
- For SAR use, NAD83 and WGS84 are functionally equivalent.

General Map Types

Two general map types encountered in SAR: Planimetric maps do not represent the shape of the land, show the general features of an area.

General Map Types

Topographic maps are shown at a larger scale (small area). The terrain is represented using contour lines.



General Map Types

Planimetric maps are used to get an overview of the area and determine roads to use to get to the general search area. They show roads, streams, and places of interest.

Topographic maps are used by searchers on foot who need terrain information to conduct ground operations.

They show terrain as contours, roads, streams, structures, elevation benchmarks, etc.

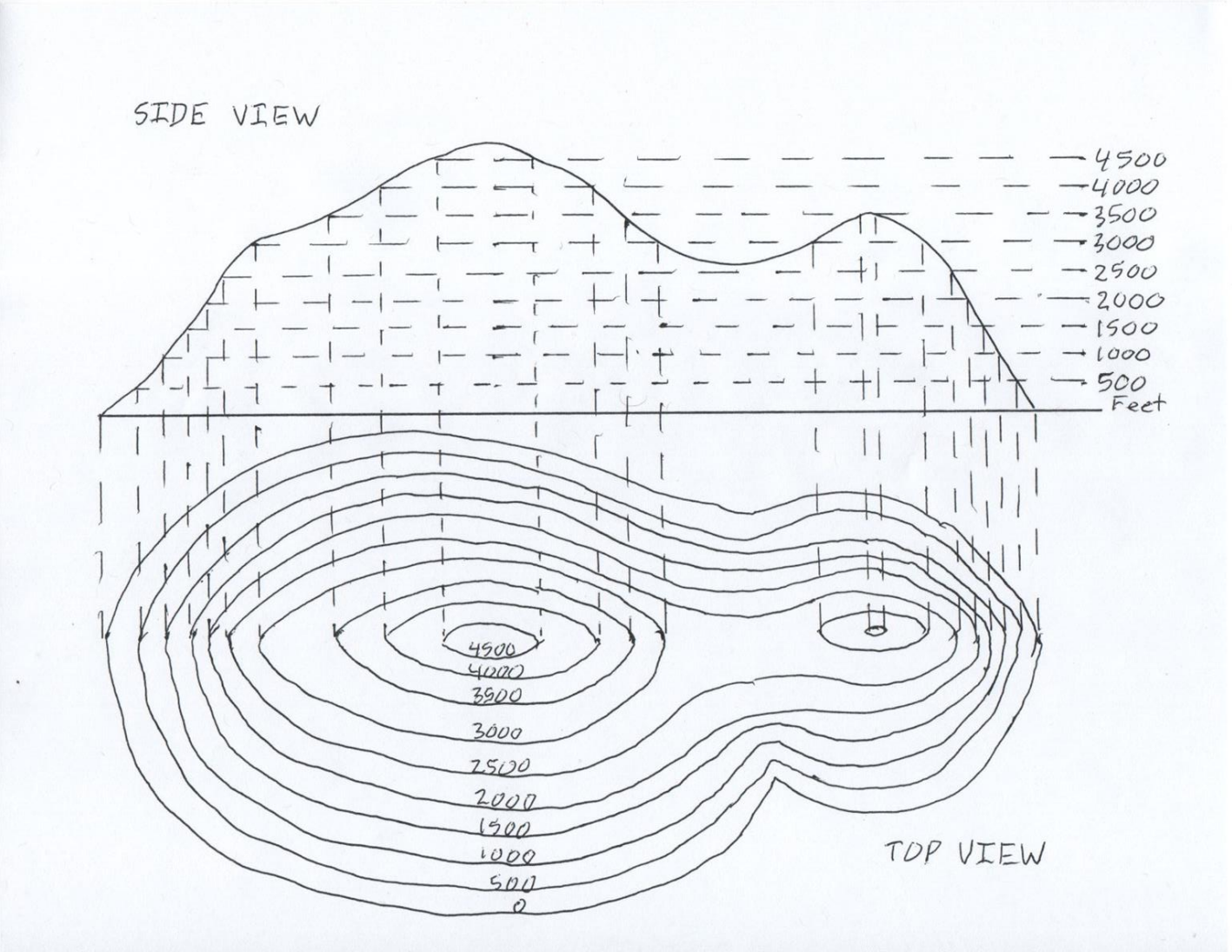
It's common to use both types of maps on a SAR mission.

Contour Lines

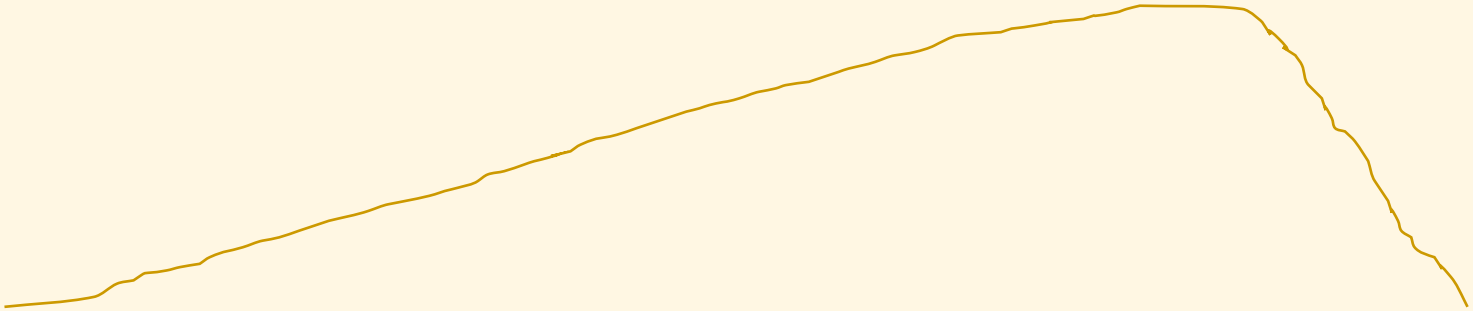
Contour lines:

- are used to represent the surface of earth projected onto a 2D surface, such as a paper map.
- are lines on a topo map that connect points of equal elevation above sea level.
- are drawn at specific elevation spacing, called contour interval. "The contour interval for this map is 40 feet", this means contour lines are separated by 40 feet in **vertical** elevation.
- ***Index contours*** – darker contour lines typically every fifth line and labeled with elevation.

Contour Lines

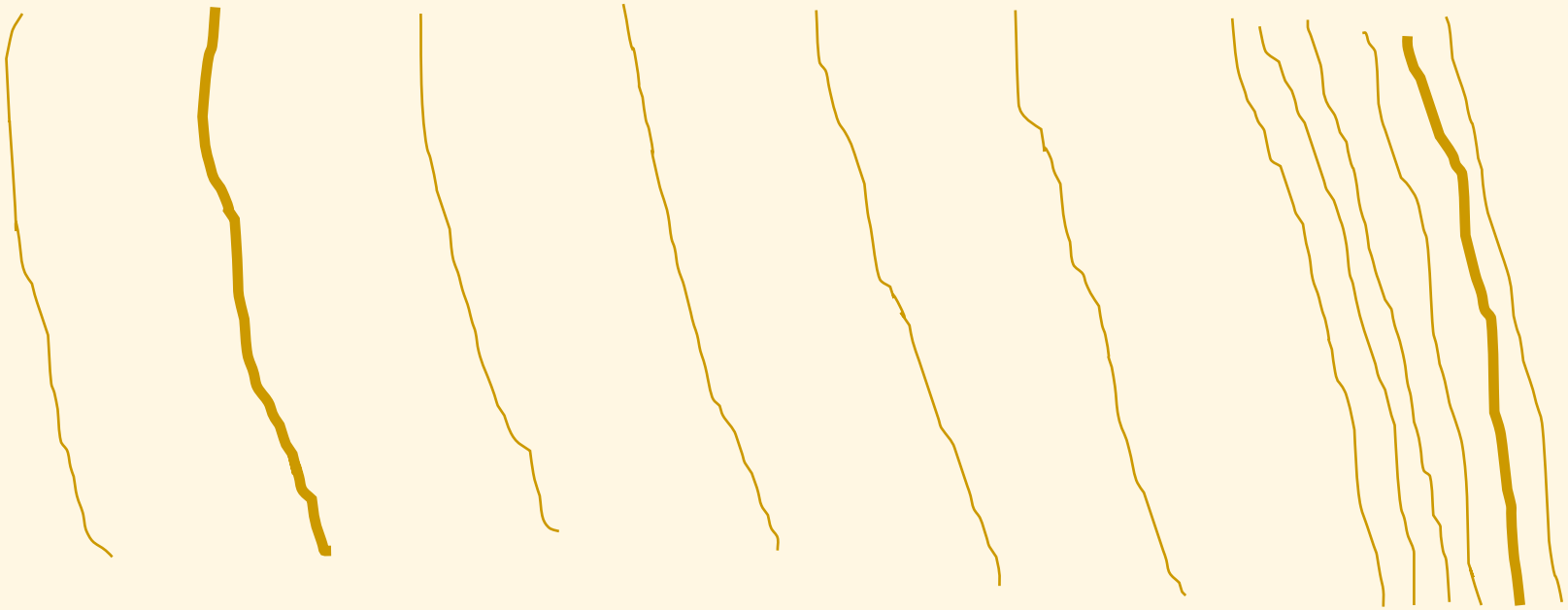


Contour Lines

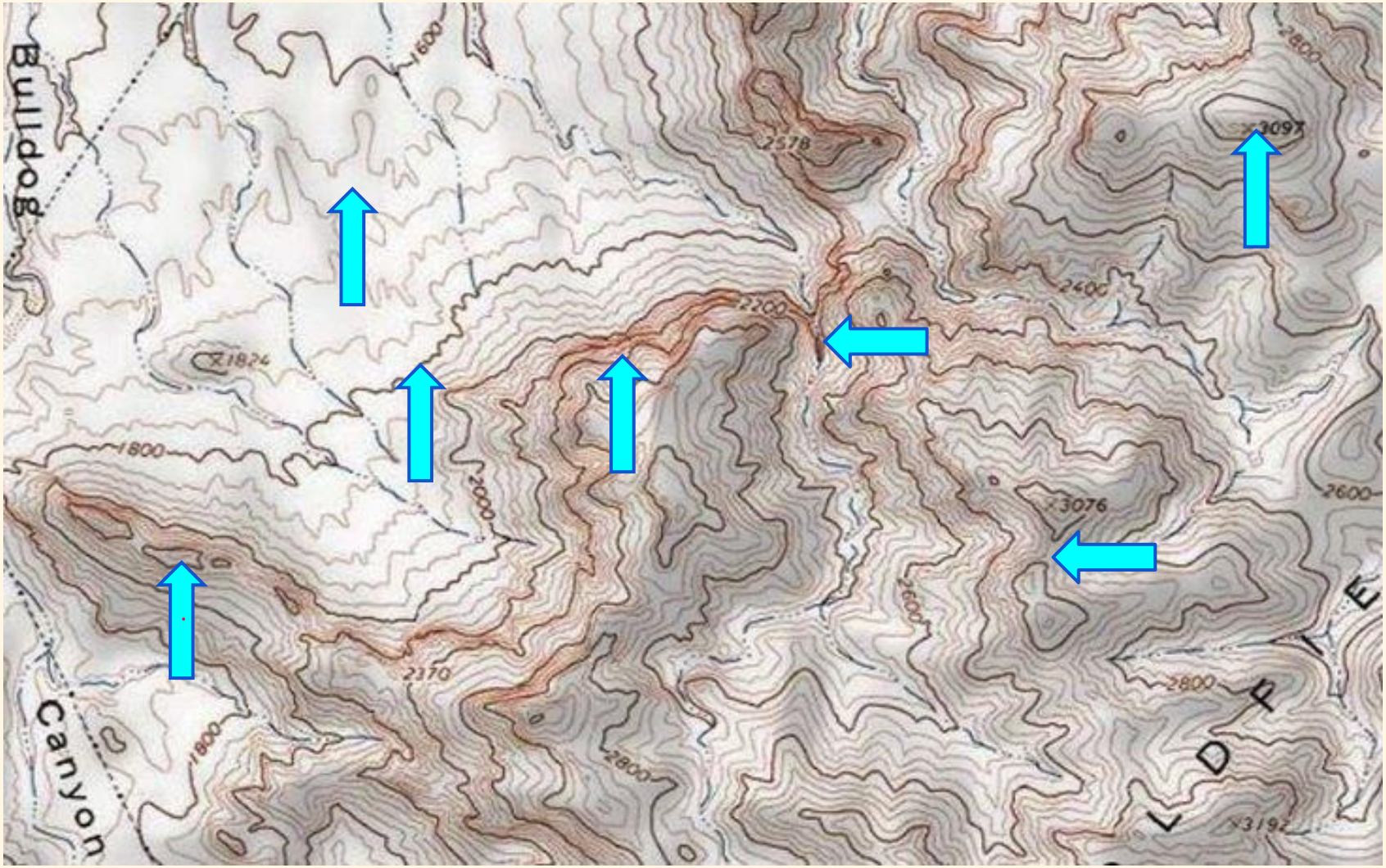


Gentle Slope

Steep Slope



Terrain Features

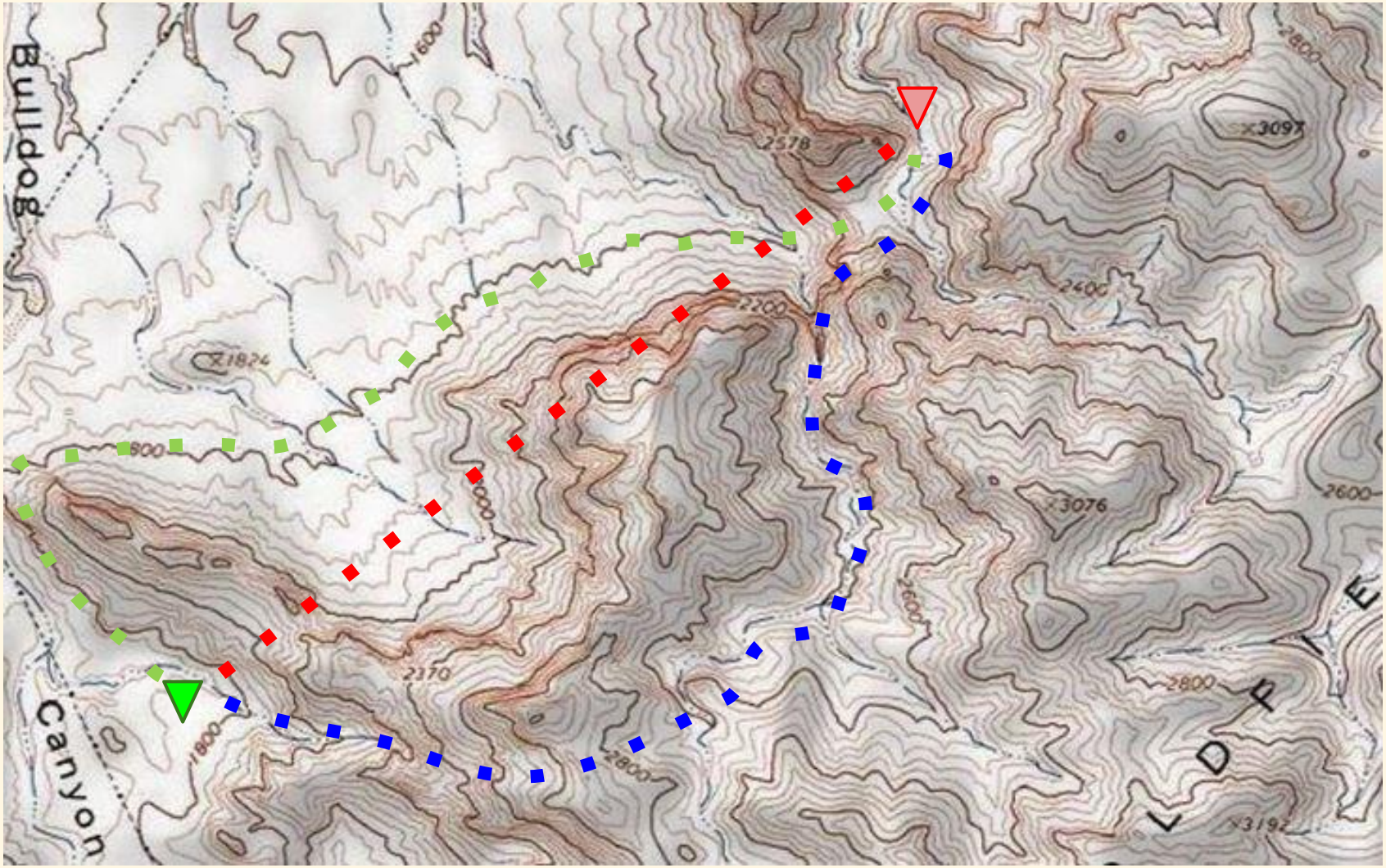


Orienteering

- Using a map and compass to navigate between checkpoints along an unfamiliar terrain (such as in the wilderness)

- The most important skill in orienteering is – orienting the map! Maps aren't meant to be held like books, with north always at the top. Maps are meant to be oriented to match the terrain.

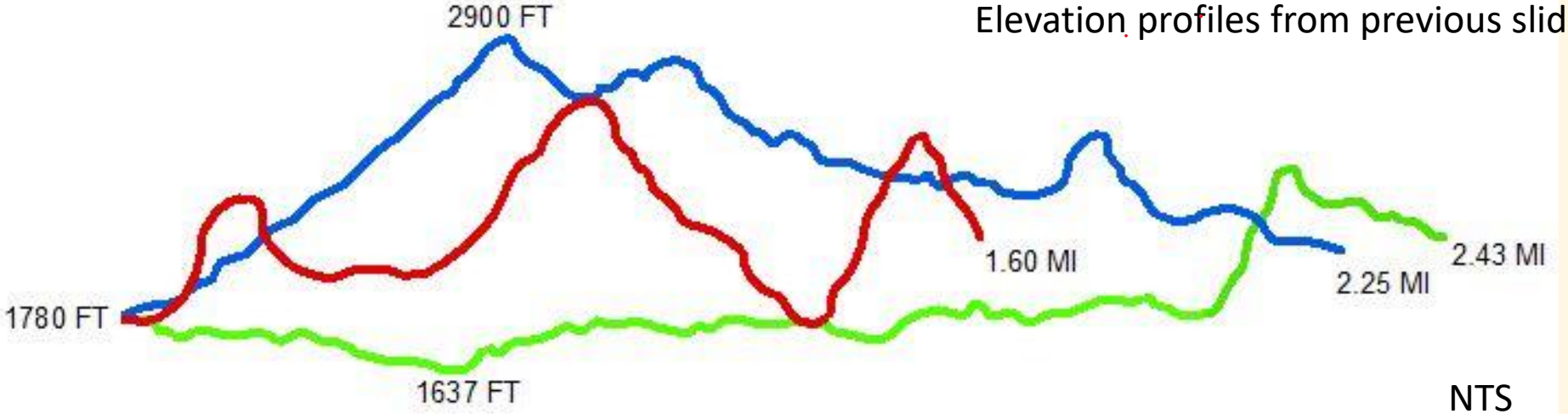
Planning Your Route



Planning Your Route

Planning your route:

- Saves energy - using terrain and/or manmade features
- Helps avoid potential hazards
- Be prepared to encounter terrain conditions hidden between the contour lines. With a 40 foot contour interval there can be a series of 38 foot hills and valleys that don't show on the map.



Elevation profiles from previous slide

NTS

Tracking Your Route

- Periodically mark your location on the map:
  - Trail junctions, road junctions, drainage crossings are good landmarks if they are distinguishable from each other.
  - Use resection (triangulation) method if local landmarks are not available (covered in compass section).
  - Use current location on GPS, mark a waypoint, and find location on map using UTM coordinates.
- Notice landmarks as you hike!

Course Outline

Maps

Reading a 7.5 Minute Topo Map

Coordinate Systems

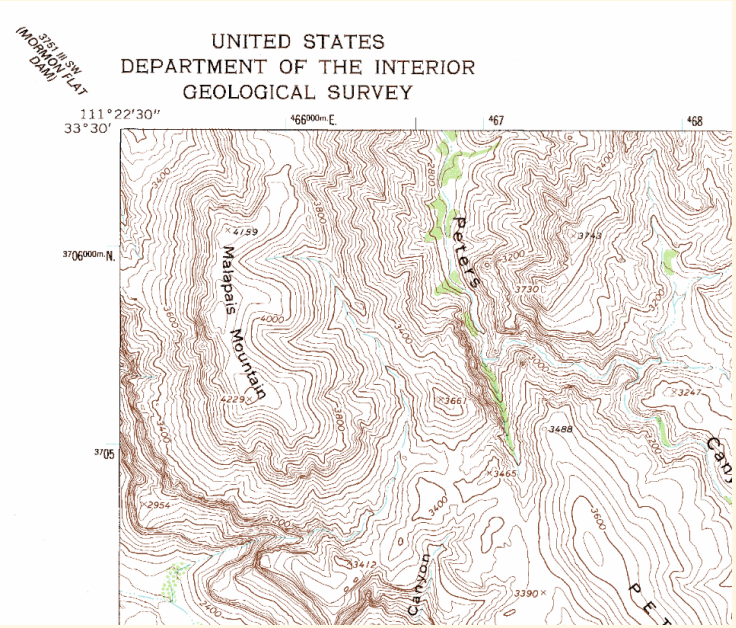
Pace Counting

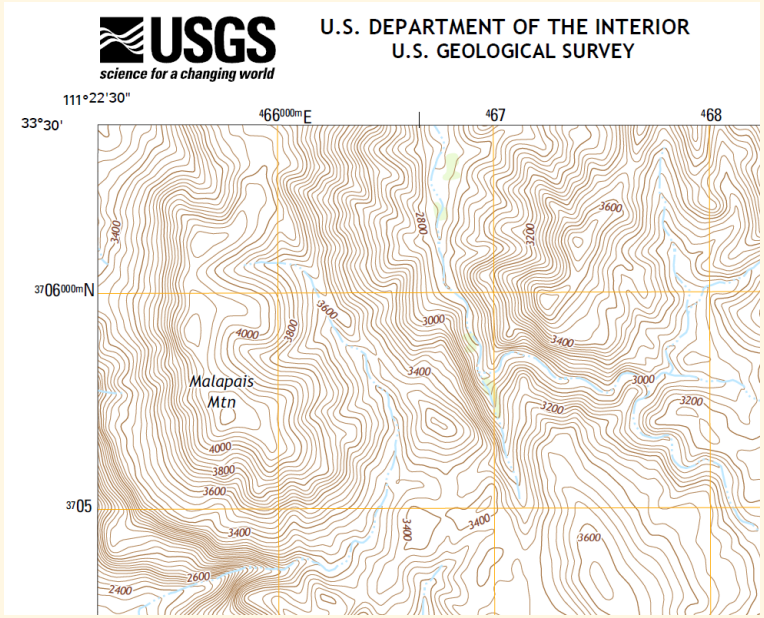
Compass

GPS

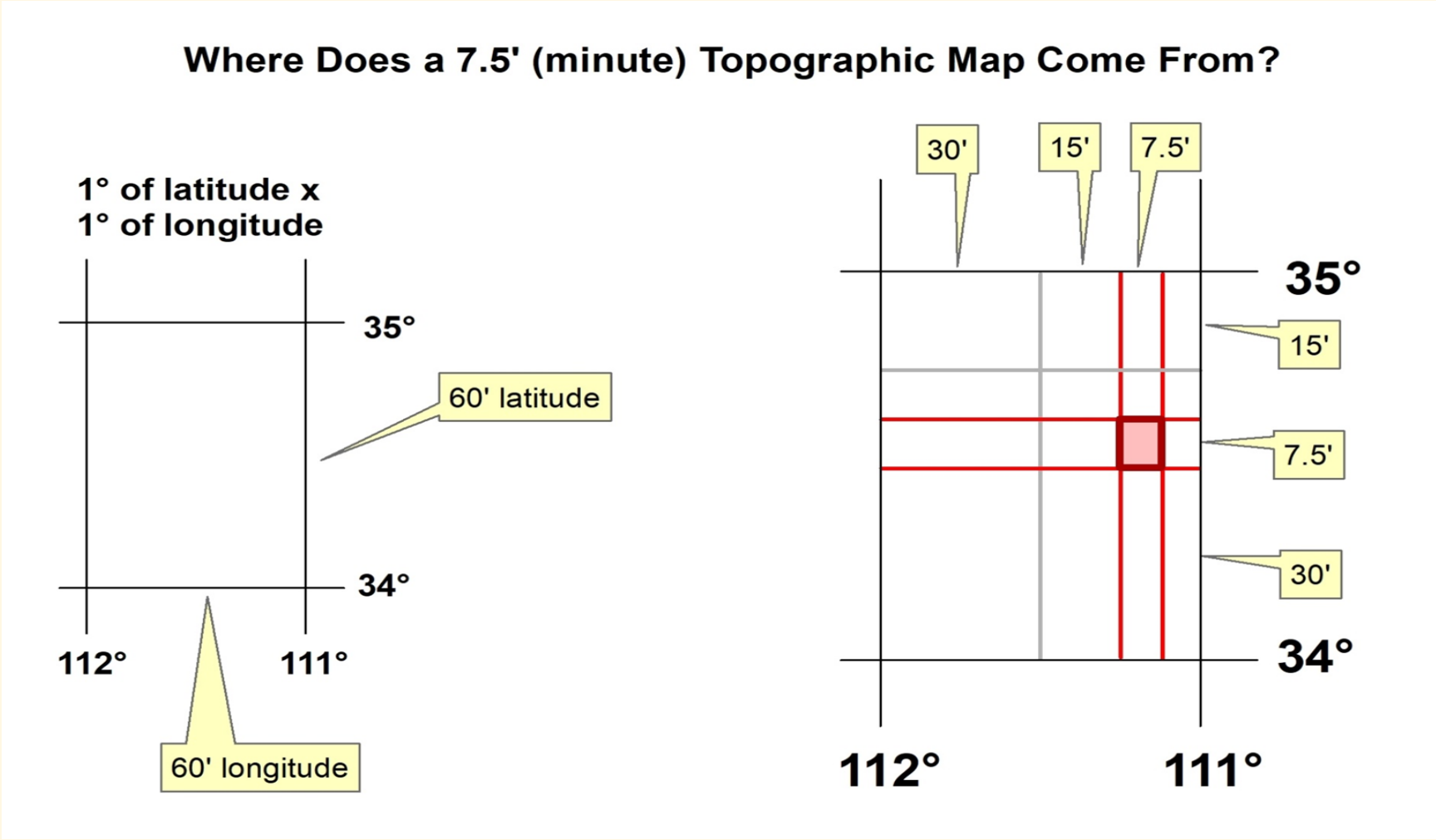
Reading a 7.5' Topo Map

- Standardized set of maps covering U.S.
- Map symbols & colors are the same
- Contour intervals may vary
- Old USGS maps vs. new USGS maps

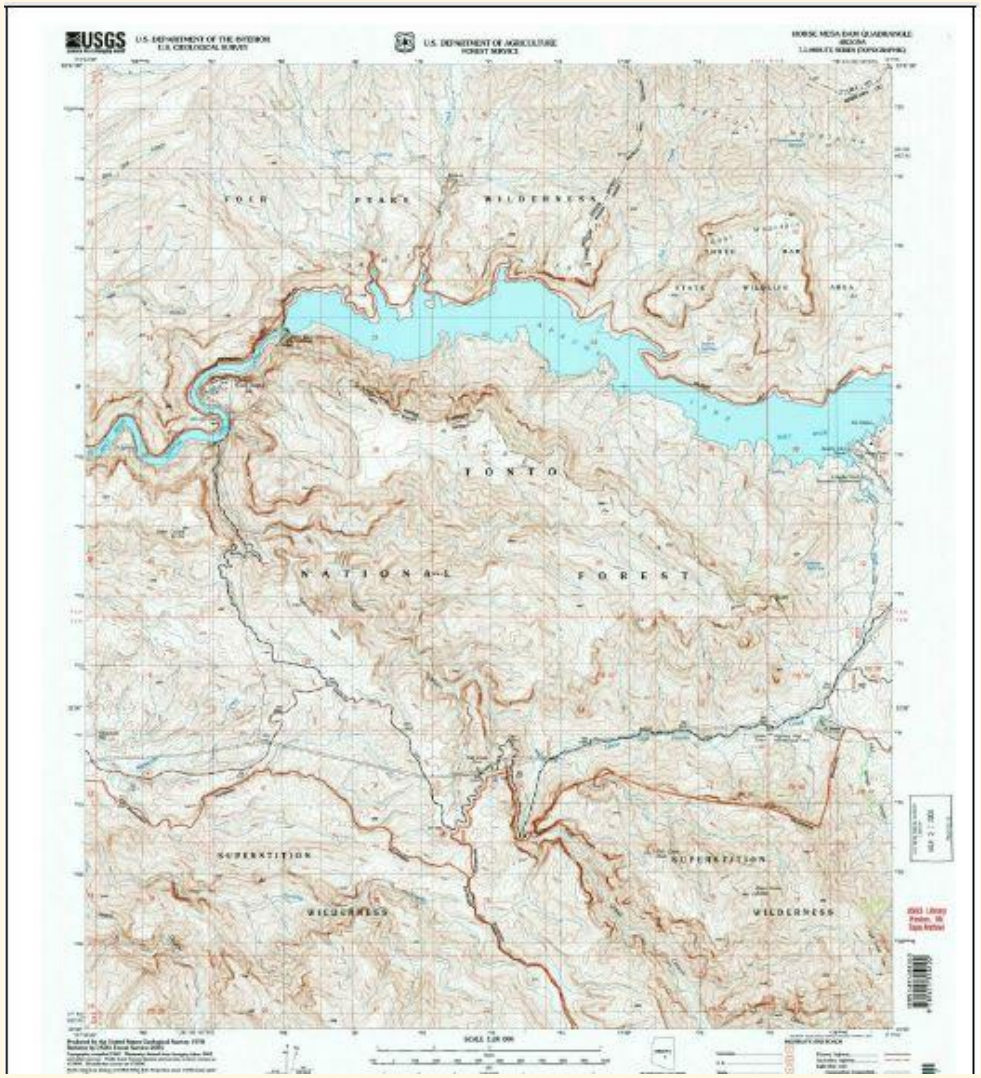




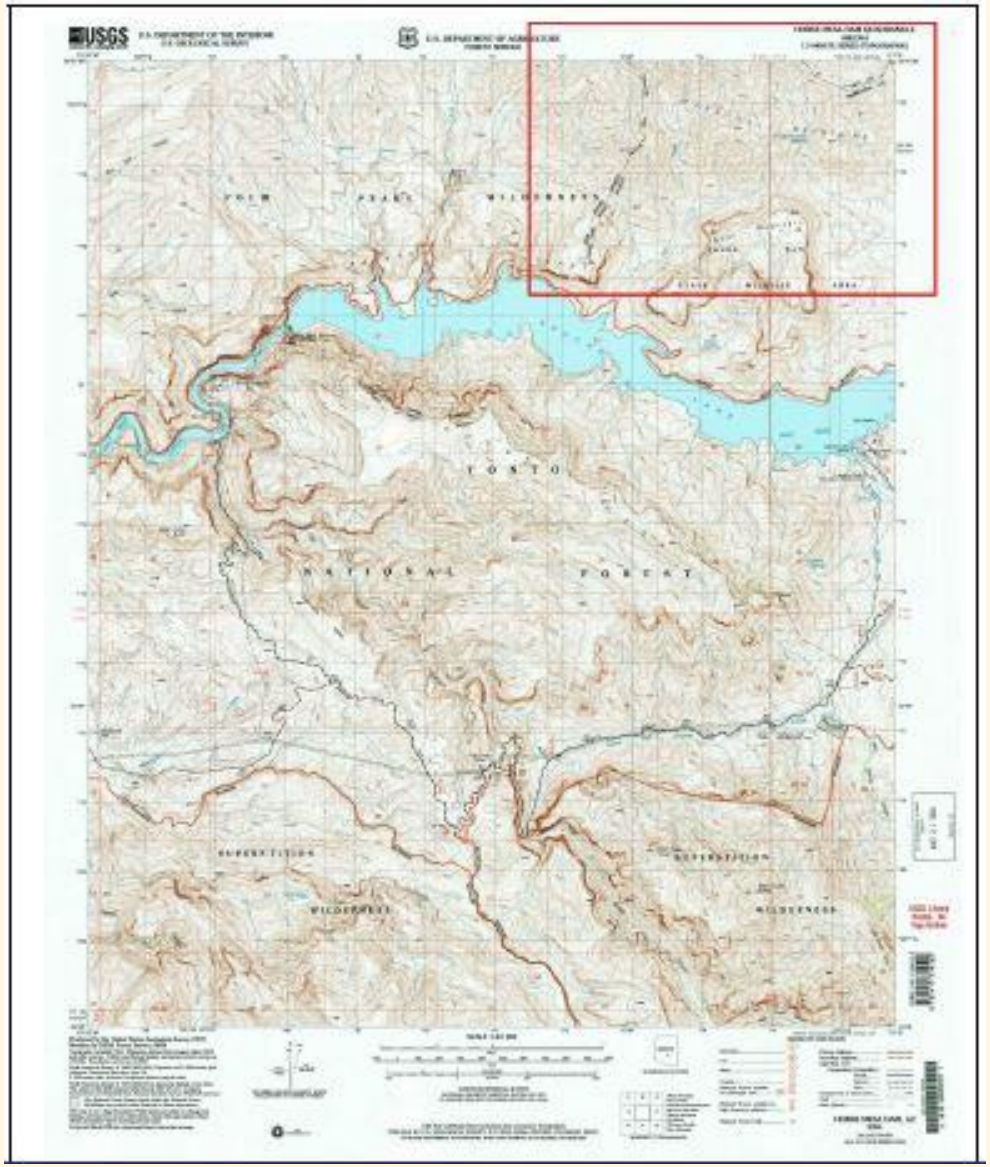
Reading a 7.5' Topo Map



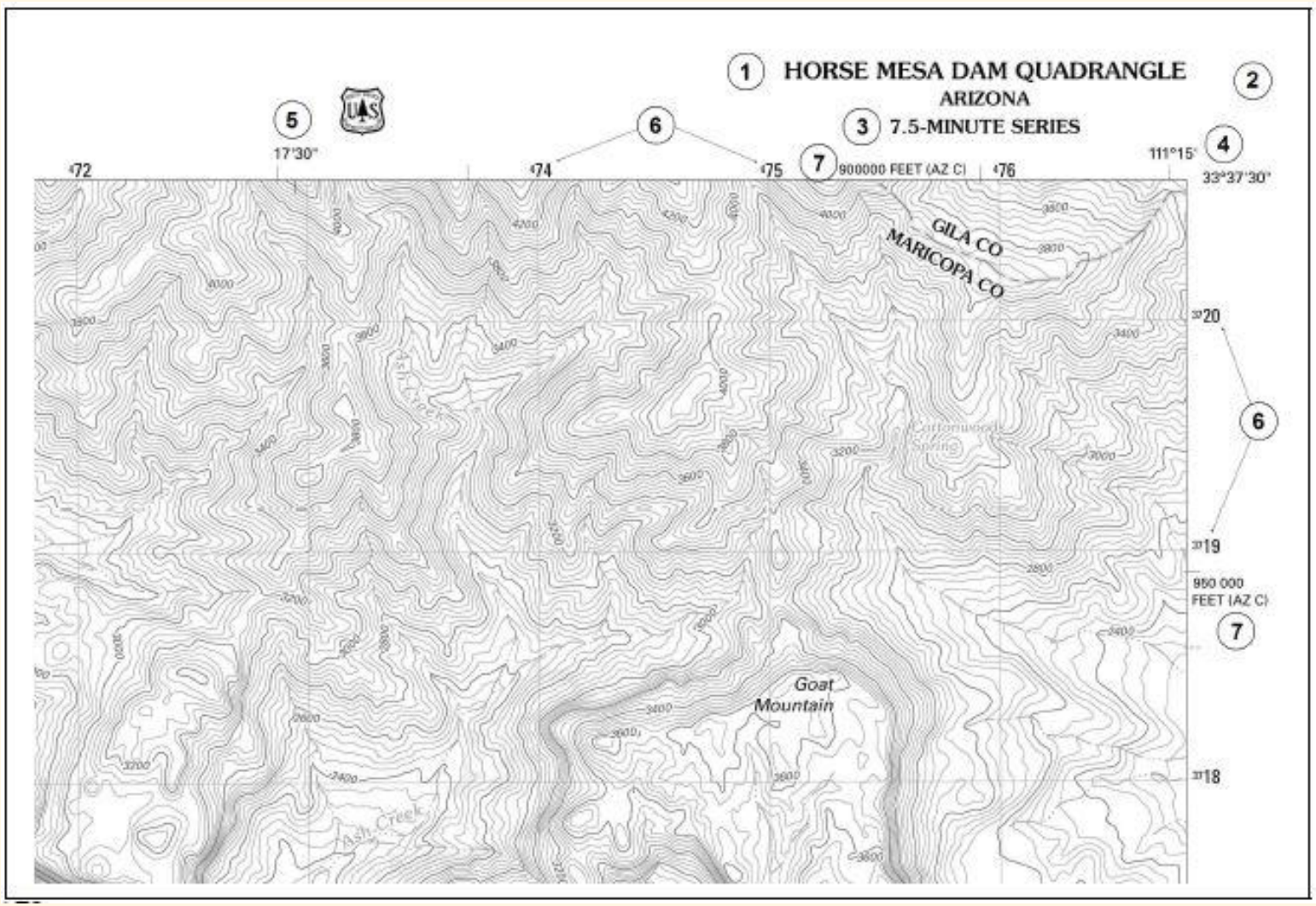
Reading a 7.5' Topo Map



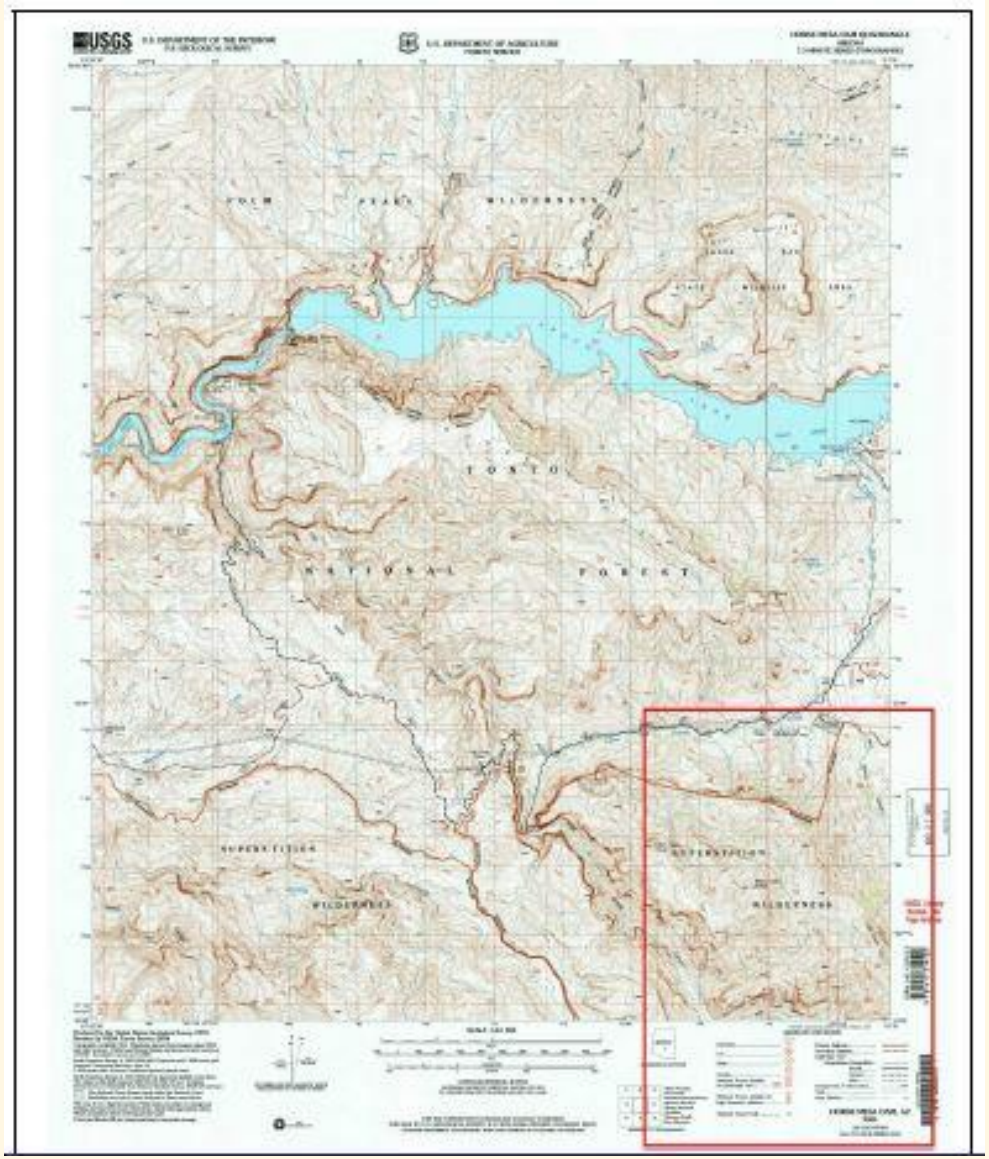
Reading a 7.5' Topo Map



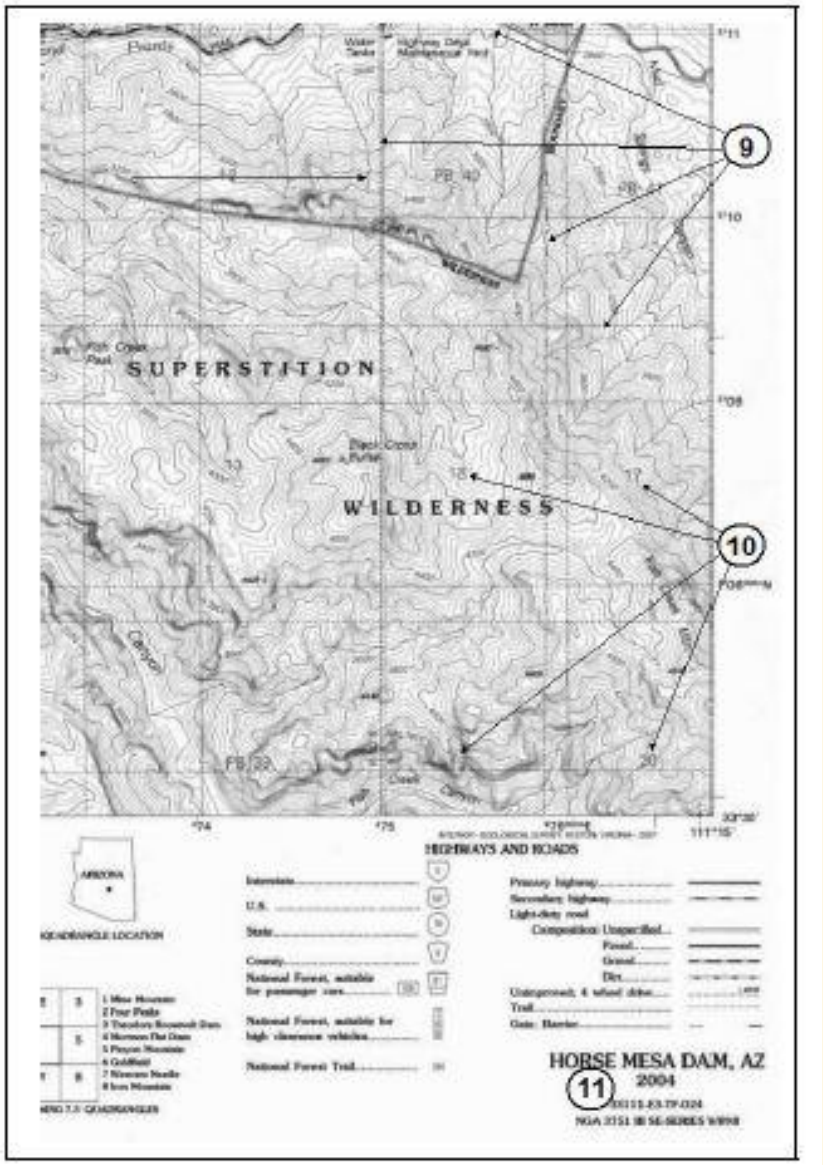
Reading a 7.5' Topo Map



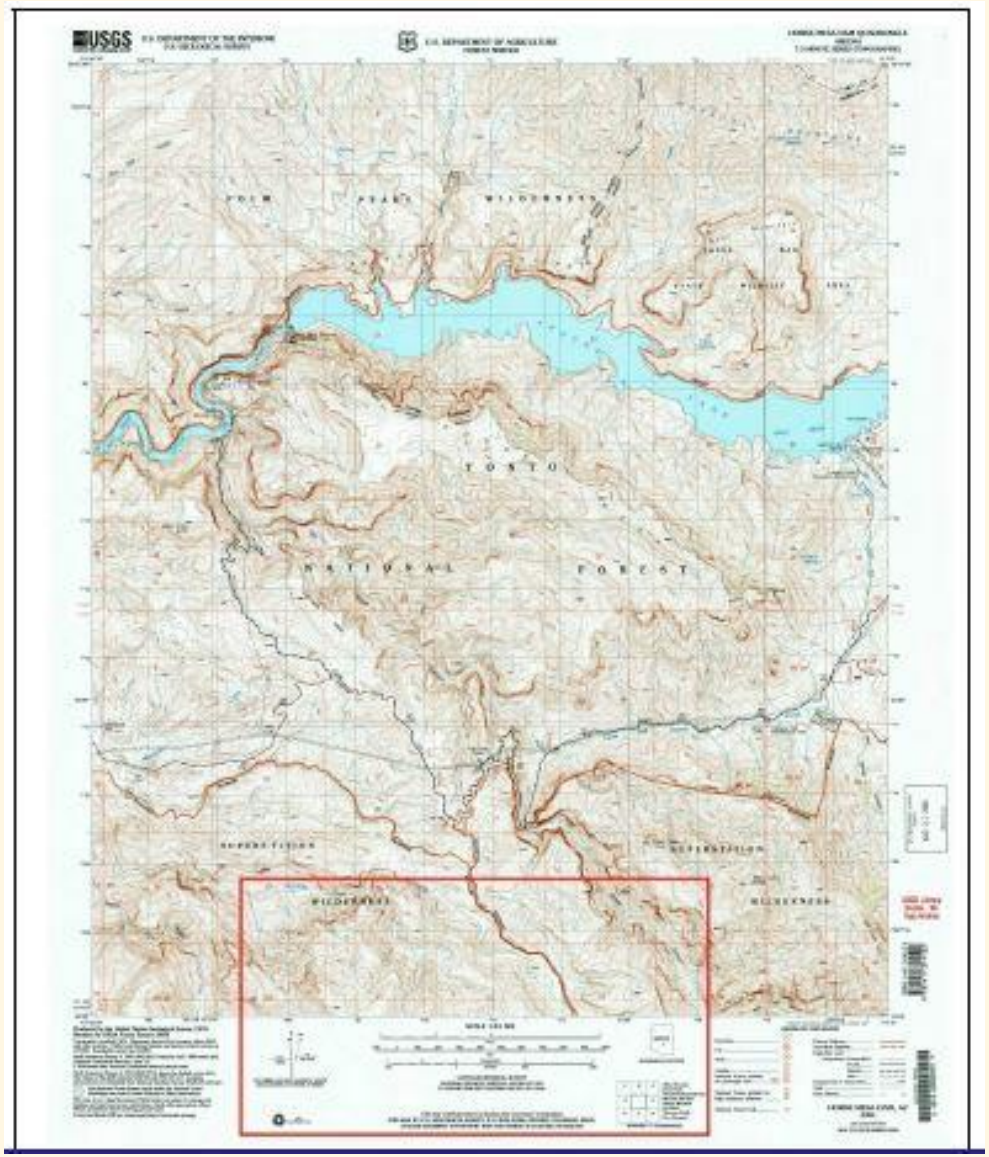
Reading a 7.5' Topo Map



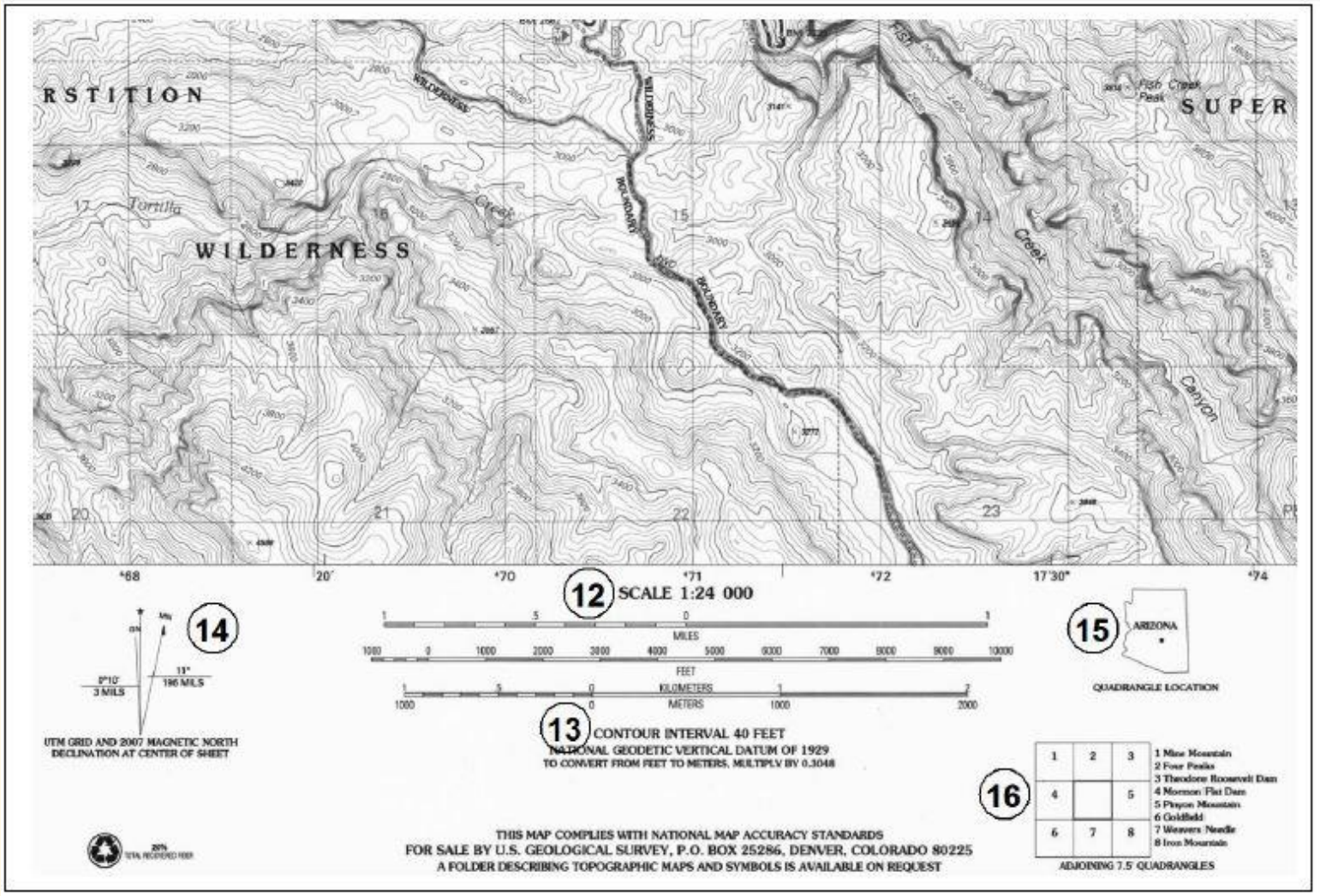
Reading a 7.5' Topo Map



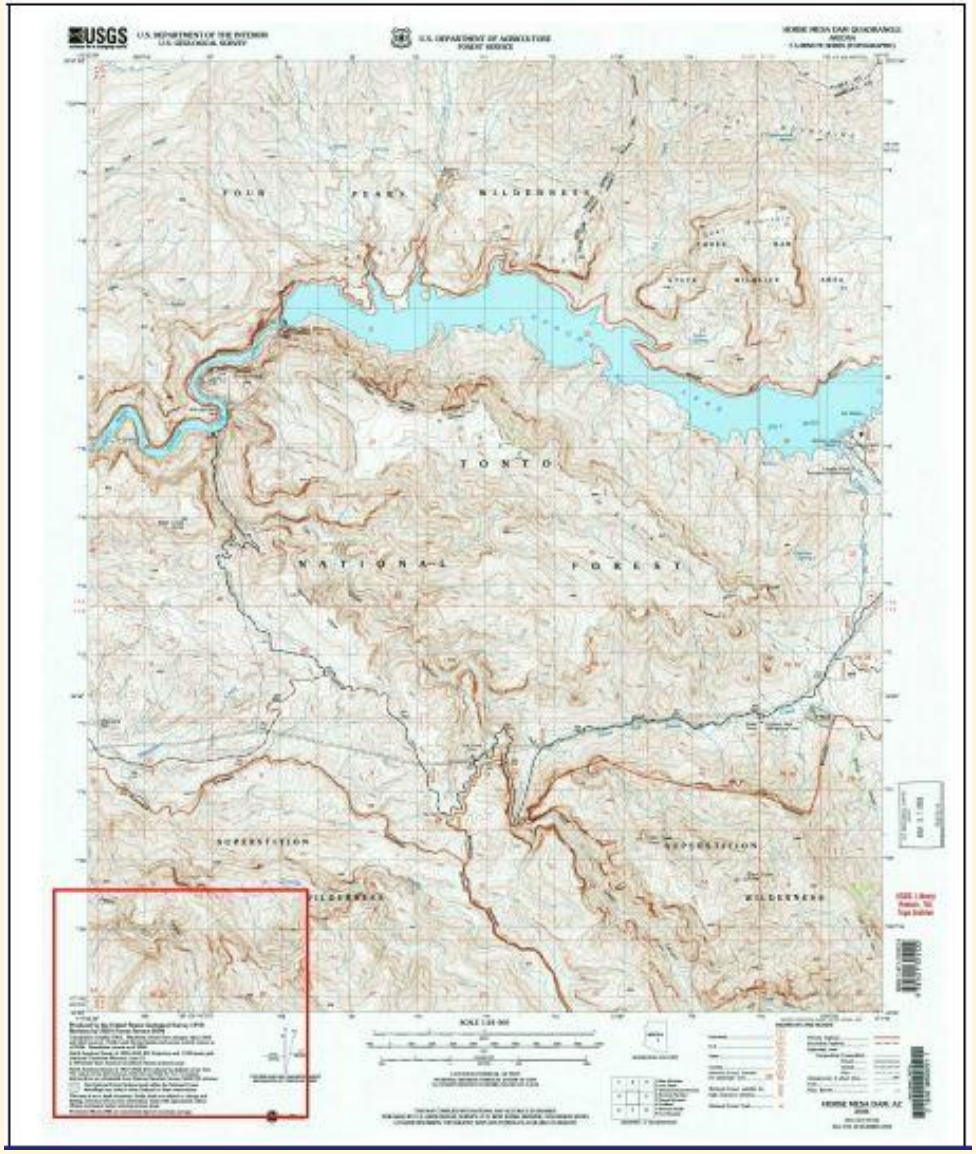
Reading a 7.5' Topo Map



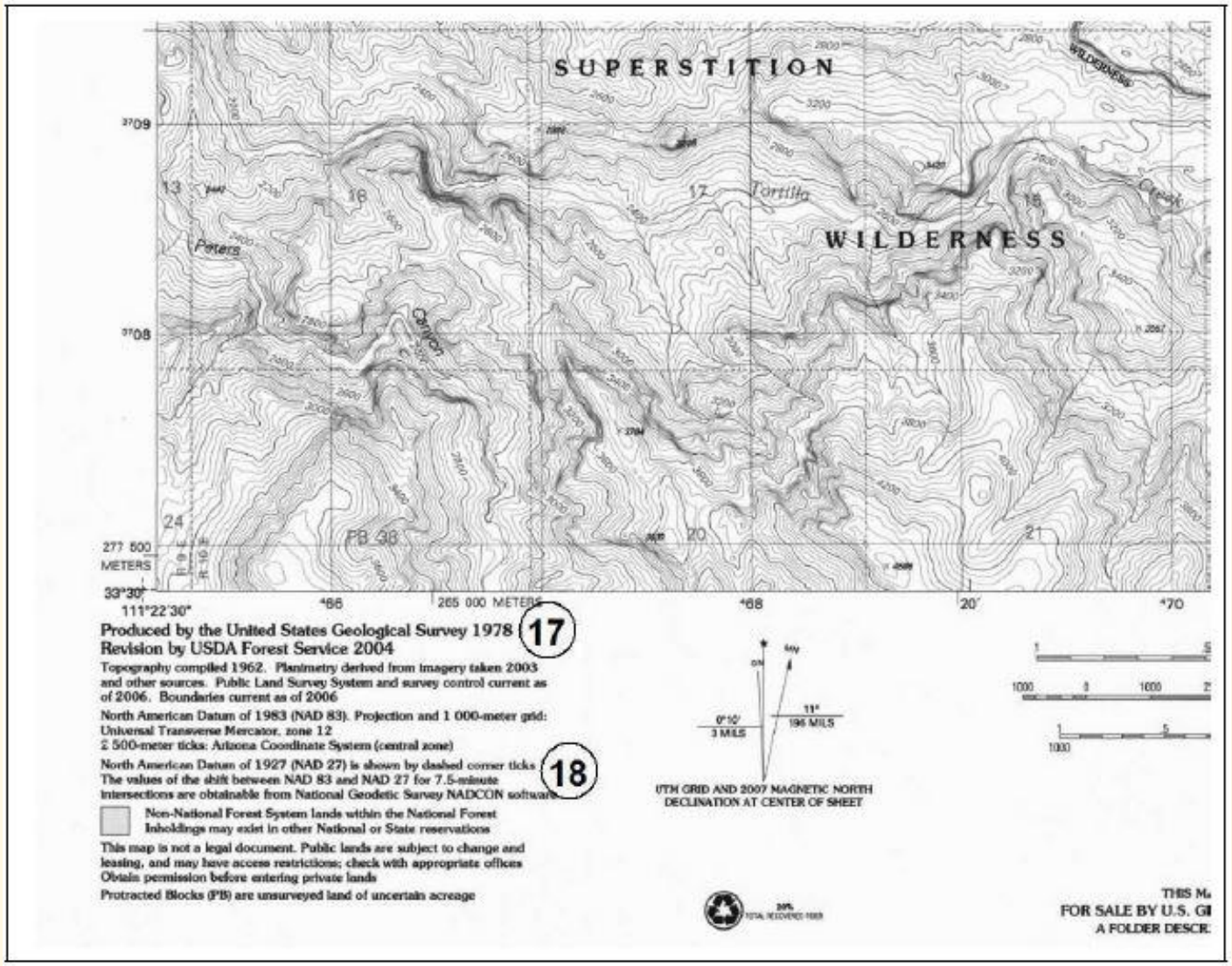
Reading a 7.5' Topo Map



Reading a 7.5' Topo Map



Reading a 7.5' Topo Map



Map Symbols

Brown - contour lines, elevation feature

Green - dense vegetation

Black - roads, manmade structures

Blue - water bodies, streams, drainages

Red - road numbers, trailheads

Purple - map updates

Black Grid - UTM grid (now brown)

Red Grid - Public Land Survey System

Resources

Free digital copies of any 7.5' USGS Topographic Map can be downloaded from:

U.S. Geological Survey store http://store.usgs.gov/

Avenza Maps
Within the APP or Online through the Store
http://www.avenzamaps.com/maps

A comprehensive topographic map symbols booklet is available at:
https://pubs.usgs.gov/gip/TopographicMapSymbols/topomapsymbols.pdf

Course Outline

Maps

Reading a 7.5 Minute Topo Map

Coordinate Systems

Pace Counting

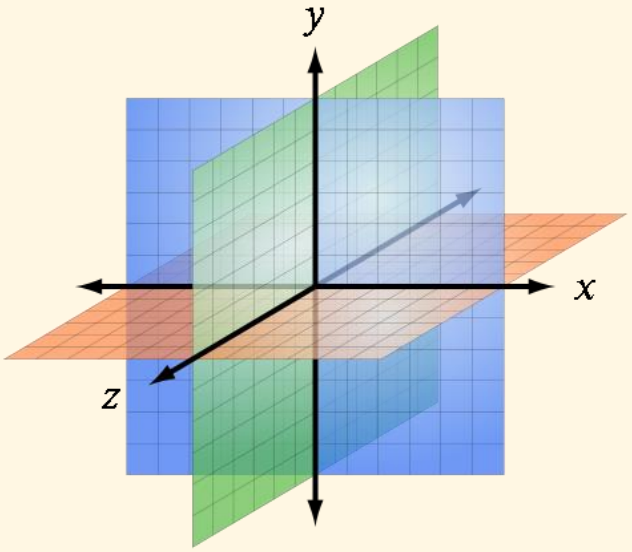
Compass

GPS

Coordinate Systems

Most common coordinate systems used by SAR personnel

- Lat/Long (Latitude/Longitude)
- UTM (Universal Transverse Mercator)
- USNG (U.S. National Grid)
- Public Land Survey System (Township and Range)



Latitude/Longitude

- Is an angular system based on the latitude (parallels) and longitude (meridians) that divide the earth.
- Latitude - 0° at the equator, 90° at the poles
- Longitude - 0° at the prime meridian, 180° at the international date line.
- Coordinates are measured as angles using degrees (°) with divisions of minutes (‘) and seconds (“)

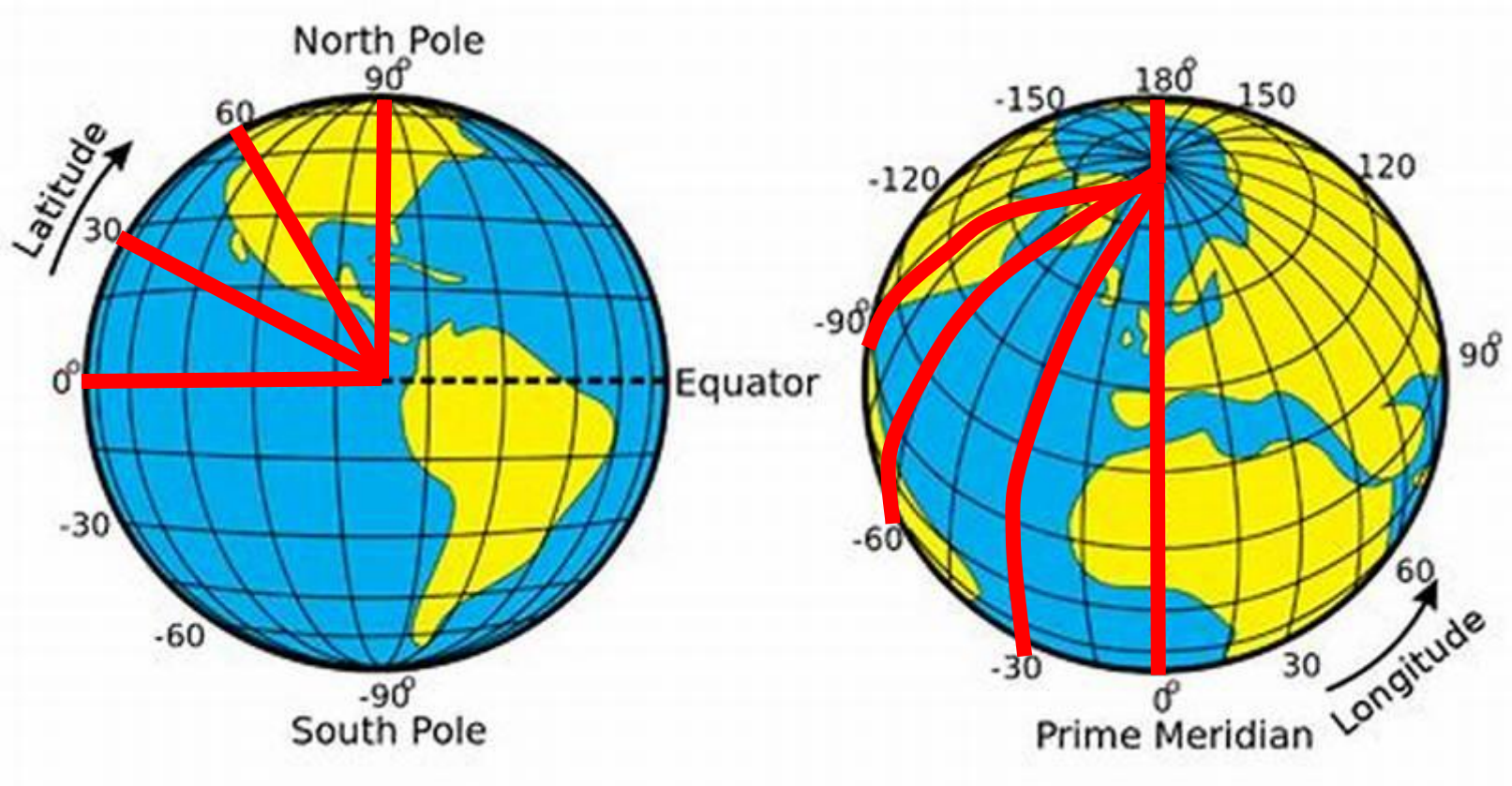
Latitude/Longitude

- Degrees° are divided into minutes' 1° = 60'
- Minutes' are divided into Seconds" 1' = 60"

The hemisphere is important as well.

- Indicated with cardinal directions before or after the coordinate part
- Can be indicated with a "-" for West or South hemispheres

Latitude/Longitude



North (+), South (-), East (+), West (-)

Latitude/Longitude - Formats

Degrees Minutes Seconds - (hddd mm ss.s),
hemisphere, degrees, minutes, decimal seconds
35°35'55.1292" N 114°05'16.2708" W

Degrees Decimal Minutes - (hddd mm.mmm),
hemisphere, degrees, decimal minutes
35°35.9188' -114°05.2712'

Decimal Degrees - (hddd.ddddd),
hemisphere, decimal degrees
35.598674° -114.087853°

Degrees, Minutes, Seconds

Degrees Minutes Seconds (DMS) - (hddd mm ss.s), hemisphere, degrees, minutes, decimal seconds
35°35'55.1292" -114°05'16.2708" or 35°35'55.1292"N 114°05'16.2708"W

Separated by spaces or characters of "degrees, minutes and seconds" (not feet and inches)

Hemisphere may be located at the beginning or the end of the coordinates. It may be represented by a nothing or a "minus" symbol (indicating West or South).

All non decimal values will never exceed 60 (with the exception of the first value of latitude and longitude) …. Values will be 00 to 59 only. If the value is higher than this, it is a different format or an indication there is a formatting error and the coordinates are NOT USABLE.

Degrees, Decimal Minutes

Degrees, Decimal Minutes - (hddd mm.mmm), hemisphere, degrees, decimal minutes
35°35.9188' -114°05.2712' or 35°35.9188'N 114°05.2712'W

Hemisphere may be located at the beginning or the end of the coordinates. It may be represented by a nothing or a "minus" symbol (indicating West or South).

All non decimal values will never exceed 60 (with the exception of the first value of latitude and longitude) …. Values will be 00 to 59 only. If the value is higher than this, it is a different format or an indication there is a formatting error and the coordinates are NOT USABLE.

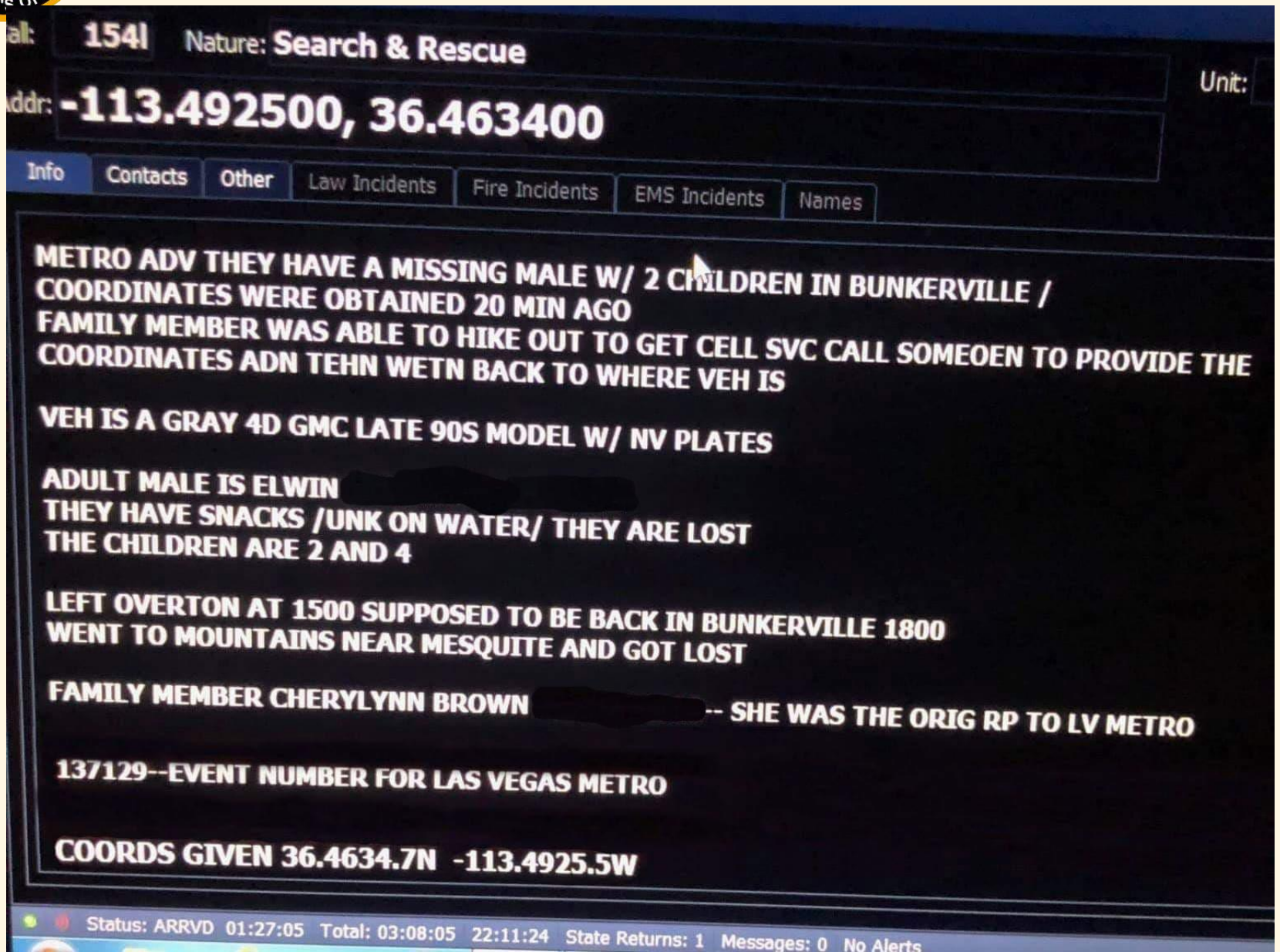
Common aviation format. DPS Ranger may provide coordinates in this format.

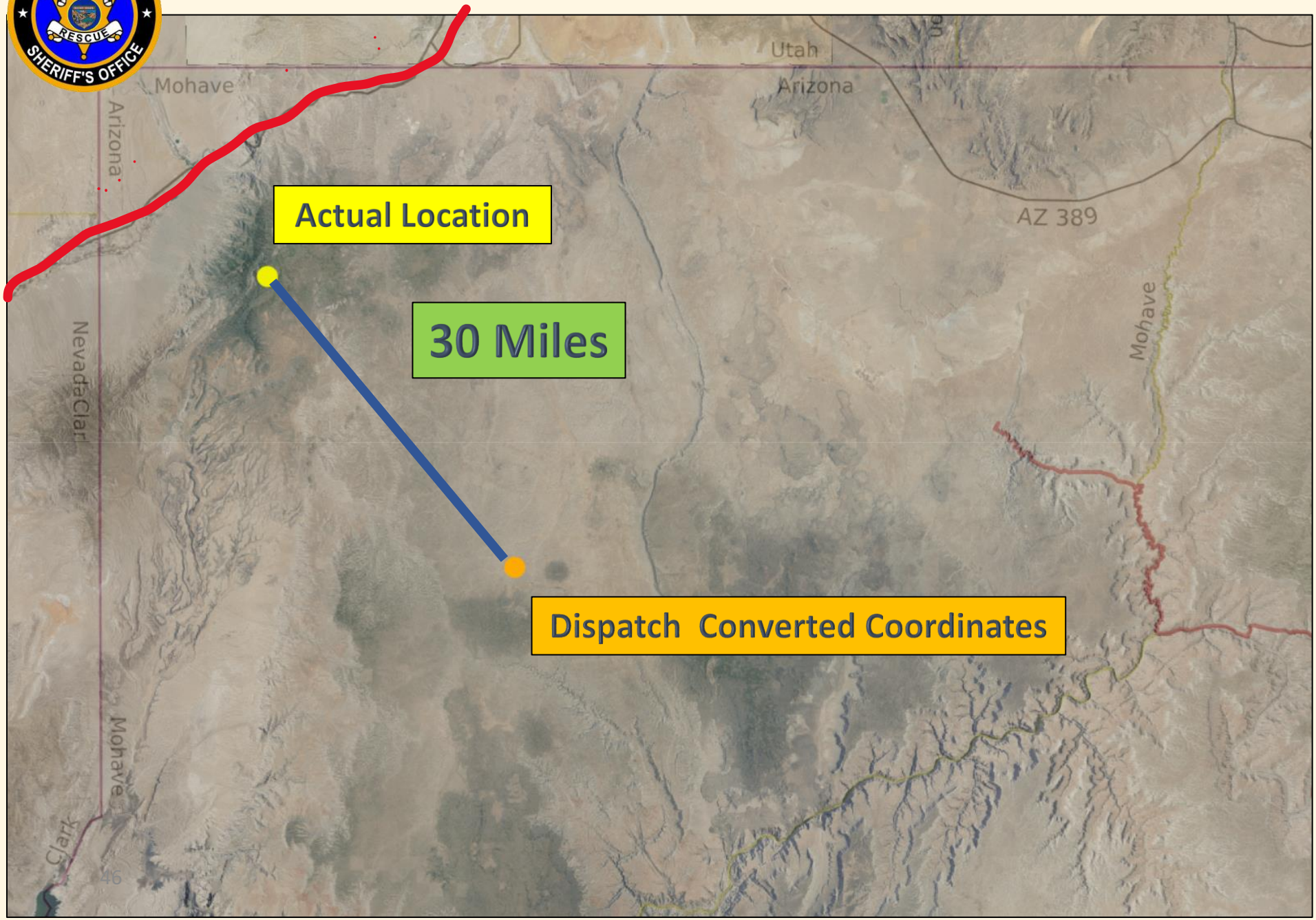
Decimal Degrees

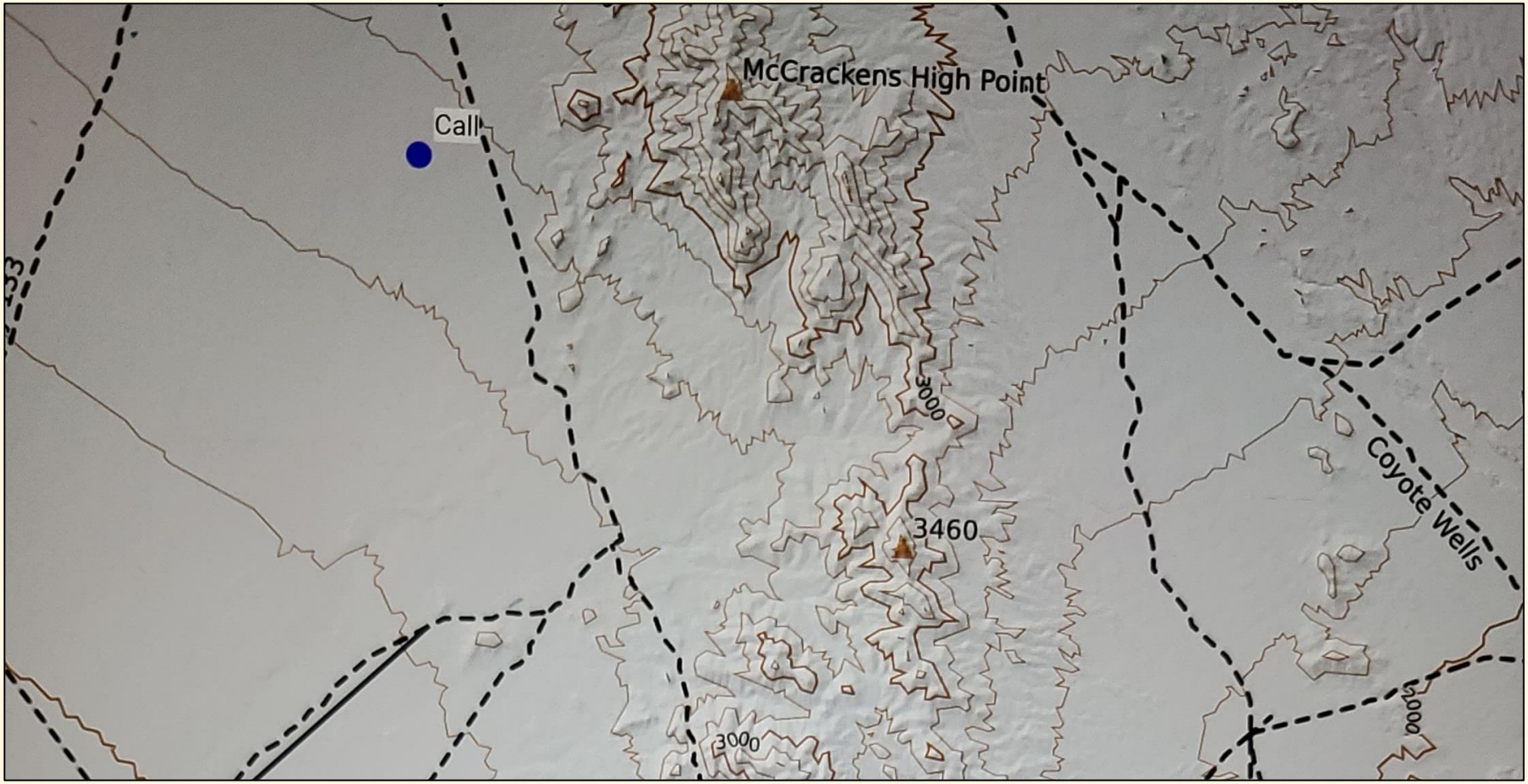
Decimal Degrees - (hddd.ddddd), hemisphere, decimal degrees
35.598674° -114.087853° or 35.598674°N -114.087853°W

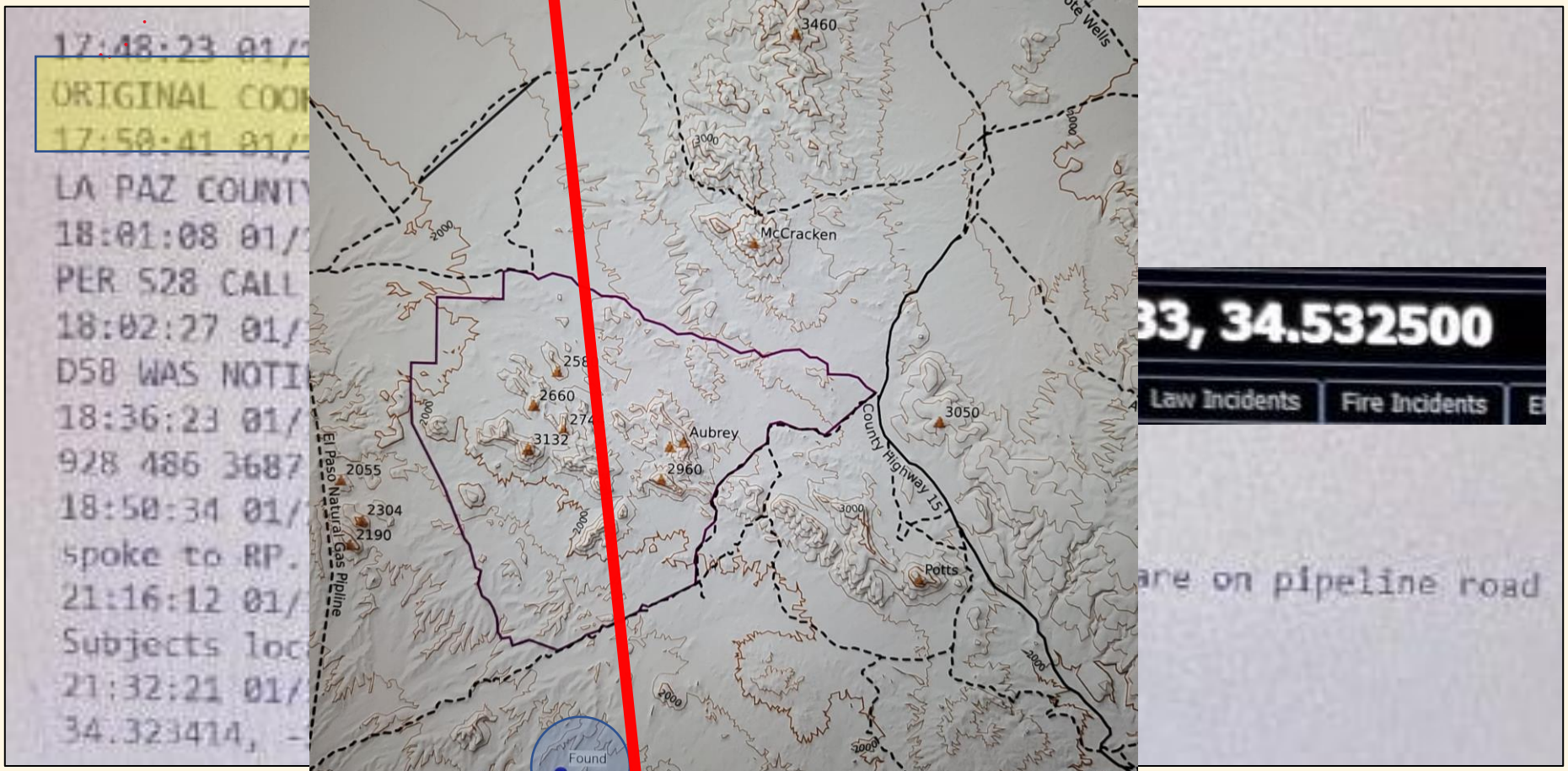
Hemisphere may be located at the beginning or the end of the coordinates. It may be represented by a nothing or a "minus" symbol (indicating West or South).

- Easiest input format
- Easiest communicative format
- State format for documentation
- Does not require special formatting
- Mohave County's Preferred Format


all: 1541 Nature: Search & Rescue
Addr: -113.492500, 36.463400
Unit:
Info
Contacts
Other
Law Incidents
Fire Incidents
EMS Incidents
Names
METRO ADV THEY HAVE A MISSING MALE W/ 2 CHILDREN IN BUNKERVILLE /
COORDINATES WERE OBTAINED 20 MIN AGO
FAMILY MEMBER WAS ABLE TO HIKE OUT TO GET CELL SVC CALL SOMEOEN TO PROVIDE THE
COORDINATES ADN TEHN WETN BACK TO WHERE VEH IS
VEH IS A GRAY 4D GMC LATE 90S MODEL W/ NV PLATES
ADULT MALE IS ELWIN
THEY HAVE SNACKS /UNK ON WATER/ THEY ARE LOST
THE CHILDREN ARE 2 AND 4
LEFT OVERTON AT 1500 SUPPOSED TO BE BACK IN BUNKERVILLE 1800
WENT TO MOUNTAINS NEAR MESQUITE AND GOT LOST
FAMILY MEMBER CHERYLYNN BROWN -- SHE WAS THE ORIG RP TO LV METRO
137129--EVENT NUMBER FOR LAS VEGAS METRO
COORDS GIVEN 36.4634.7N -113.4925.5W
Status: ARRVD 01:27:05 Total: 03:08:05 22:11:24 State Returns: 1 Messages: 0 No Alerts


Utah
Arizona
Mohave
Arizona
AZ 389
Mohave
Nevada
Clark
Mohave
Clark
Actual Location
30 Miles
Dispatch Converted Coordinates

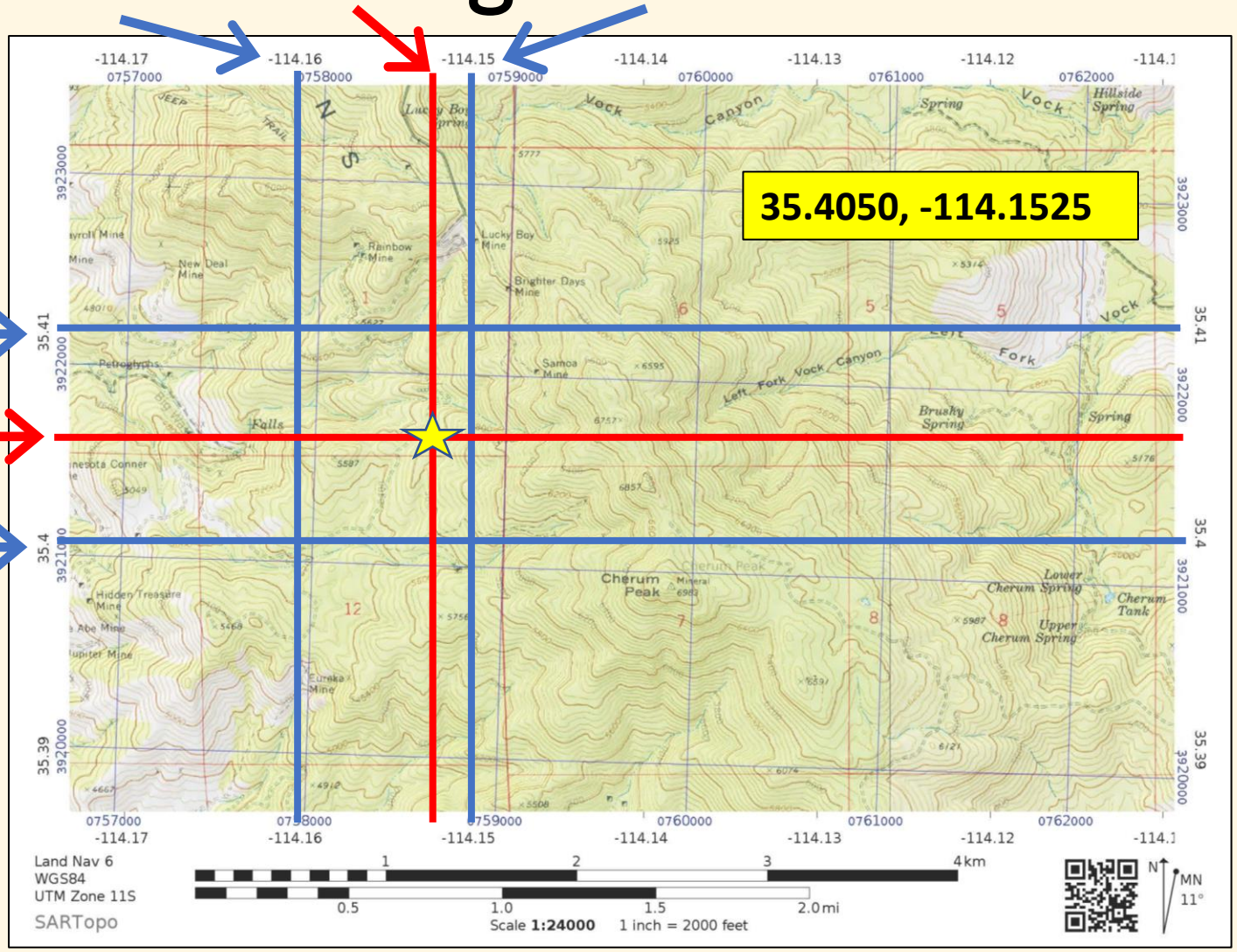

McCrackens High Point
Call
3000
3460
Coyote Wells
3000
3000


17:48:23 01/
ORIGINAL COO
17:58:41 01/
LA PAZ COUNTY
18:01:08 01/
PER 528 CALL
18:02:27 01/
D58 WAS NOTI
18:36:23 01/
928 486 3687
18:50:34 01/
spoke to RP.
21:16:12 01/
Subjects loc
21:32:21 01/
34.323414, -
33, 34.532500
Law Incidents
Fire Incidents
are on pipeline road
McCrackens High Point
Call
3460
Coyote Wells
McCracken
2660
3132
Aubrey
2960
3050
County Highway 15
El Paso Natural Gas Pipline
2055
2304
2190
Potts
Found
Actual
Miller
Pools
2884
2466
Black Mesa

Coordinate Conversion Tools

- There are many different coordinate conversion tools on the web and available for Android and iOS platforms
- Know how to use your tools
- Latitude and longitude coordinates can be converted by hand or with a calculator – but it is not necessary to know how to do it for this class

Plotting Coordinates



Demonstration of Knowledge

- Complete the questions
- You can use any coordinate conversion tool
- When done, take a 5-minute break

Demonstration of Knowledge

1. Which format below is Decimal Degrees?
   - A 33°35'48.607"N 114°4'26.864"W
   - B 33°35.81012' -114°04.44773'
   - C 33.5968353° -114.0741288°
   - D 33 75.263 -114 62.159

2. Which format below is Degrees, Decimal Minutes?
   - A 35.123456, -114.987654
   - B 35 07.4074, -114 59.2592
   - C 35 07 24.4416, -114 59 15.5544
   - D 35 61.6785, -114 17.32546

Knowledge Review

3. Which format below is Degrees, Minutes, Seconds?

A 33°35'48.607"N 114°4'26.864"W

B 33°35.81012' -114°04.44773'

C 33.5968353° -114.0741288°

D 33 75.263 -114 62.159

4. Is there an error with this coordinate and what is it?

33 75.263 -114 62.159

Minutes and seconds do not exceed 60

Knowledge Review

5. Is there an error with this coordinate and what is it?

33.5968353° 114.0741288°

If this is a coordinate in China, it is okay.

Missing the correct hemisphere information for longitude.

6. Is there an error with this coordinate and what is it?

35 77 24.4N, 114 59 15.5W

Minutes and seconds do not exceed 60

Knowledge Review

7. Convert to Decimal Degrees

   35 08 34.7, -114 53 25.2

   35.142972, -114.890333

8. Convert to Degrees, Decimal Minutes

   35 17 26.4, -114 43 13.4

   35 17.440N, -114 43.2233

Knowledge Review

9. Convert to Degrees, Minutes, Seconds

   35.78654, -114.67324

   35 47 11.54, -114 40 23.664

10. Convert to Decimal Degrees

    35 18.9874, -114 38.4473

    35.316457, -114.640788

Knowledge Review

11. Which format is preferred in Mohave County?

A UTM

B Degrees, Decimal Minutes

C Decimal Degrees

D Degrees, Minutes, Seconds

Universal Transverse Mercator

UTM Zone - Zone number and latitude band letter.

12 S is most of Arizona. Western Arizona transitions to 11 S.

Easting - found using a **Central Meridian** running north/south through the center of each UTM zone. The central meridian is given a value of 500 KM. The digits in the coordinate are relative to the central meridian, i.e. 746 KM is larger than 500 KM and is 246 KM east of the central meridian.

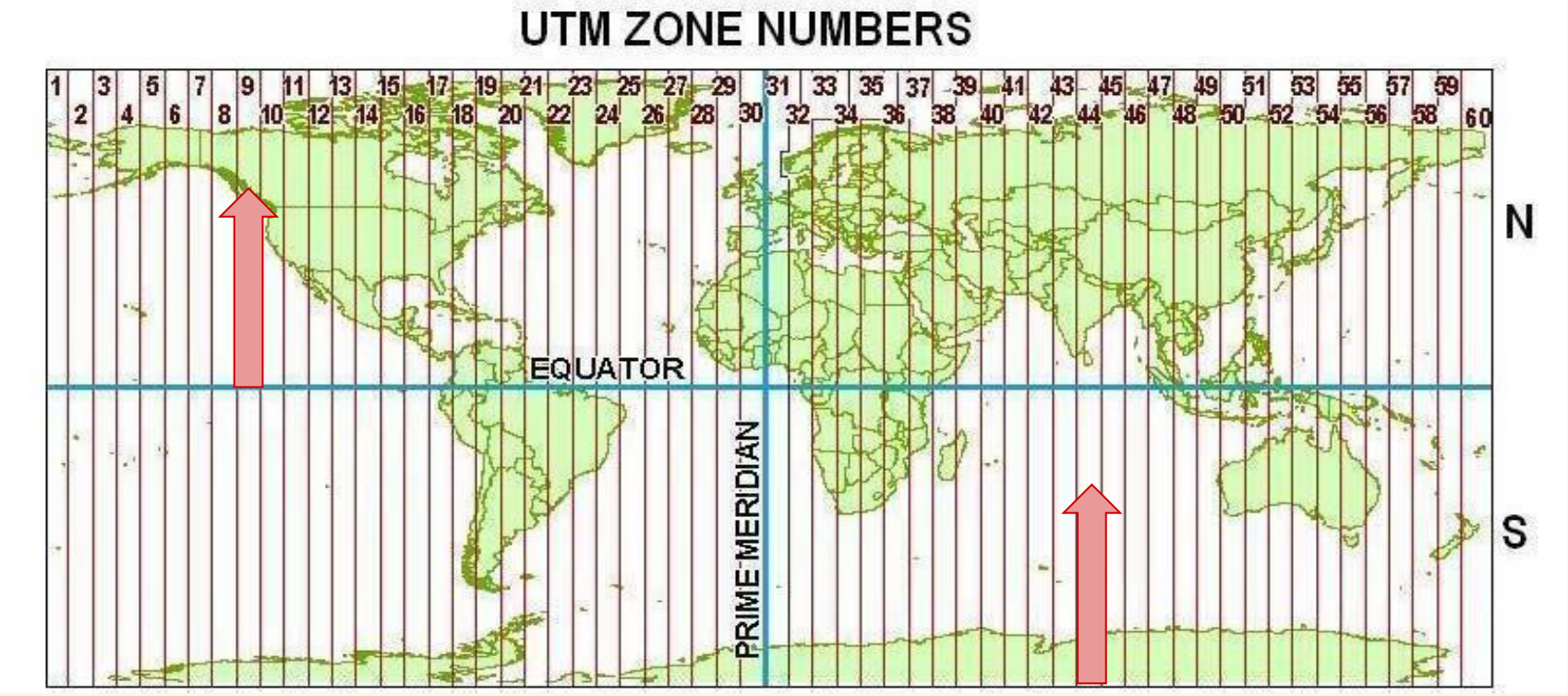
Northing - measured in Meters from the equator, in N. Hemisphere

UTM Coordinate System

- Not used in Mohave County because we are in the middle of two zones (11 and 12)
- Very effective method to use to navigate on topographic maps
- Based on ground distance

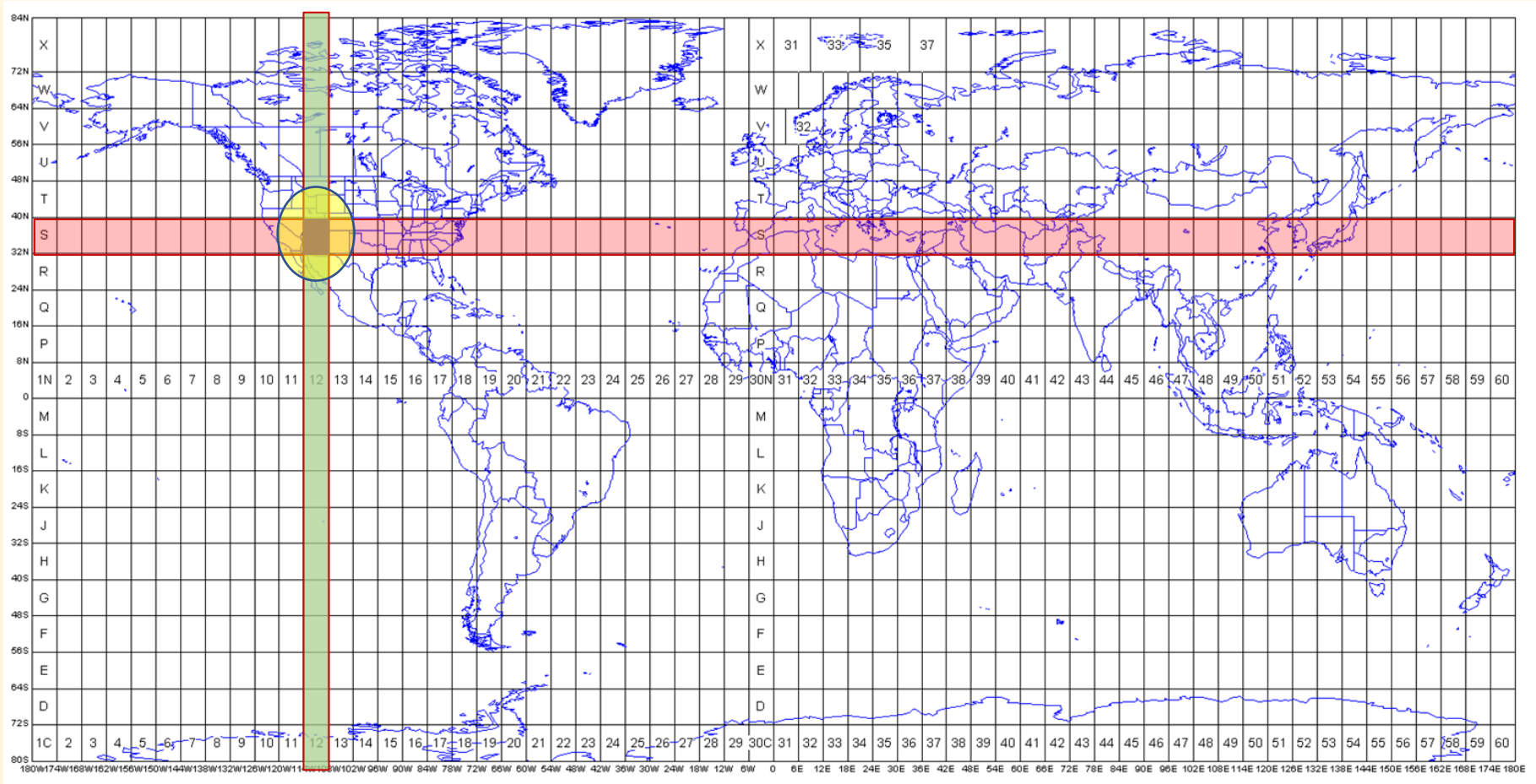
UTM Coordinate System

- Earth is divided into 60 north/south zones.
- In the Northern Hemisphere, the northing coordinate is measured from the equator.
- In the Southern Hemisphere, the northing coordinate is measured from 10,000,000 meters from south of the equator.

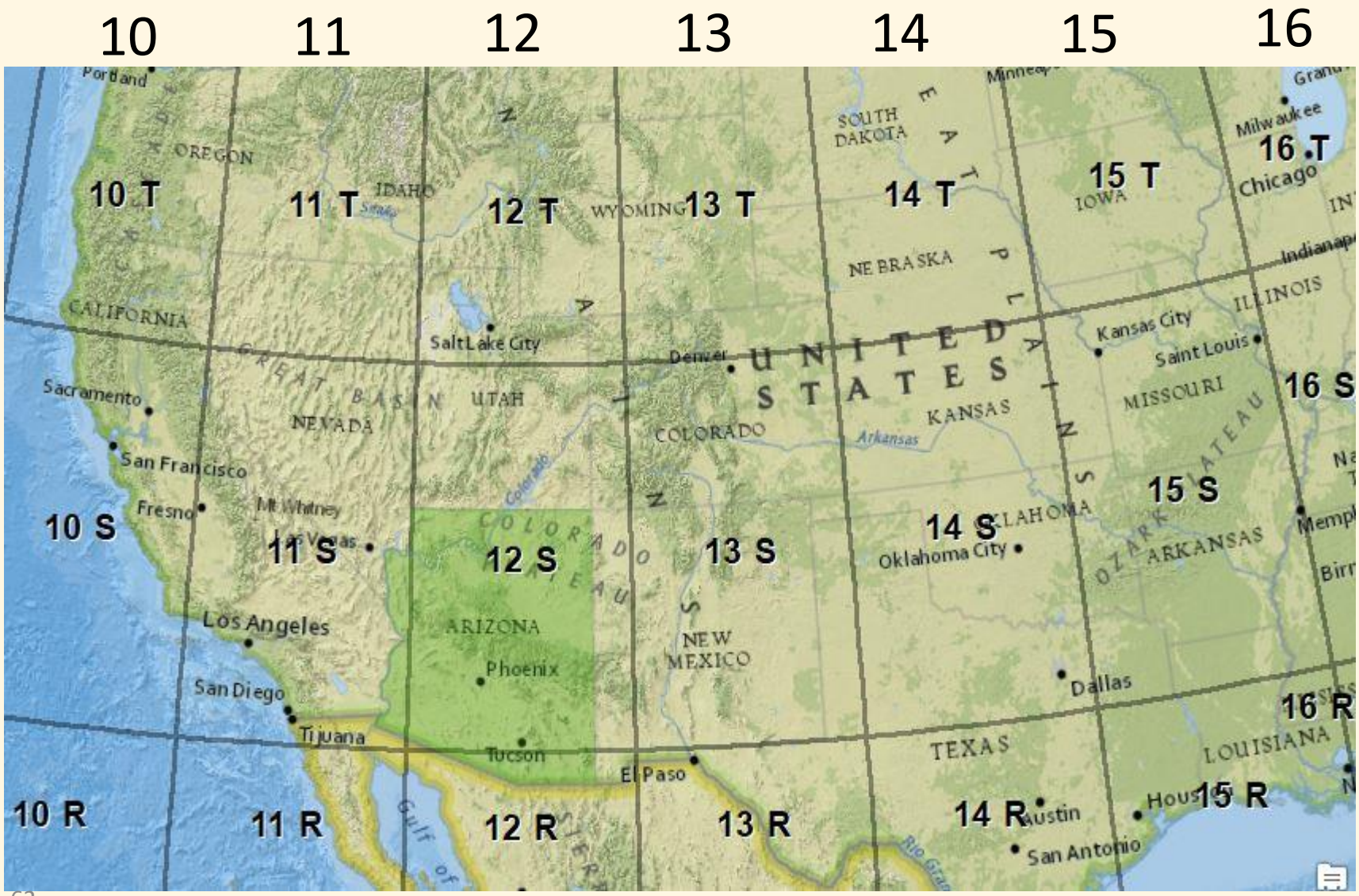


UTM Zone

UTM also incorporates latitude bands identified with letters



UTM Zone


10
11
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11 S
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14 S
15 S
16 S
10 R
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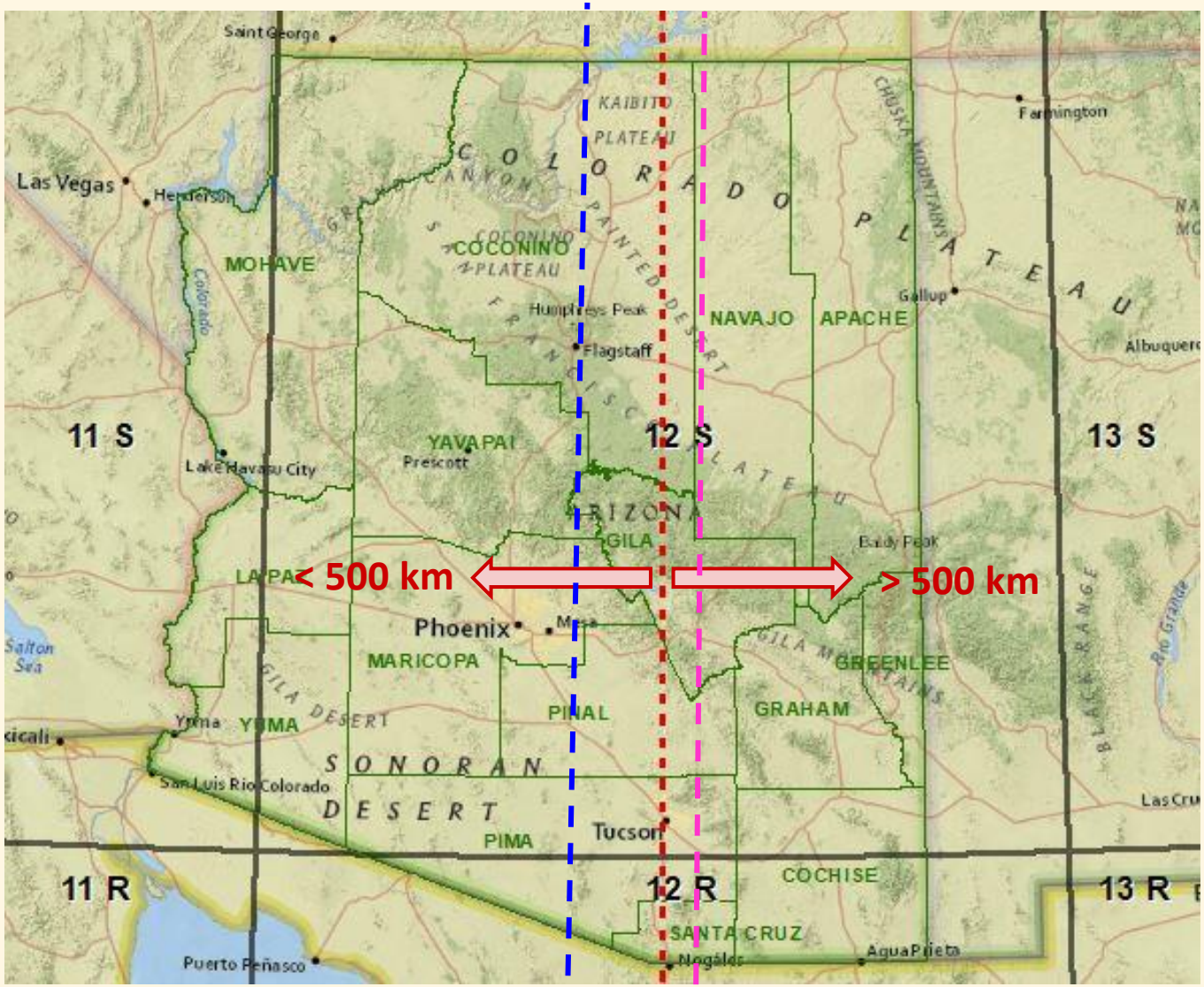
14 R
15 R
16 R
Portland
OREGON
IDAHO
WYOMING
SOUTH DAKOTA
NEBRASKA
IOWA
Milwaukee
Chicago
CALIFORNIA
Salt Lake City
Denver
UNITED STATES
Kansas City
Saint Louis
ILLINOIS
MISSOURI
Sacramento
GREAT BASIN
UTAH
NEVADA
COLORADO
KANSAS
Arkansas
San Francisco
Fresno
Mt Whitney
Las Vegas
OKLAHOMA
Oklahoma City
ARKANSAS
OZARK PLATEAU
COLORADO PLATEAU
Los Angeles
ARIZONA
Phoenix
NEW MEXICO
Dallas
San Diego
Tijuana
Tucson
El Paso
TEXAS
LOUISIANA
Houston
Austin
San Antonio
Gulf of Mexico

UTM Easting

Easting 400 KM

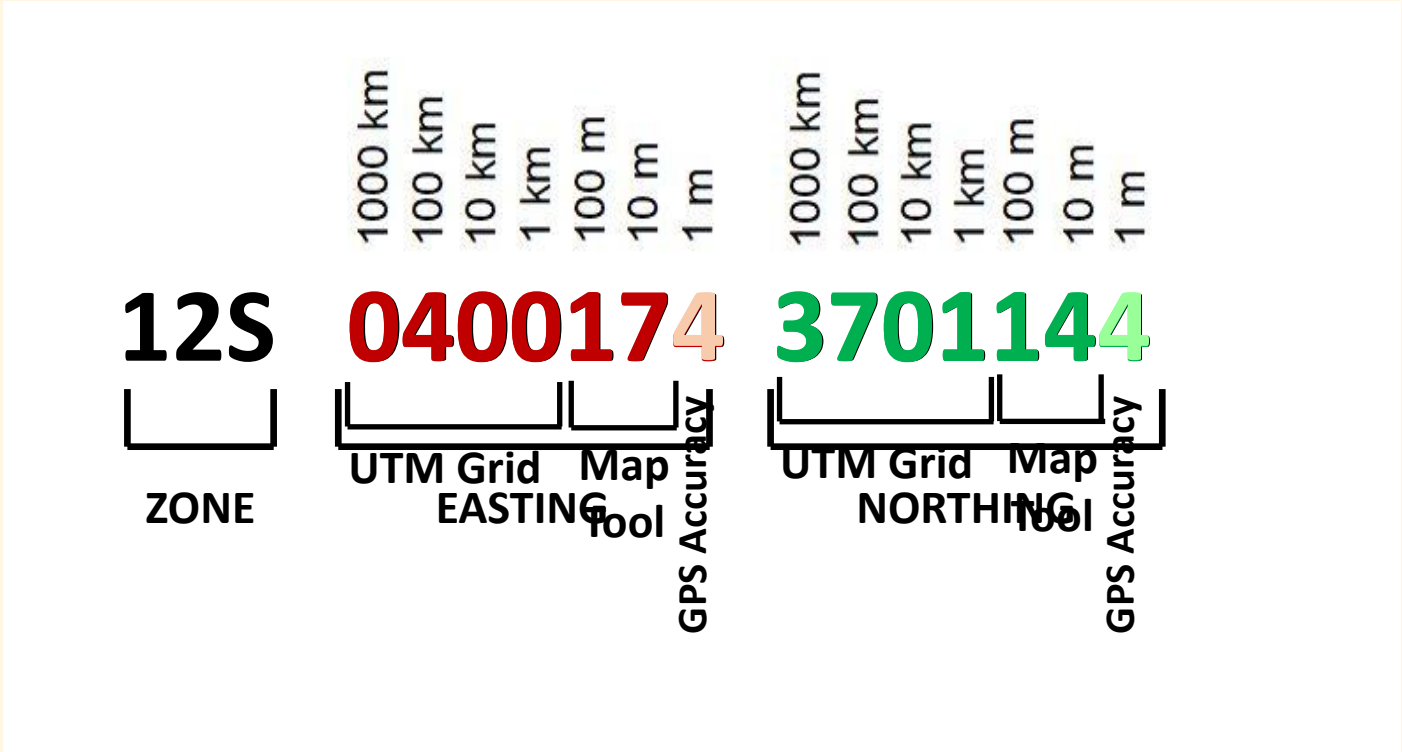
Easting 525 KM



Central Meridian (500,000 meters from west)

UTM Coordinate System

Breakdown of the UTM coordinate format:



UTM Coordinate System

Step 1: Locate 1KM grid coordinates

$^{03}96^{000}$ E

EASTING

$^{37}07^{000}$ N

NORTHING

0400174 3701144

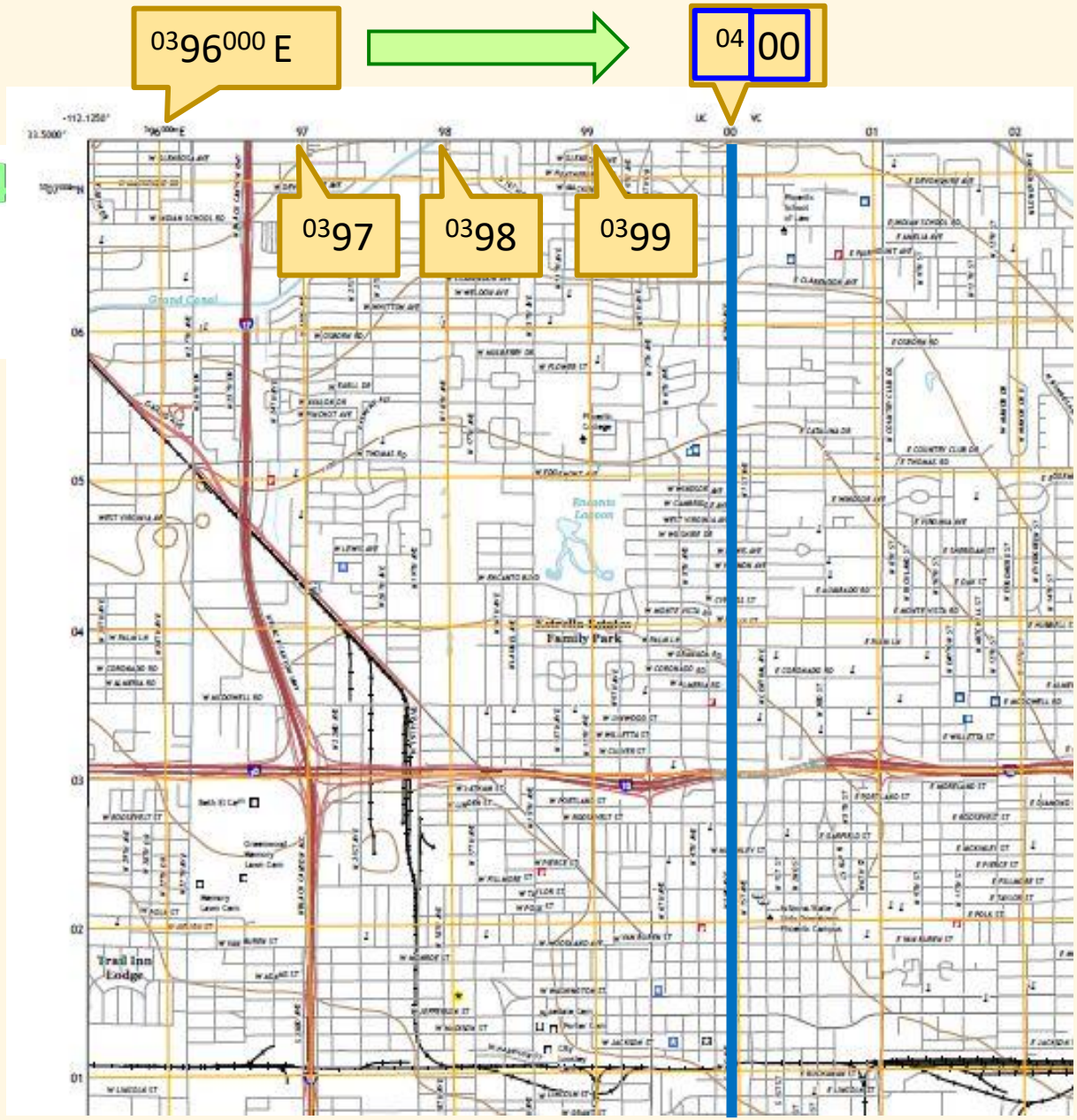
UTM GRID | Map Tool | UTM GRID | Map Tool

USGS 7.5' Quadrangle

UTM
EASTING

0400174 3701144

UTM GRID | Map Tool | UTM GRID | Map Tool



Step 2: Locate 1KM easting line

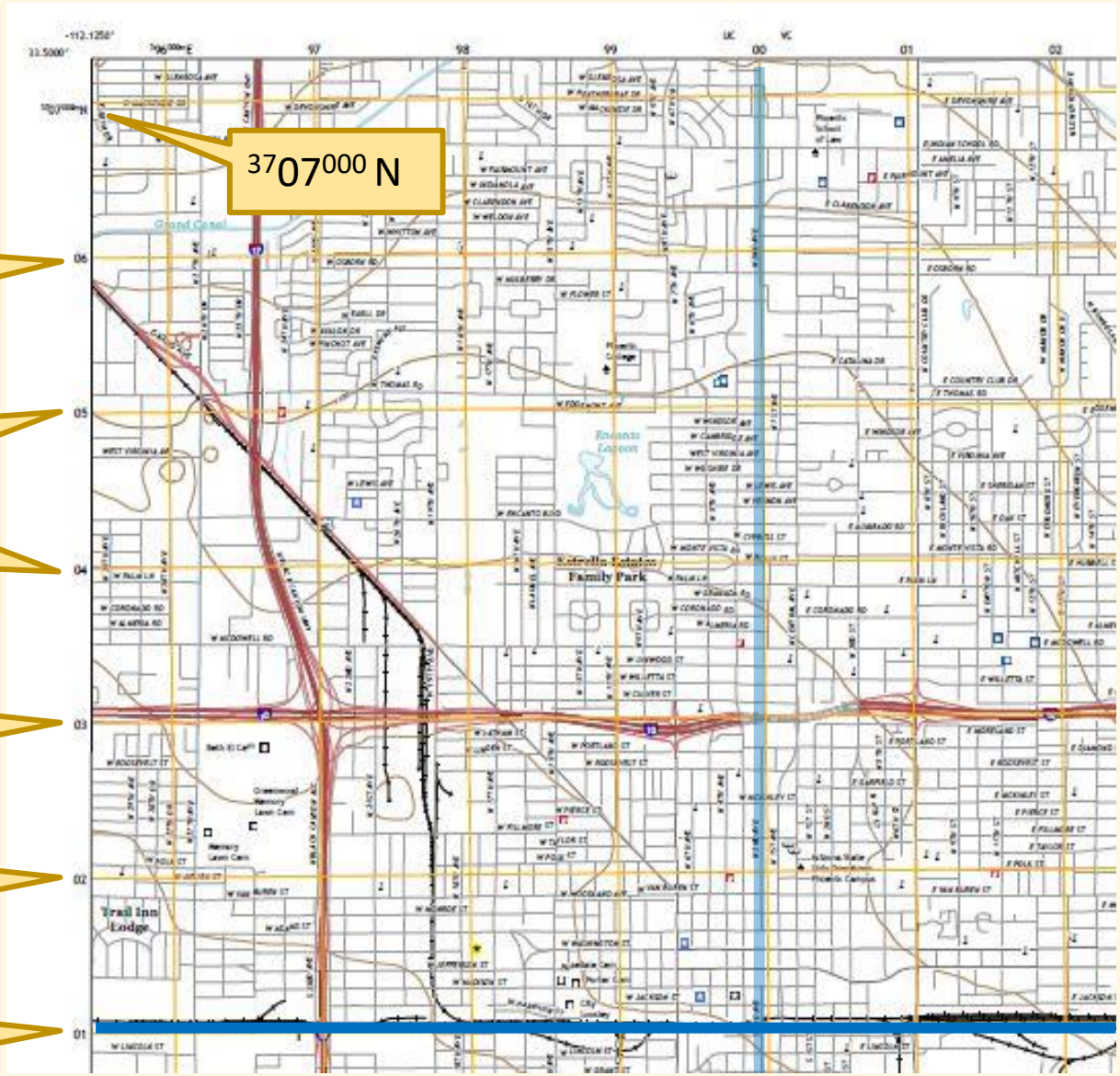
USGS 7.5' Quadrangle

UTM NORTHING

0400174 3701144

UTM GRID | Map Tool | UTM GRID | Map Tool

Step 3: Locate 1KM northing line



USGS 7.5' Quadrangle

UTM

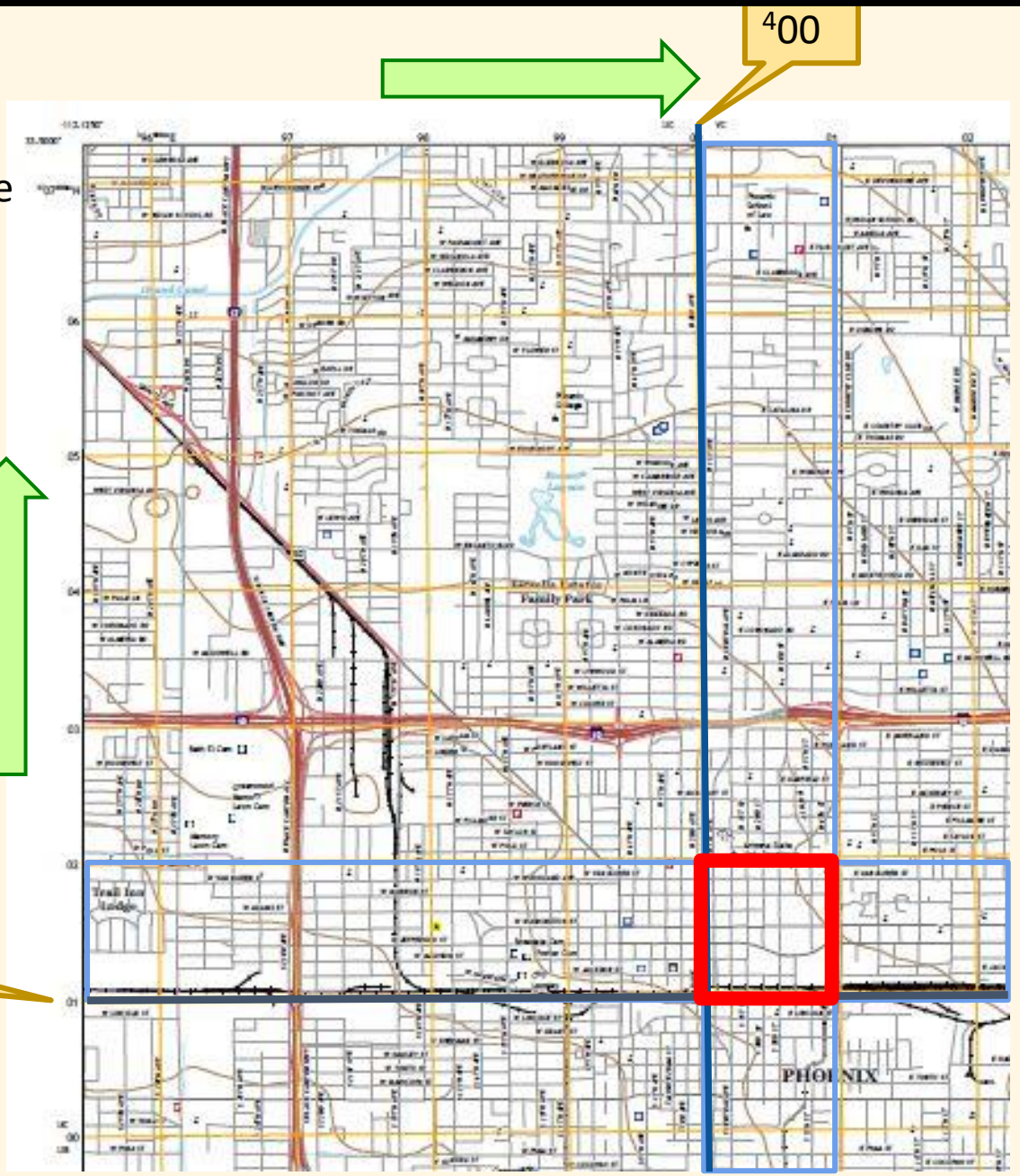
Step 4: Locate 1KM grid square

EASTING **NORTHING**

0400174 3701144

UTM GRID | Map Tool | UTM GRID | Map Tool

USGS 7.5' Quadrangle



UTM

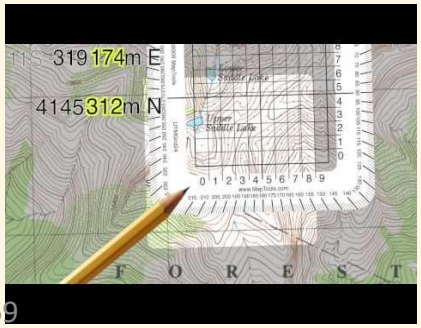
EASTING **NORTHING**

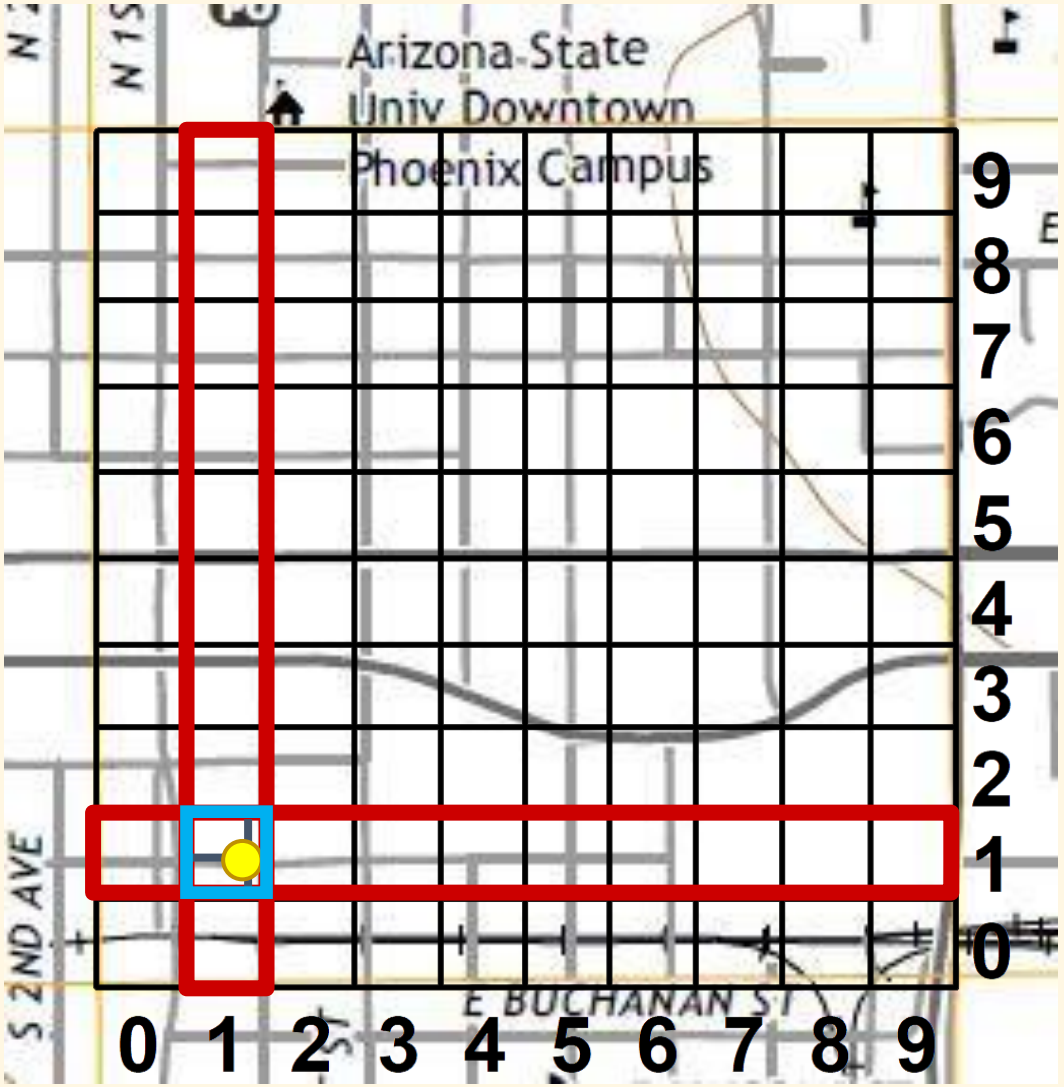
0400174 **3701144**

UTM GRID | Map Tool | UTM GRID | Map Tool

Step 5: Use UTM grid tool to locate 100 meter grid square

Step 6: Estimate 10 meter location within 100 meter square





UTM Exercise

SAR Topo 24,000 Map: Land Nav 5

What features are here?

11S 0739320 3887900	Bench Mark 3628
11S 0737560 3887680	Bench Mark 2748
11S 0740890 3885180	Bench Mark 3962

UTM Exercise

What are the UTM Coordinates of these features? Include Zone and Band.

Battleship Mountain	11S 0738710 3884340
Mine Shaft	11S 0737990 3883850
End of Road/Prospect Pit	11S 0737690 3885320

UTM Summary

UTM Zone - Zone Number & Band Letter

Easting - distance in meters in relation to zone's Central Meridian

Northing - distance in meters from the Equator

Easting	Northing
0400	3701

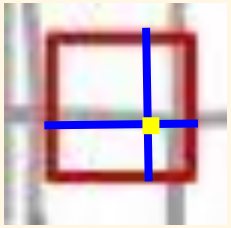
8 Digit Grid Coordinate
1 km grid location

Easting	Northing
04001	37011

10 Digit Grid Coordinate
100 m grid location

Easting	Northing
040017	370114

12 Digit Grid Coordinate
10 m grid location



Demonstration of Knowledge

- Complete the questions
- Use the UTM Map Grid Tool
- When done, take a 5-minute break

U.S. National Grid

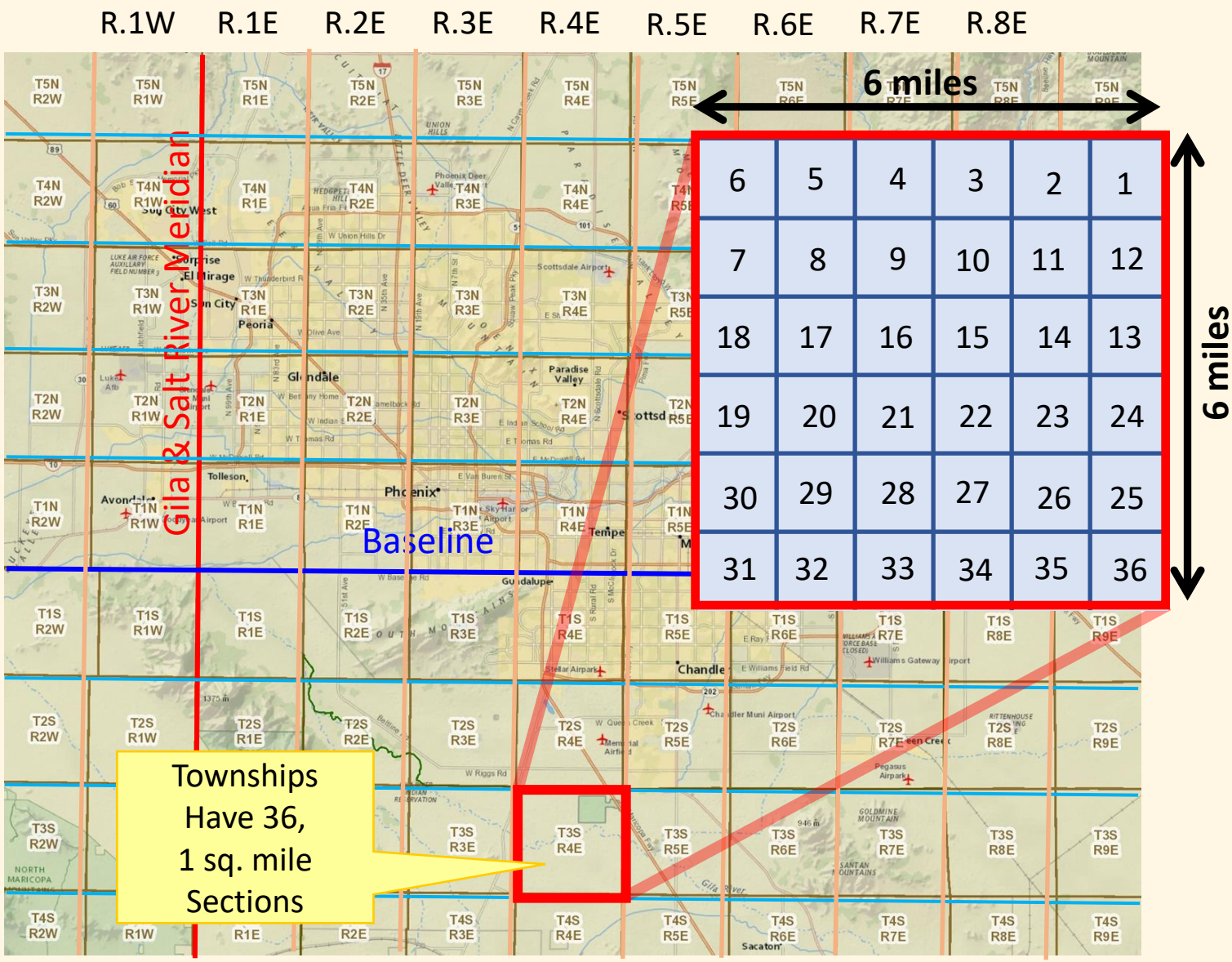
- Grid system is alpha-numeric point reference system overlaid on UTM numerical grid system.
- Main difference between UTM and USNG:
  - USNG uses 100,000 meter Grid Zone Designator, replaces first two digits in the UTM Easting and Northing coordinate strings.
- Location in UTM 12S 0453609 3892176 is "12SVD5360992176" in USNG. The "04" and "38" in the Easting and Northing respectively have been replaced by a single "VD". Labeled on recently revised Topo map set.
- Designed as a universal SAR coordinate system, but lacks aviation standards.
- Most often used in National or Statewide run operations

Public Land Survey System

Public Land Survey System (Township & Range)

- Based off Named Meridian (longitude) and Baseline (latitude)
- Townships (TWP, T.) - run North & South numerically from the Baseline
- Ranges (RNG, R.) - run East & West numerically from the Named Meridian
- N, S, E, W directional must be included
- Area broken down as: Townships, Sections, fractions of sections, i.e. NW1/4, SE1/4, S.15
- 36 sections in a township

Public Land Survey System



Course Outline

Maps

Reading a 7.5 Minute Topo Map

Coordinate Systems

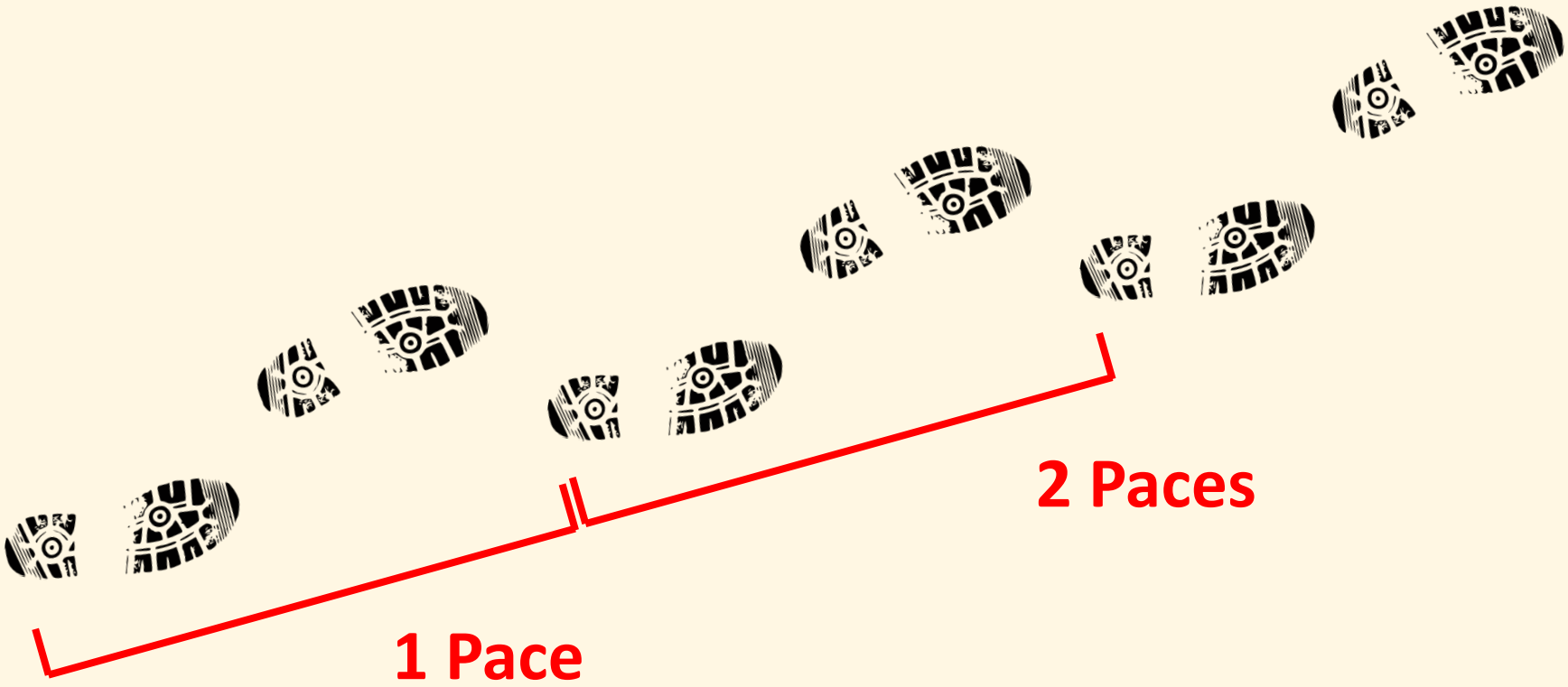
Pace Counting

Compass

GPS

Pace Counting

One Pace is the distance the same foot hits the ground at your normal walking speed.



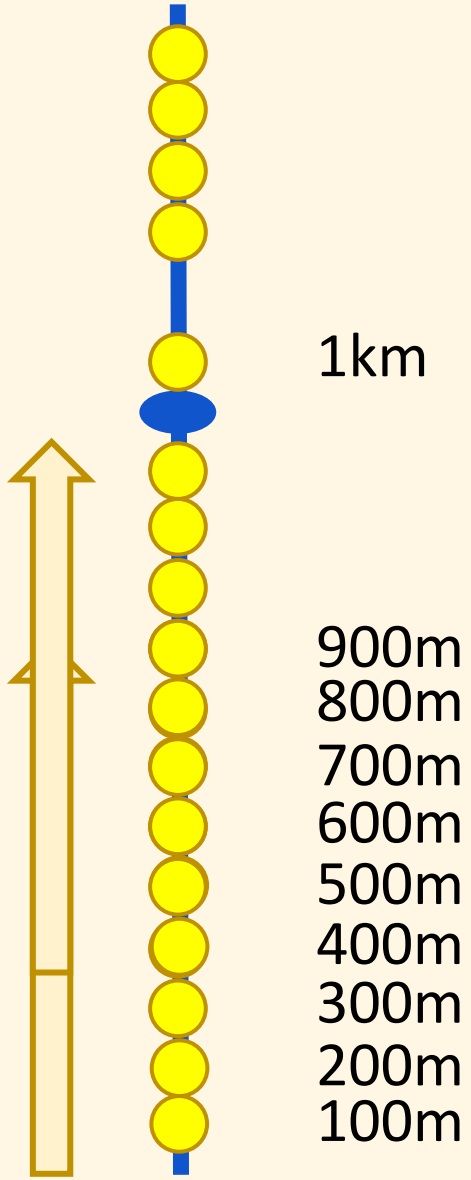
Pace Counting

- Typically measured over a 100 meter distance
- "My pace count is 57 paces over 100 meters"
- Uphill terrain will shorten your pace, increase pace count.
- Downhill terrain will lengthen your pace, decreasing pace count.

Pace Counting

Pace Beads

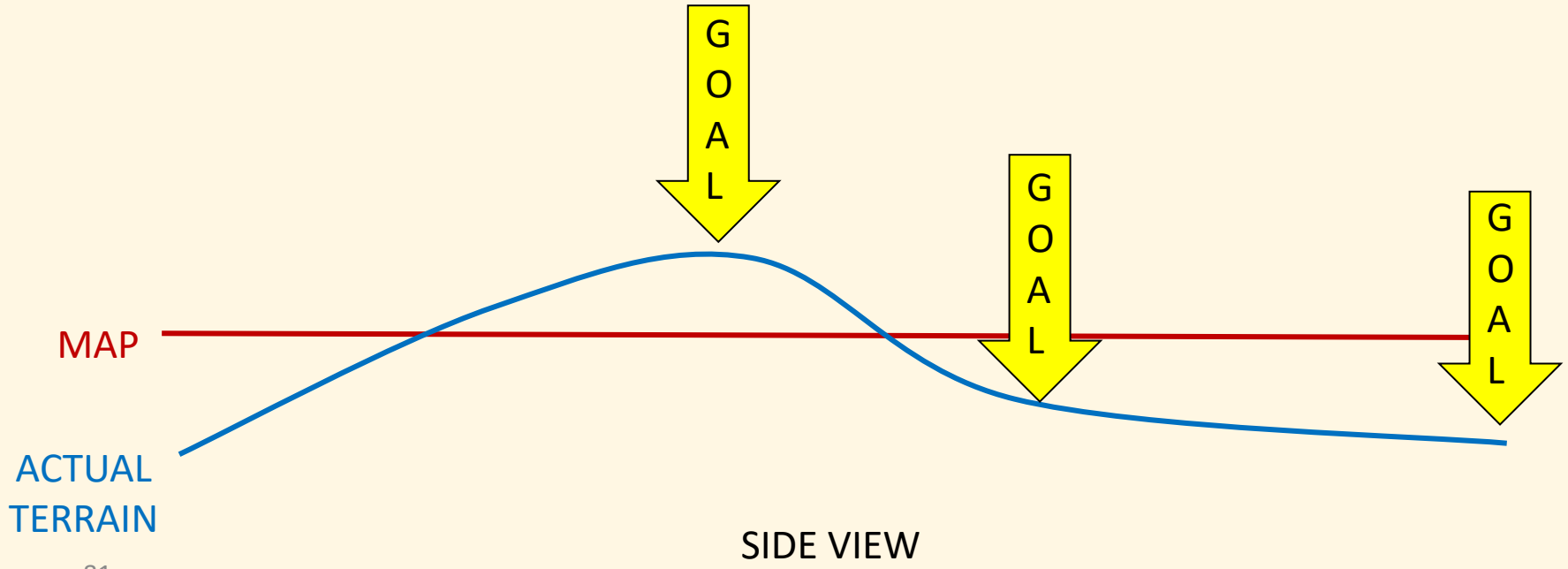
- For every 100 meters you walk you move a lower bead
- On the 10th 100 meter count you move an upper bead, representing 1 kilometer
- Reset the nine 100m beads after every 1 kilometer



Measuring Distance

Map Distance vs. Actual Distance

- Distance on a map doesn't account for the distance traveled over varying terrain
- Dividing your route into smaller goals, to account for different terrain, may help accuracy.



SIDE VIEW

Measuring Distance

Measuring by Timing

- Traveling at 2.5 mi/hr = 5 miles after 2 hours
- Takes time to know your pace over terrain
- With both pace counting and timing, fatigue will affect accuracy.
- Know your average time on trail vs. off trail
- Area search vs. Route & Location search
- Creates a safety check or boundary to indicate you should replot and check your position/route.

Measuring Distance

Measuring Curved Distances

- Straight line routes don't account for terrain obstacles.
- Using string, twist ties, pipe cleaners, etc placed along the curved route, then stretched along the map scale will give a better distance estimate.
- Paper can also be marked and placed along the route to estimate the distance.

Course Outline

Maps

Reading a 7.5 Minute Topo Map

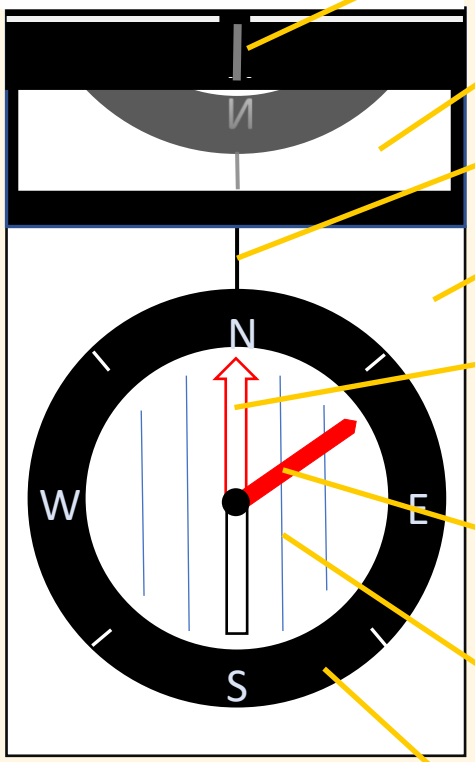
Coordinate Systems

Pace Counting

Compass

GPS

Compass



SIGHTING NOTCH

MIRROR

INDEX MARK

BASEPLATE

NORTH ORIENTING ARROW

MAGNETIC NEEDLE

N-S ORIENTING LINES

BEZEL / DIAL

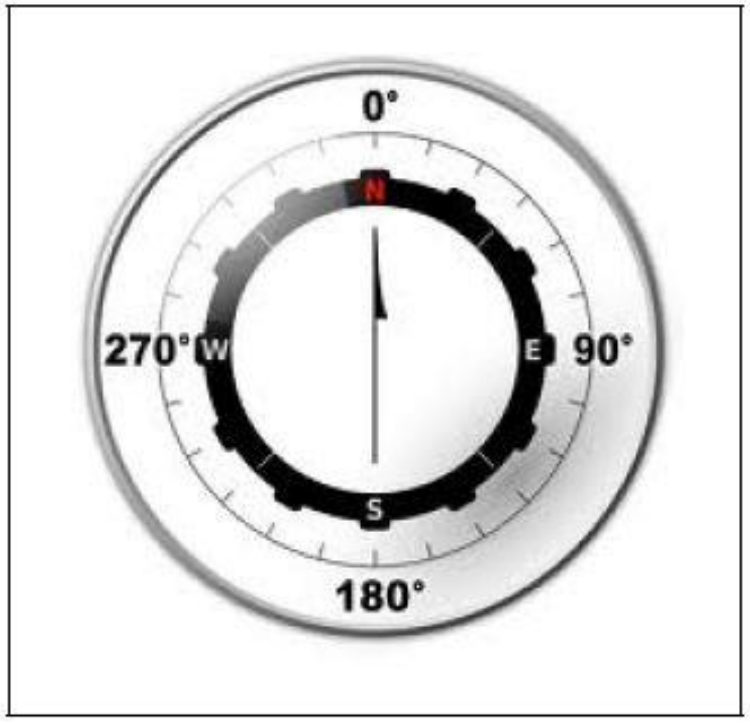
Good quality base plate compass for use in SAR should have:

- Declination adjustment
- 1° to 2° graduation marks
- Direction of travel arrow
- Index mark
- N-S orienting lines
- Sighting mirror

Compass

The bezel markings:

- Compass is divided into 360° (degrees)
  - North at 0° or 360°
  - East at 90°
  - South at 180°
  - West at 270°
- Bezel marked in 1° or 2° increments



Compass

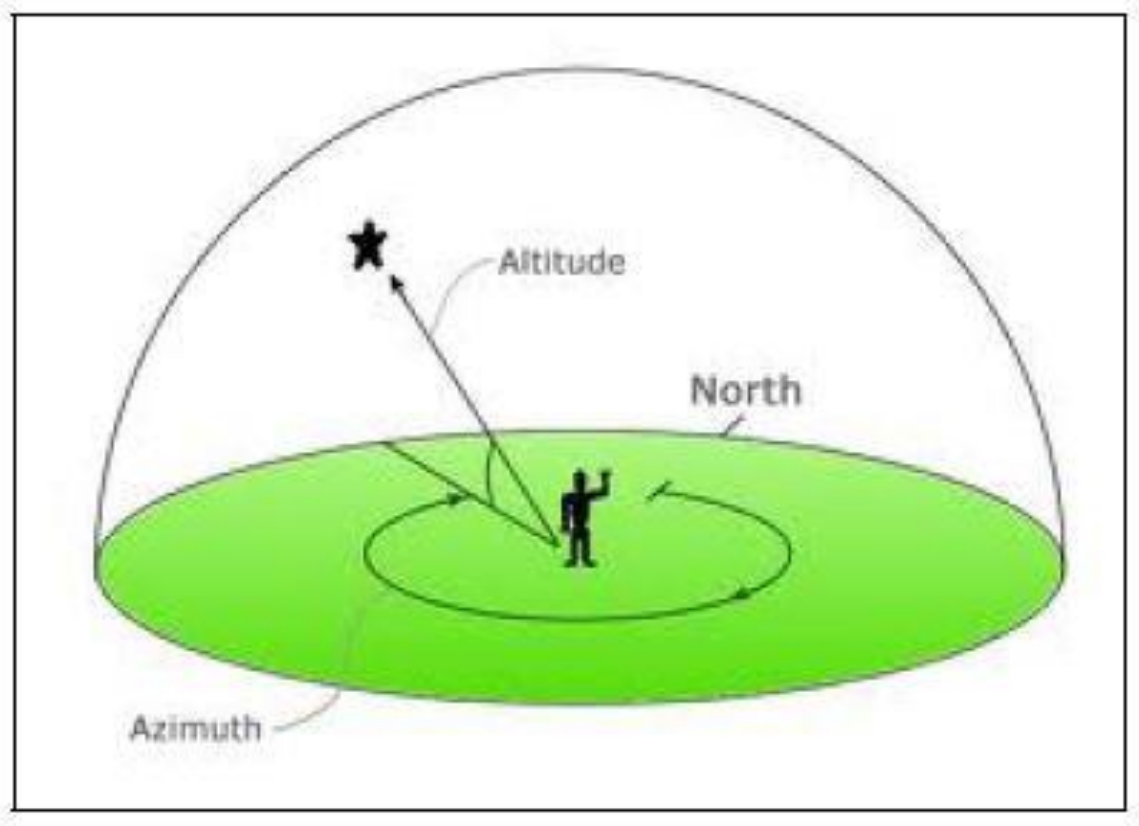
Compass Techniques

- **On a map** (NOT using magnetic needle)
  - Compass used as a protractor
- **In the field** (using magnetic needle)
- **Combining** the previous two methods
  - Must deal with declination…more to come

All techniques use the bezel/azimuth ring/dial

Compass

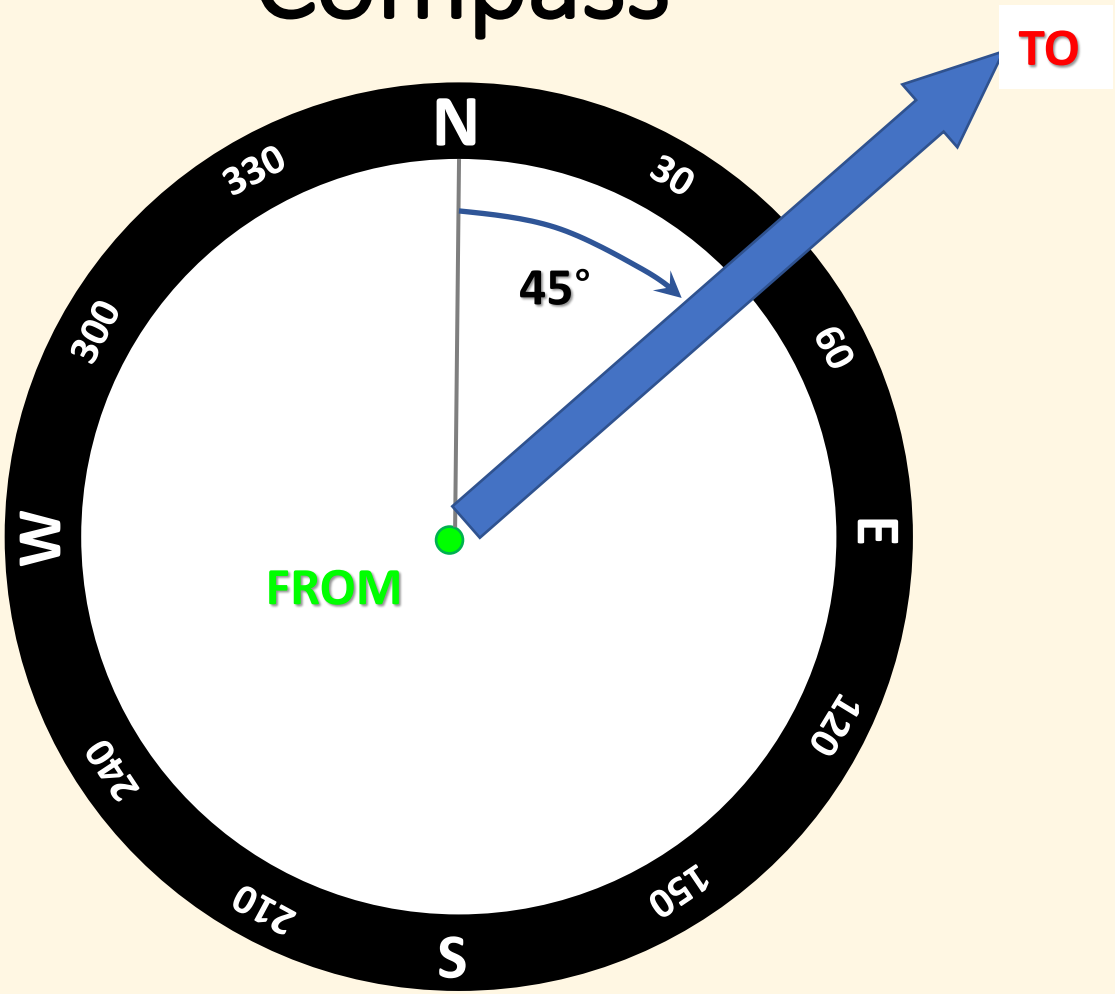
Azimuth: angle of horizontal deviation, measured clockwise, of azimuth from north. Between 0° and 360°.



Compass

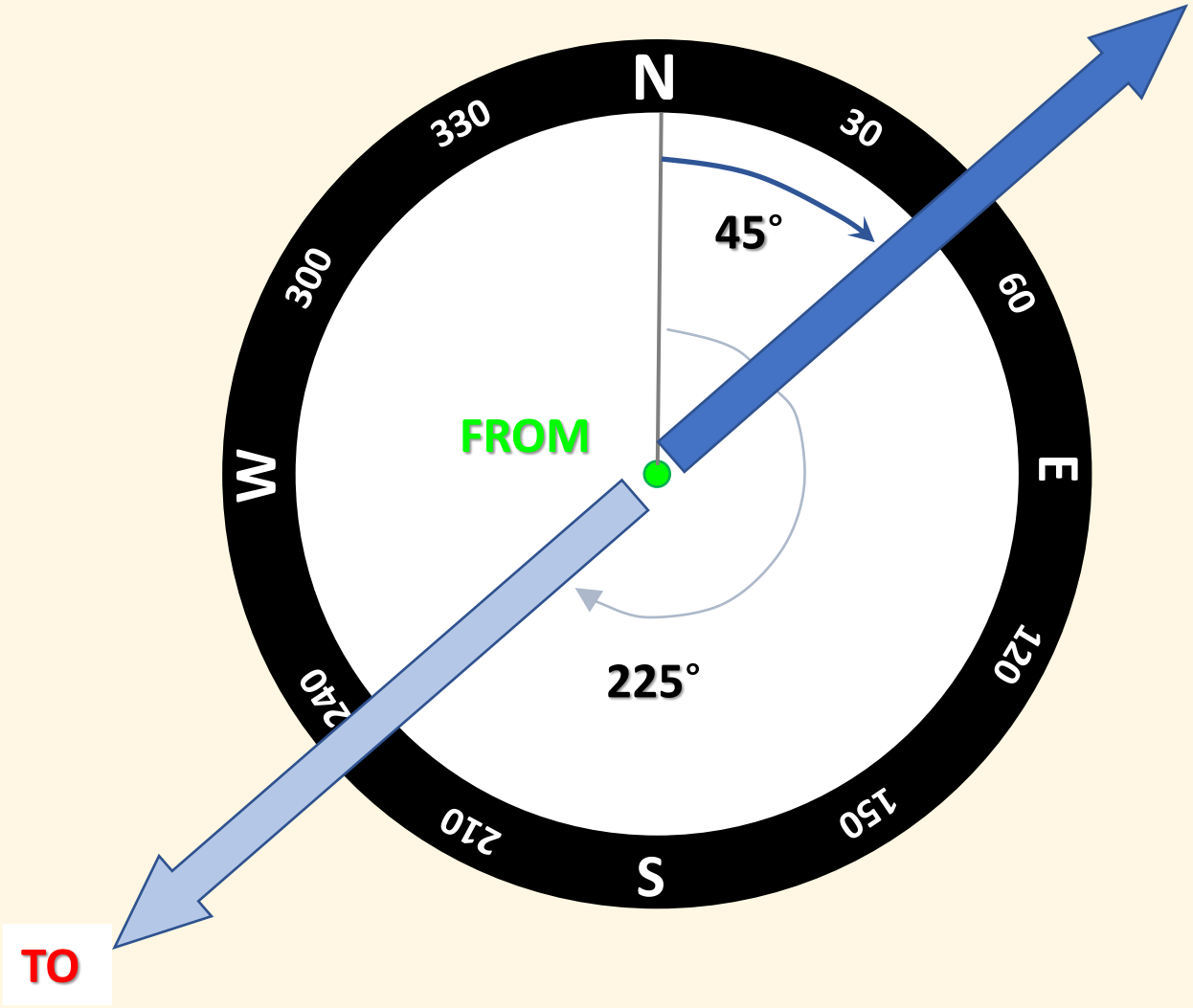
- **Azimuth** is taken **from** a location **to** an object.
  - From and to indicate a **direction of travel**
  - " The azimuth from me to the cell tower is 135° "
  - The terms "azimuth" and "bearing" may be used interchangeably. Azimuths are measured from North between 0 & 360°. Bearings can have other formats.
- **Back Azimuth** is taken from an object to the current location.
  - If azimuth is less than 180°, then add 180° to azimuth
  - If azimuth is greater than 180°, then subtract 180° from azimuth

Compass



45° Azimuth

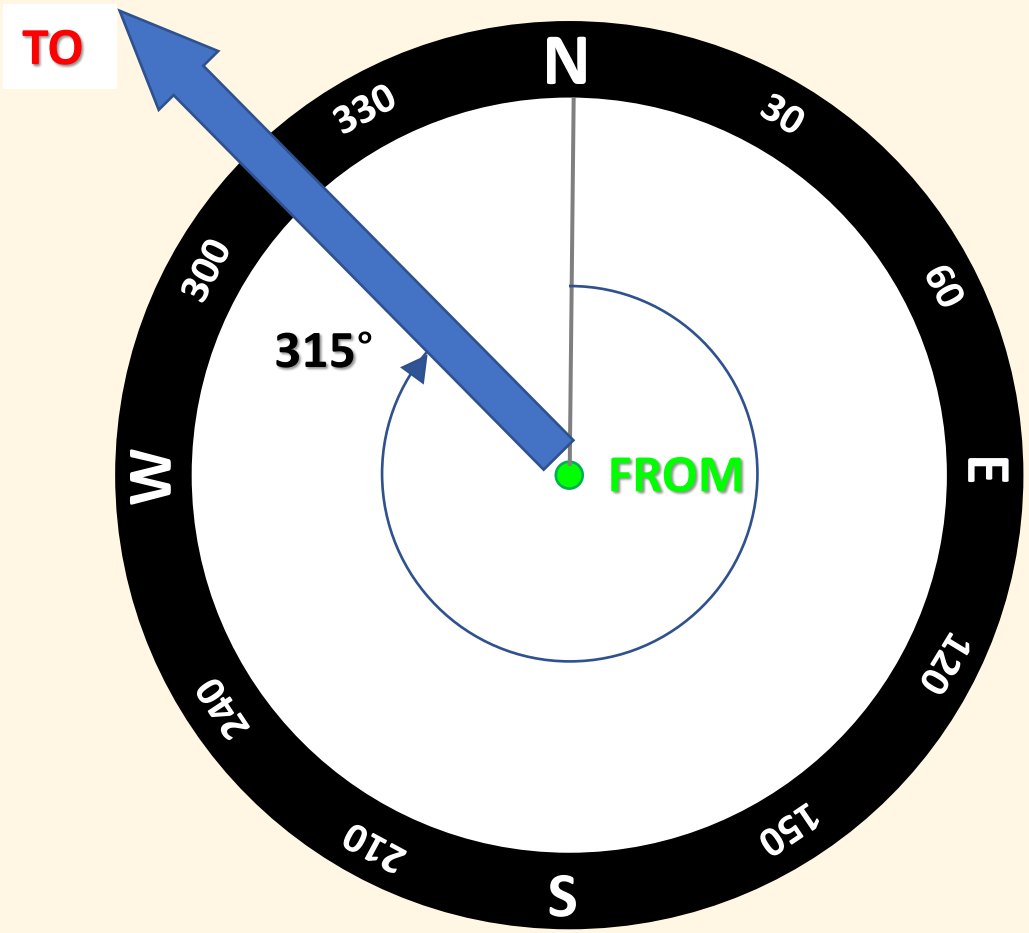
Compass



45° Azimuth

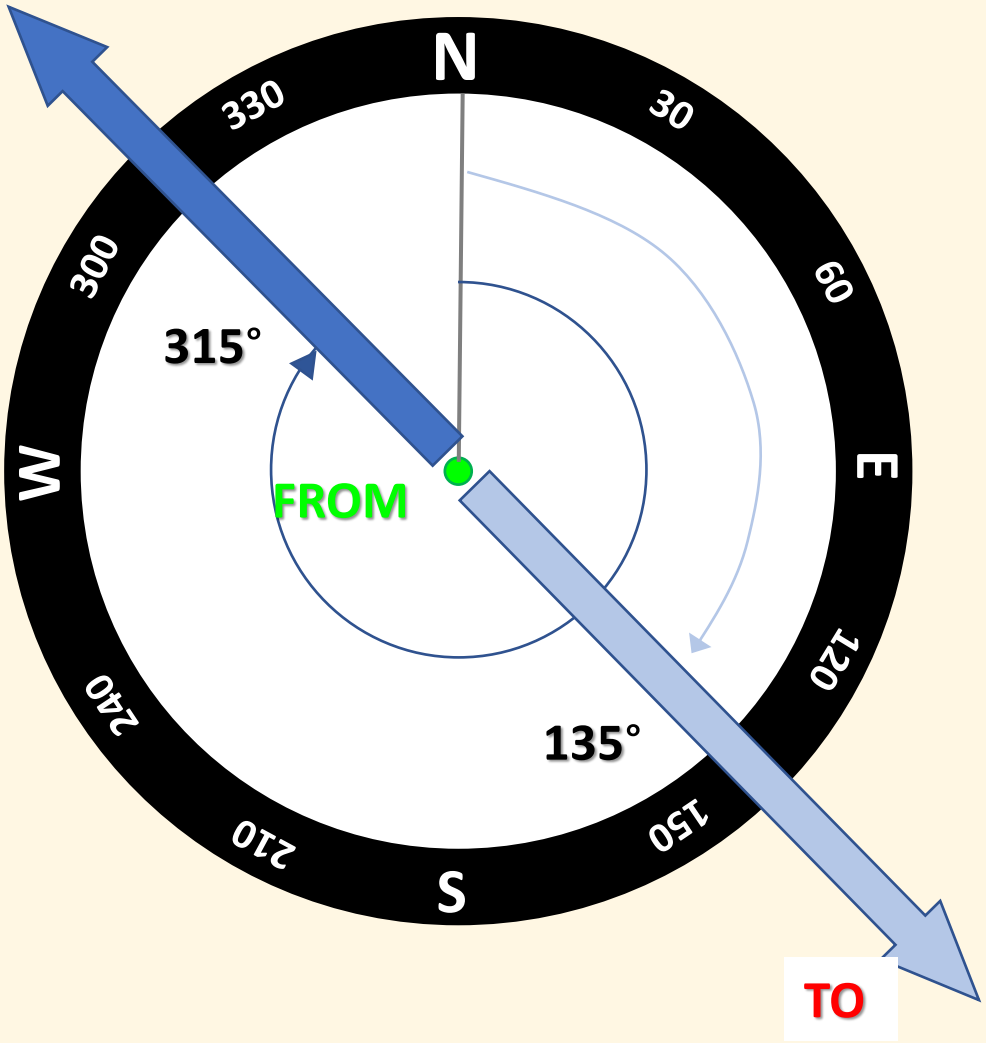
45° + 180° = 225° Back Azimuth

Compass



315° Azimuth

Compass



315° Azimuth

315° - 180° = 135° Back Azimuth

Compass on Maps

Using a compass on a map (as a protractor)

1. Use the base plate edge & direction of travel arrow to align origin and target points.
2. Rotate the dial so 0° is roughly pointing to North on the map, then fine tune with North South orienting lines on compass and map grid.
3. Read the azimuth at the index mark (° True)

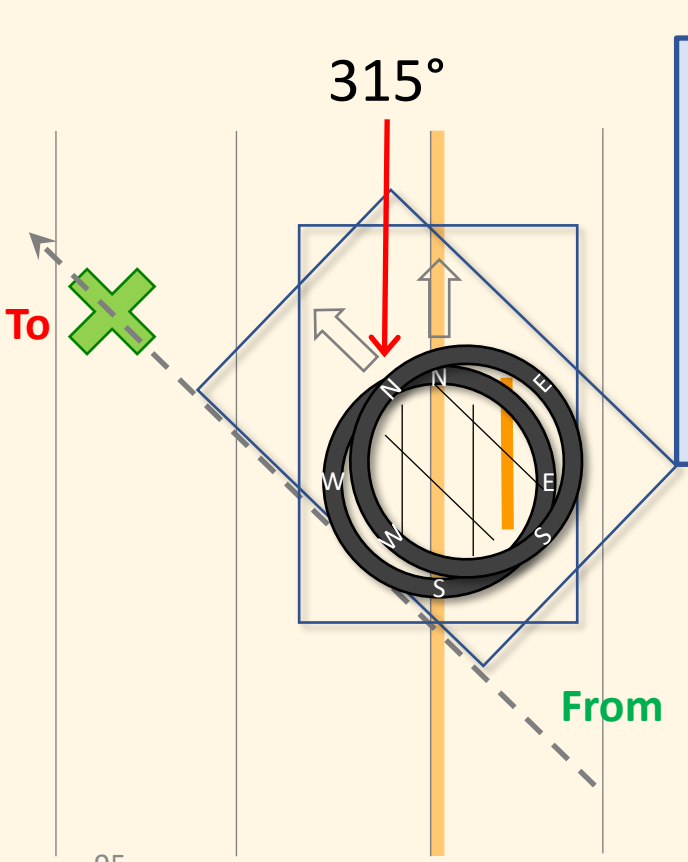
Don't use the magnetic needle

Compass

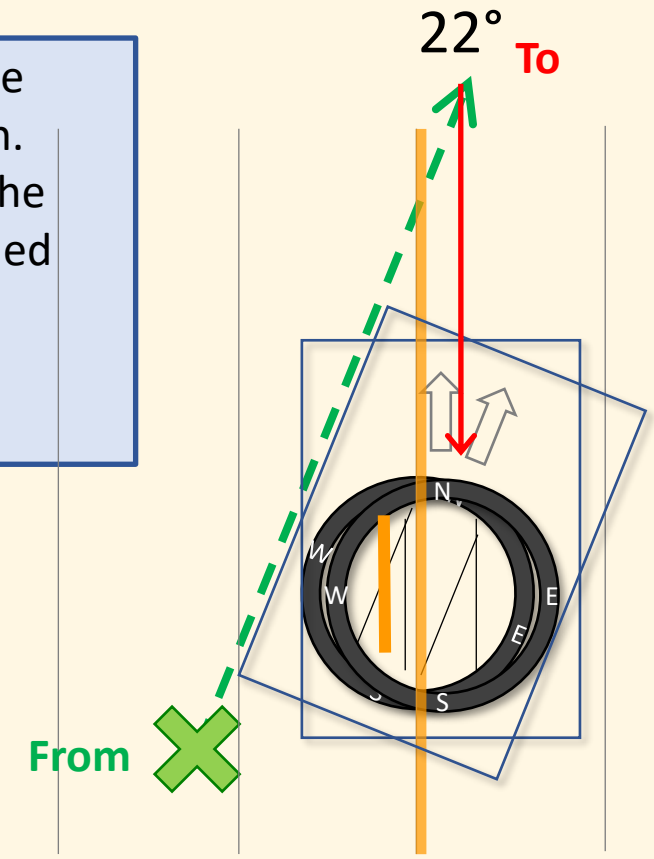
Using a compass on a map (as a protractor)

From Unknown
(resection)

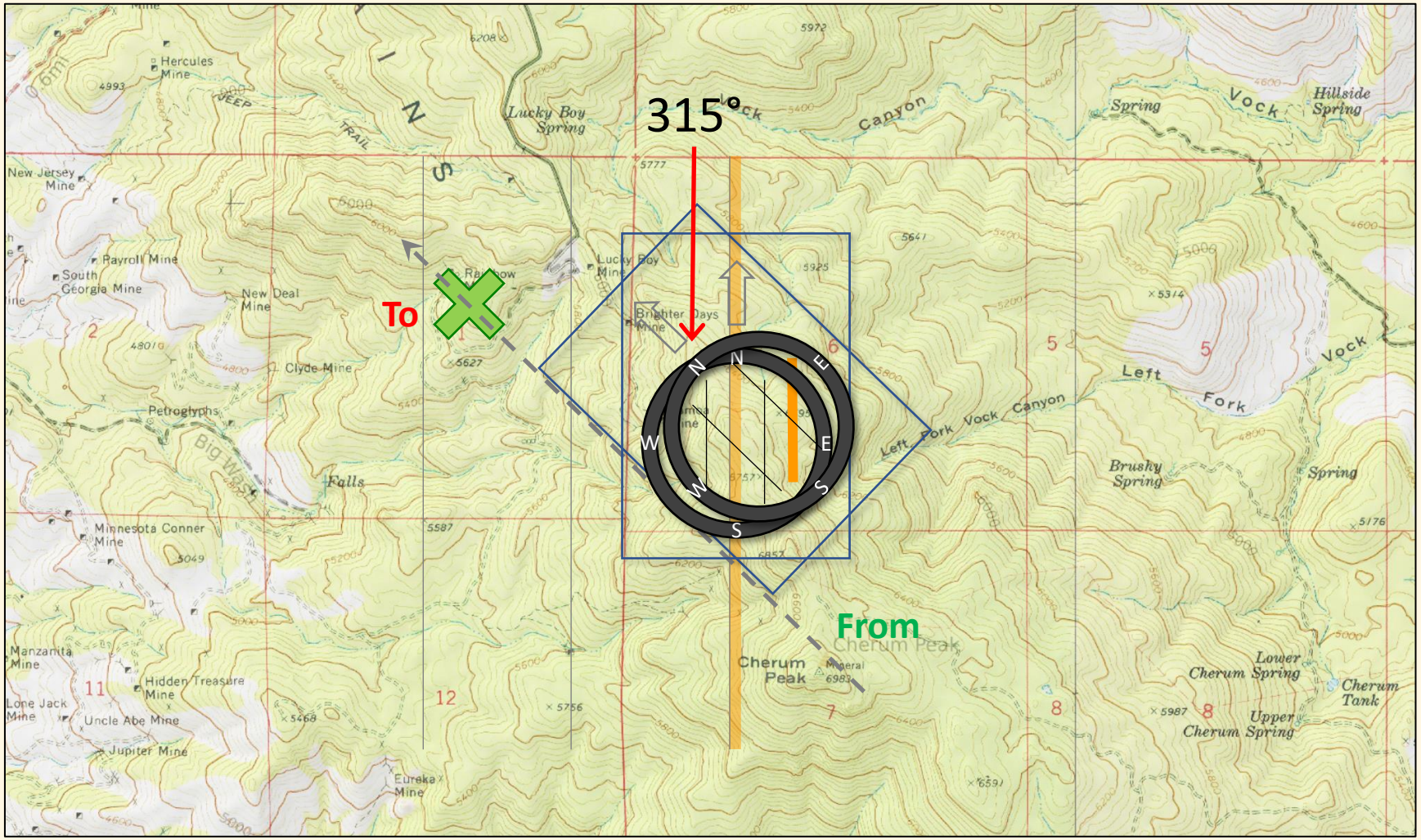
From Known
(plotting a route)



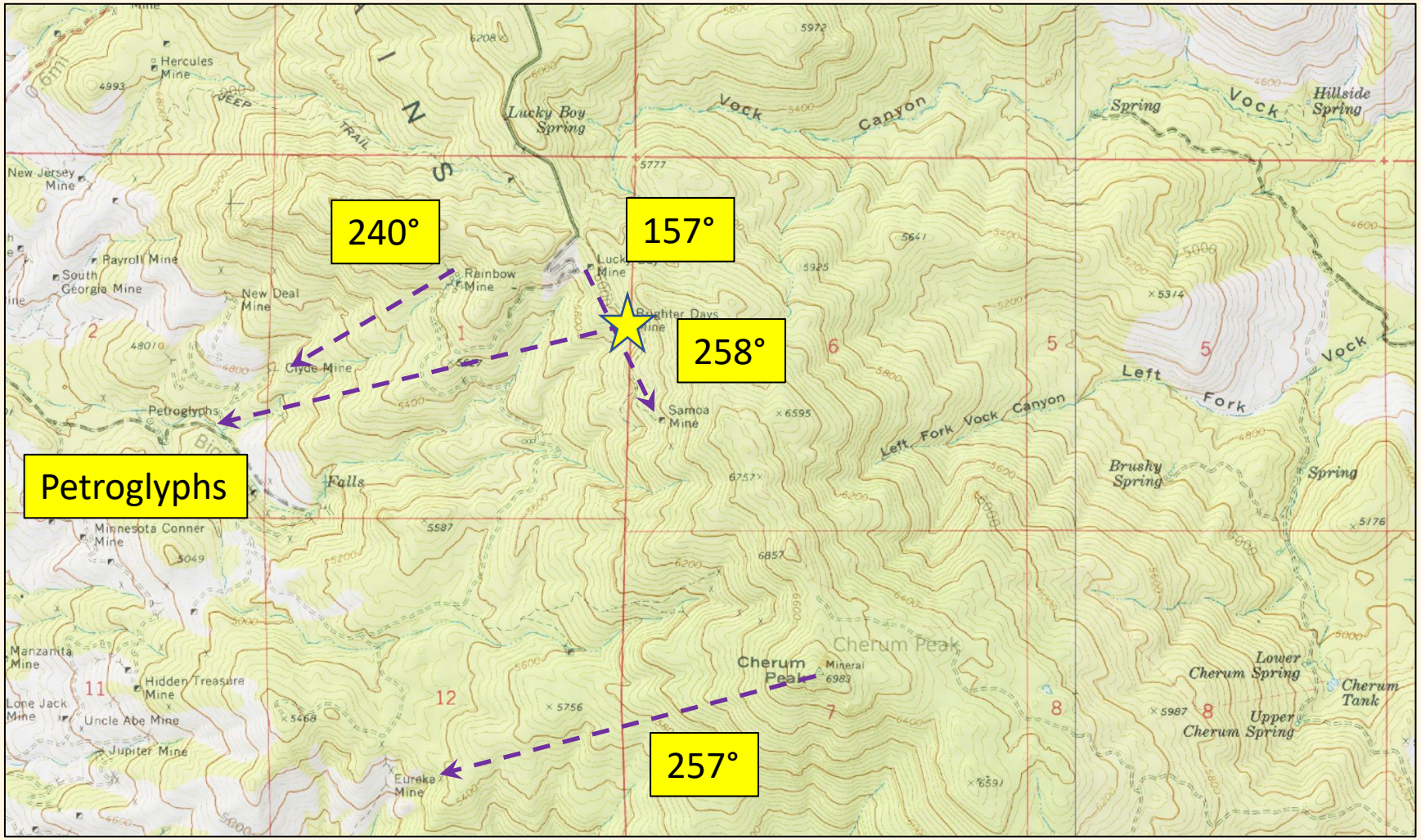
1) Align baseplate edge with the route direction.
2) Rotate the bezel so the orienting lines are aligned with the map grid.
3) Read the azimuth at the index mark.



Using Compass on a Map



Using Compass on a Map



Compass

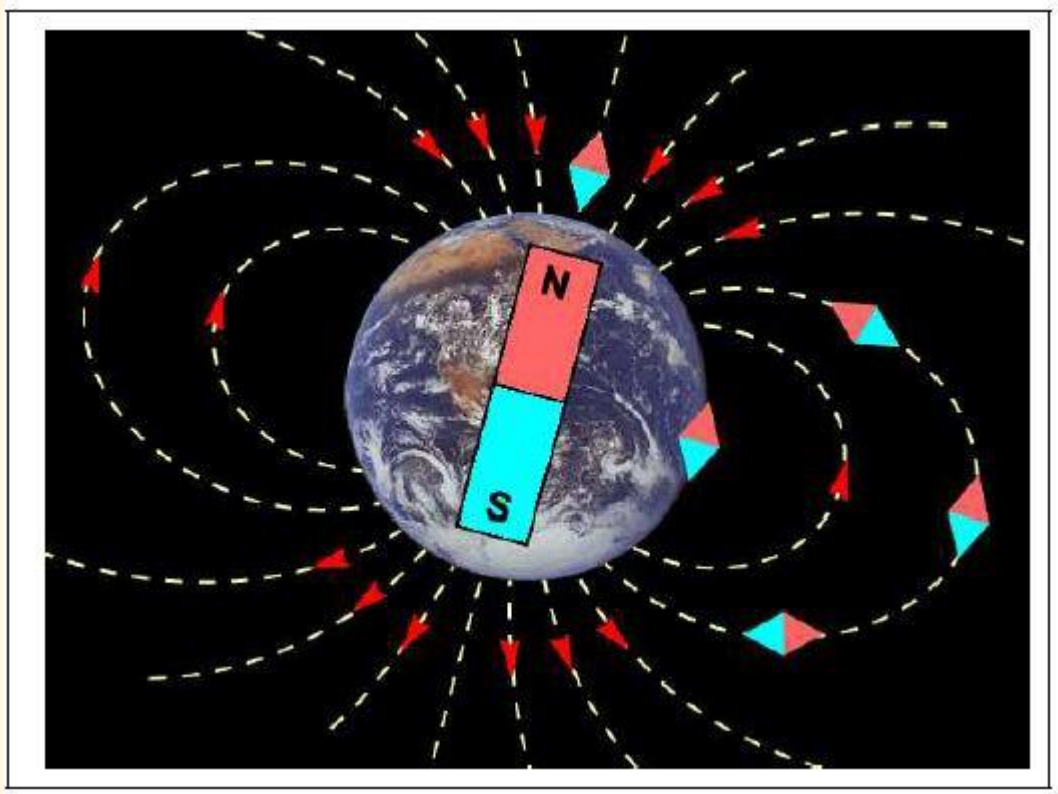
Using the compass in the field

…but first some things to consider:

- How the magnetic needle works
- Objects that affect the needle's accuracy

Compass

- Compass works by aligning its magnetic needle with magnetic force lines of Earth's magnetic field
- Compass needle does not necessarily point to magnetic north pole or to true north.



Compass Accuracy

Make sure compass is away from iron metal objects and electronics such as:

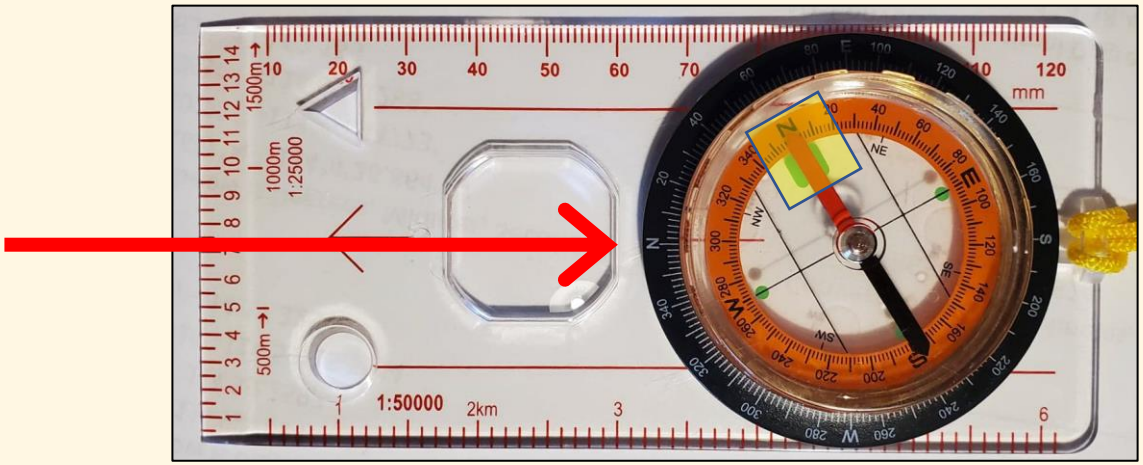
Radios	Batteries	Vehicles
Magnets	Power lines	Fences
Belt buckles	Knives, Guns	Rings, Jewelry

- Metal and electronic objects can dramatically affect magnetic needle in compass and contribute to error.
- Iron in the earth may even affect the needle, use common sense.
- Check your compass before using, compare with a teammate's.

Compass

Using the compass in the field - Technique A

- **Finding the azimuth from you to an object:**
  1. Sight the object
  2. Use the bezel and turn the bezel until the magnetic needle (red) is boxed to "North'.
  3. Read the azimuth at the index mark (° Magnetic)



Compass

Using the compass in the field - Technique B

- **Orienting yourself to a specified azimuth:**

1. Turn bezel to the given azimuth, aligning with index mark.
2. Turn compass (and yourself) until the magnetic needle is boxed to "North".
3. Sight to a target along the azimuth. To travel along the azimuth:
   a) Pick an identifiable object along the azimuth
   b) Go to the object
   c) Using the compass sight and pick the next object

Declination

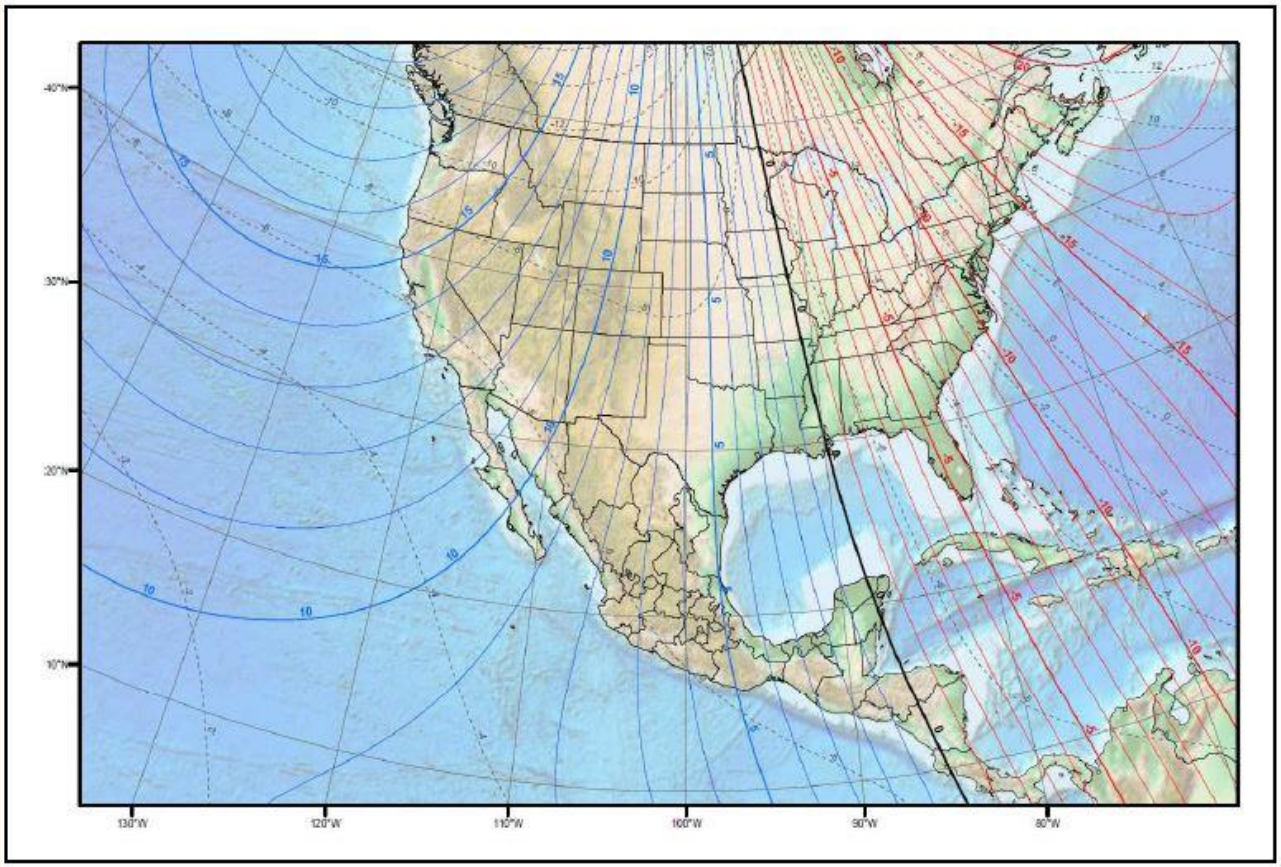
Using the previous compass techniques with maps.

When transferring an azimuth between map & compass you must account for declination!

Declination – the difference (in degrees) between True North (map) and Magnetic North (compass).

- Measured in the U.S. as degrees East or West of 0°, true north.
- Because the magnetic field changes over time, magnetic north changes as well, therefore declination will change over time (years).

Declination



- Western U.S. has EAST declination
- Eastern U.S. has WEST declination
- Black line is 0° declination or True North

Declination

- Arizona's declination is generally between 9° (in southeast AZ) and 11° (in northwest AZ)
- When transferring an azimuth between the compass and map you will have to add or subtract the declination from the original azimuth.

Map to Field, subtract declination from azimuth
- 50 ° (True) on map will be 40 ° (Mag.) on the compass*

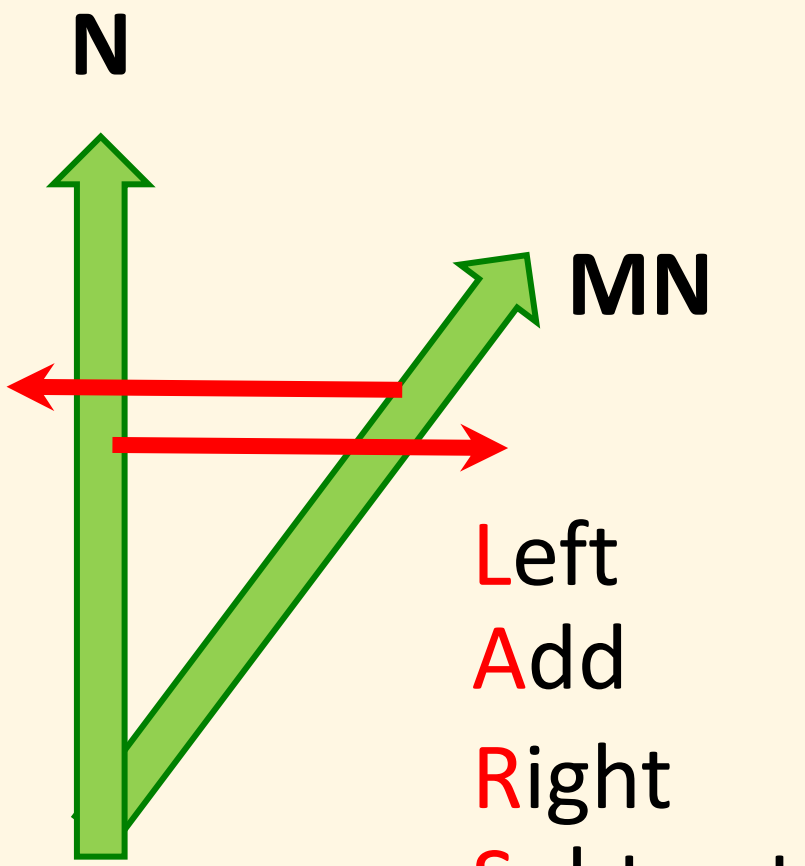
Field to Map, add declination to the azimuth
- 40 ° (Mag.) on the compass will be 50 ° (True) on the map*

*Assuming 10° East declination

Declination

L.A.R.S. Method - Easy to use but only with an east declination

1. Draw a vertical arrow pointing up, this is **True North**
2. Draw an arrow pointing up and to the northeast, this is **Magnetic North**



Left
Add
Right
Subtract

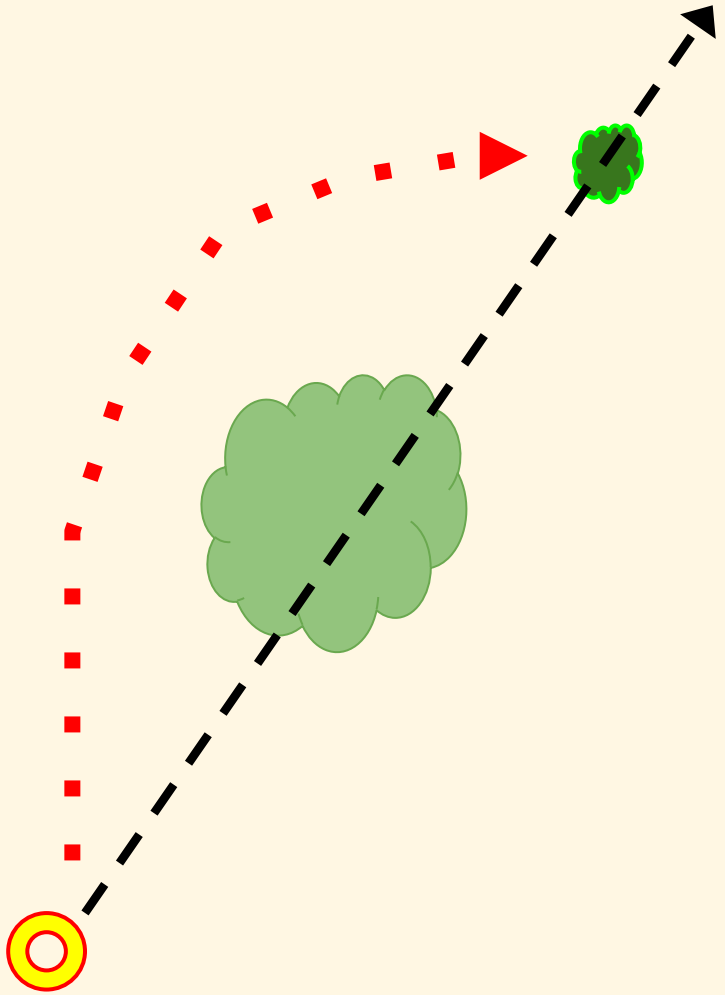
Field (MN) to Map (N) - Left

Map (N) to Field (MN) - Right

Obstacles

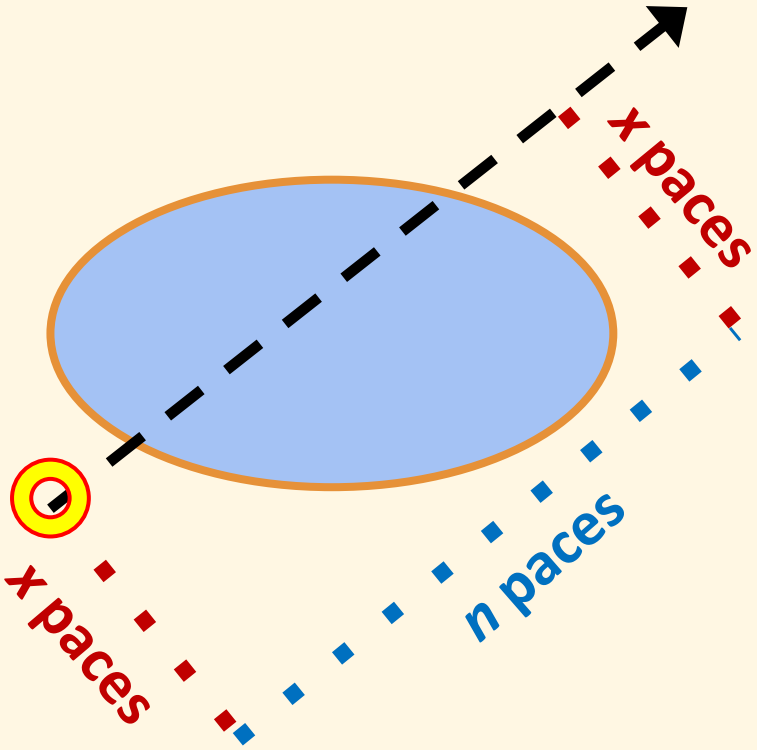
Leapfrog: Pick an object (or position a person) on your azimuth, on the other side of the obstacle, go to the target, then continue on the original azimuth.

Also used for night navigation with lights



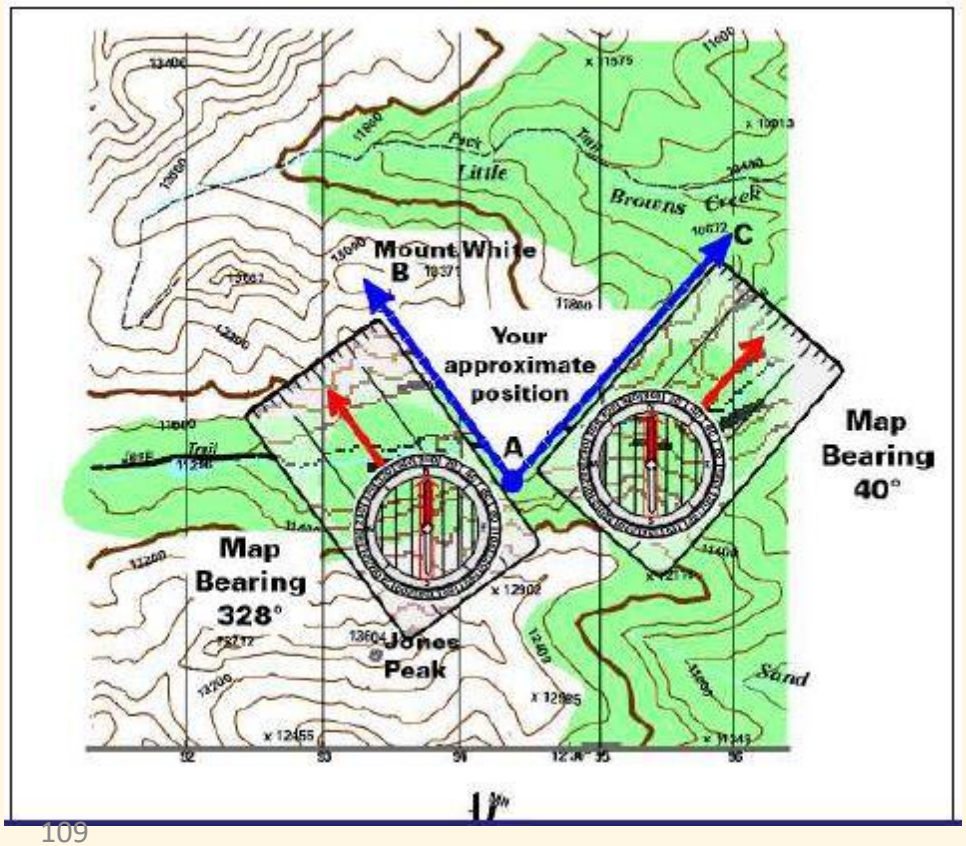
Obstacles

Detour: Approach the obstacle, choose an azimuth 90° left or right of your target azimuth, follow this new azimuth and count x paces until you have cleared the obstacle. Return to the original azimuth. Turn 90° back toward the original azimuth, count x paces back to original azimuth.



Resection

Resection – Take at least two azimuths of landmarks (about 90° apart) plot those azimuths on the map. Where the lines intersect is approximately your location. If an additional landmark is available you can plot it to create a triangle to show your approximate location.



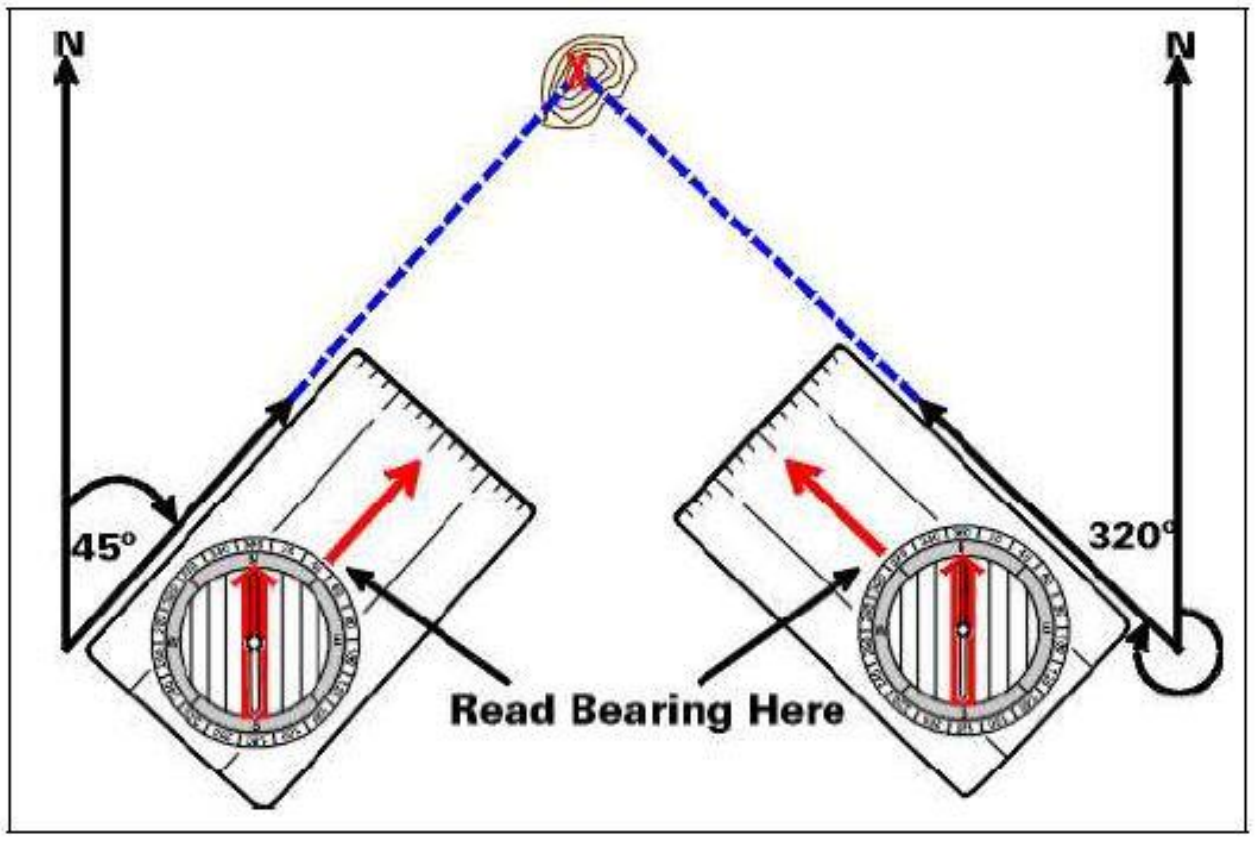
Step 1: Sight a landmark, plot its azimuth on the map (A to B)

Step 2: Sight a second landmark, about 90° from the first, plot its azimuth on the map (A to C)

Step 3: Where the lines intersect is your position

Intersection

Intersection - Sighting the azimuth of a single landmark from two widely spaced locations to locate the landmark on the map.



Intersection Scenario

Two teams are on a search at night, about a mile from each other. Team 1 spots a campfire in the distance, slightly higher than their current elevation. Team 1 radios Team 2, Team 2 also sees the campfire. Team 2 takes an azimuth to the campfire and relays it to Team 1. Team 1 also takes an azimuth to the campfire and plots both azimuths on the map. They see there's a mountain "Tall Peak" on the map where the two lines intersect. They radio to Command to report the location of the campfire on the side of Tall Peak.

Using Map with Compass

- Using a compass on a map doesn't use the magnetic needle
- When transferring an azimuth to a map from a compass and vice versa you must account for declination
- Biggest contributor to compass error is user.

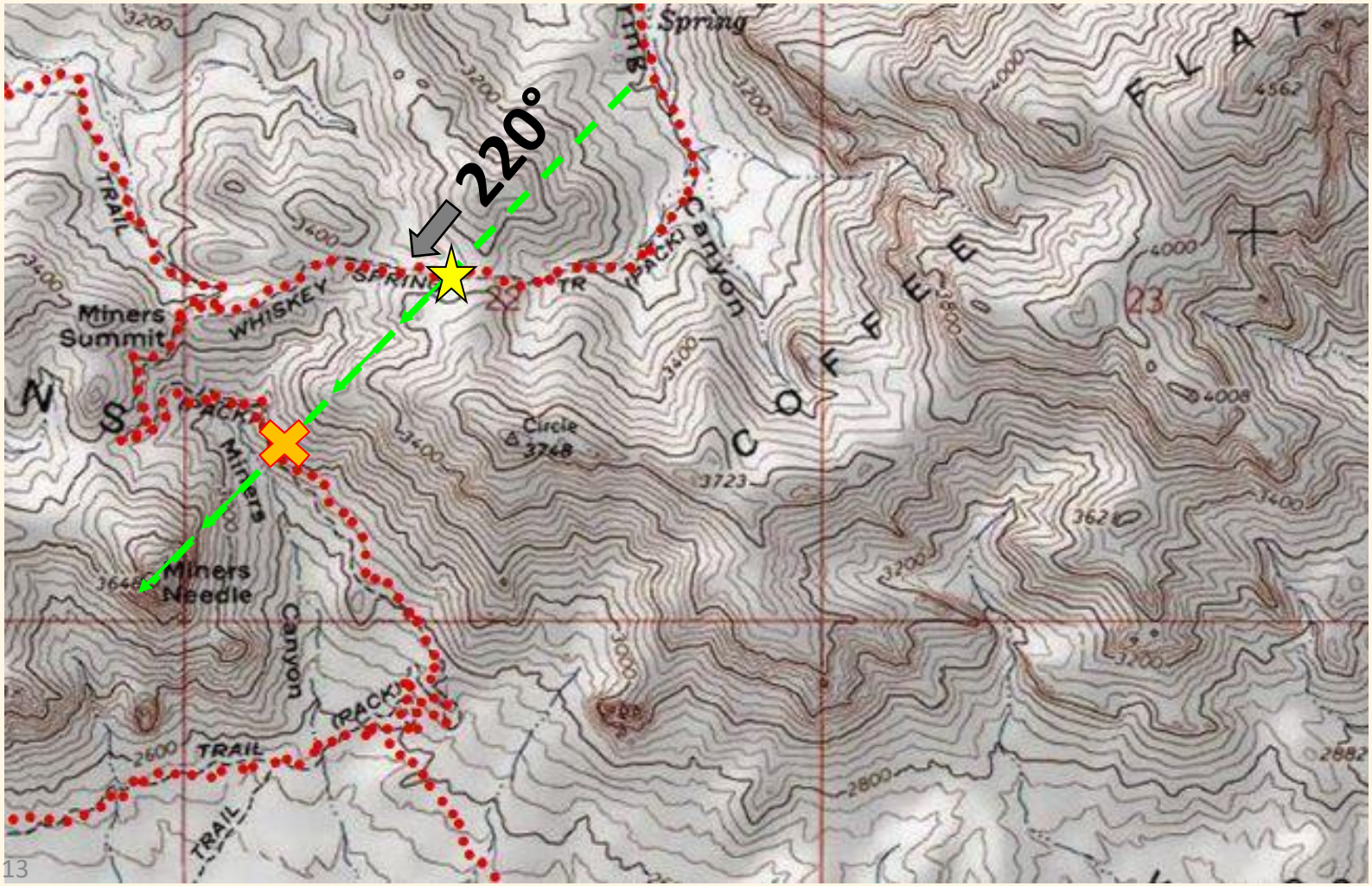
1° error equates 31 yards of error after 1 mile.

Error in bearing	1	2	3	4	5	6	7	8	9	10
Error after 1 mile	31	61	92	123	154	184	215	246	276	307

http://www.magnetic-declination.com/

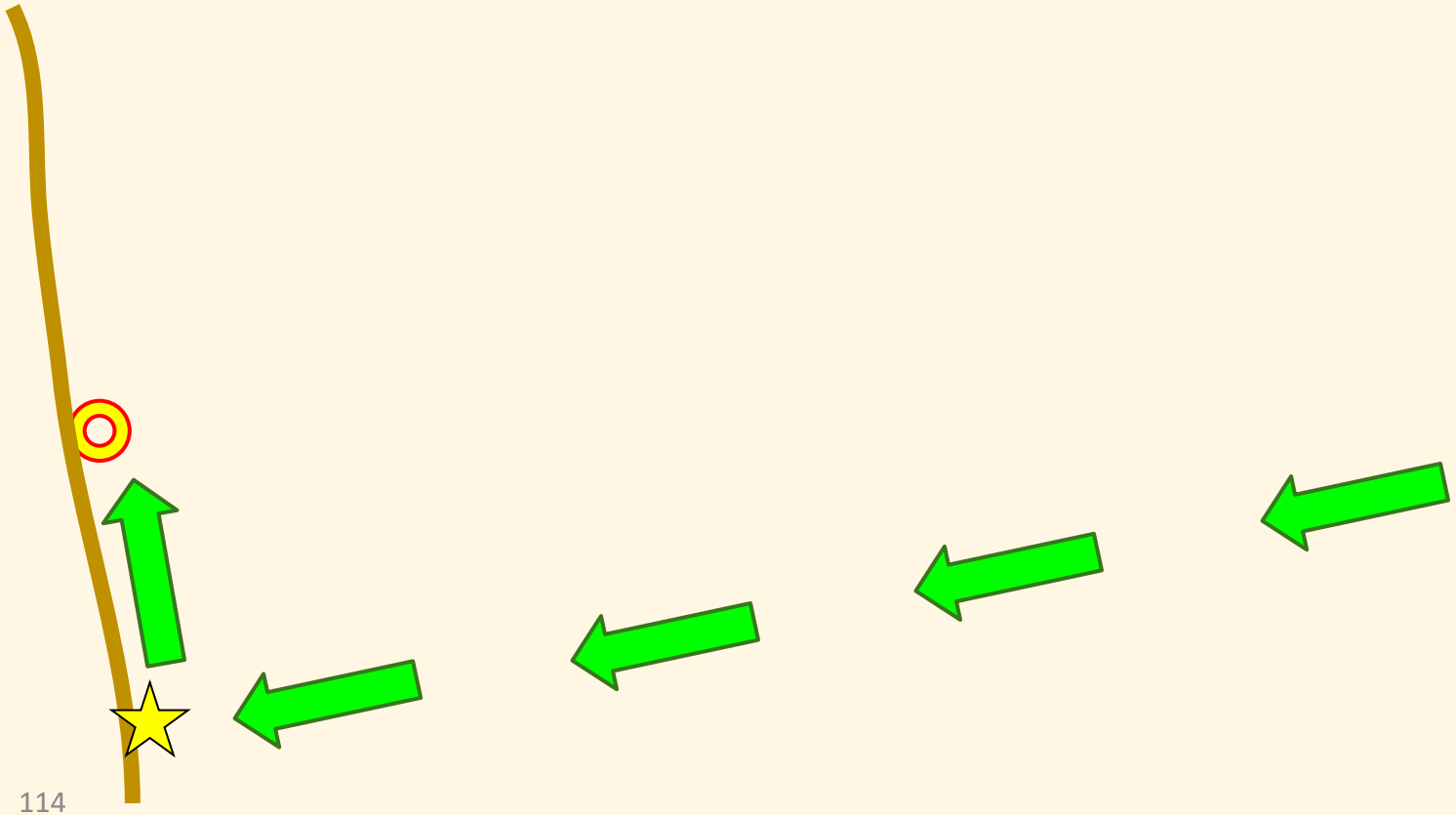
Additional Techniques

Finding your location with a landmark & linear feature



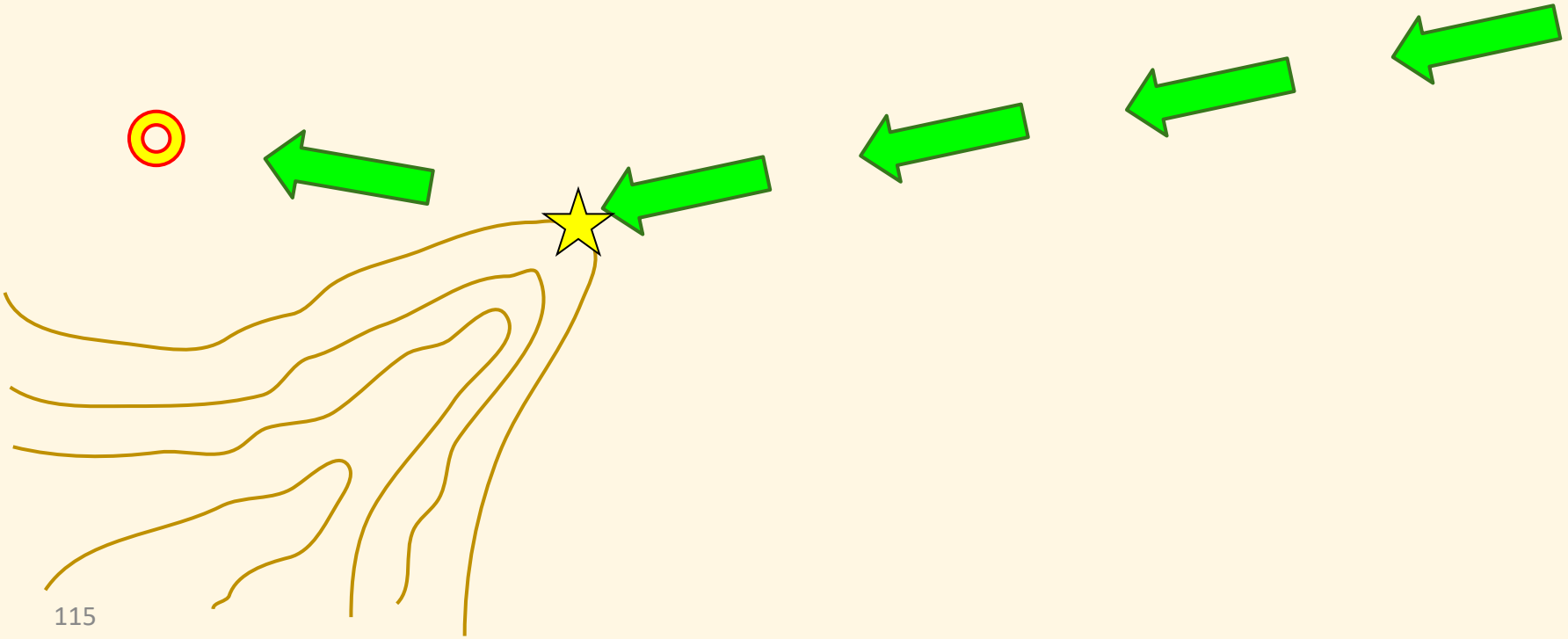
Additional Techniques

Aiming Off - Intentionally aiming to the left or right of the objective, then following a linear feature to the objective. It's easier to hit a linear feature than a point.



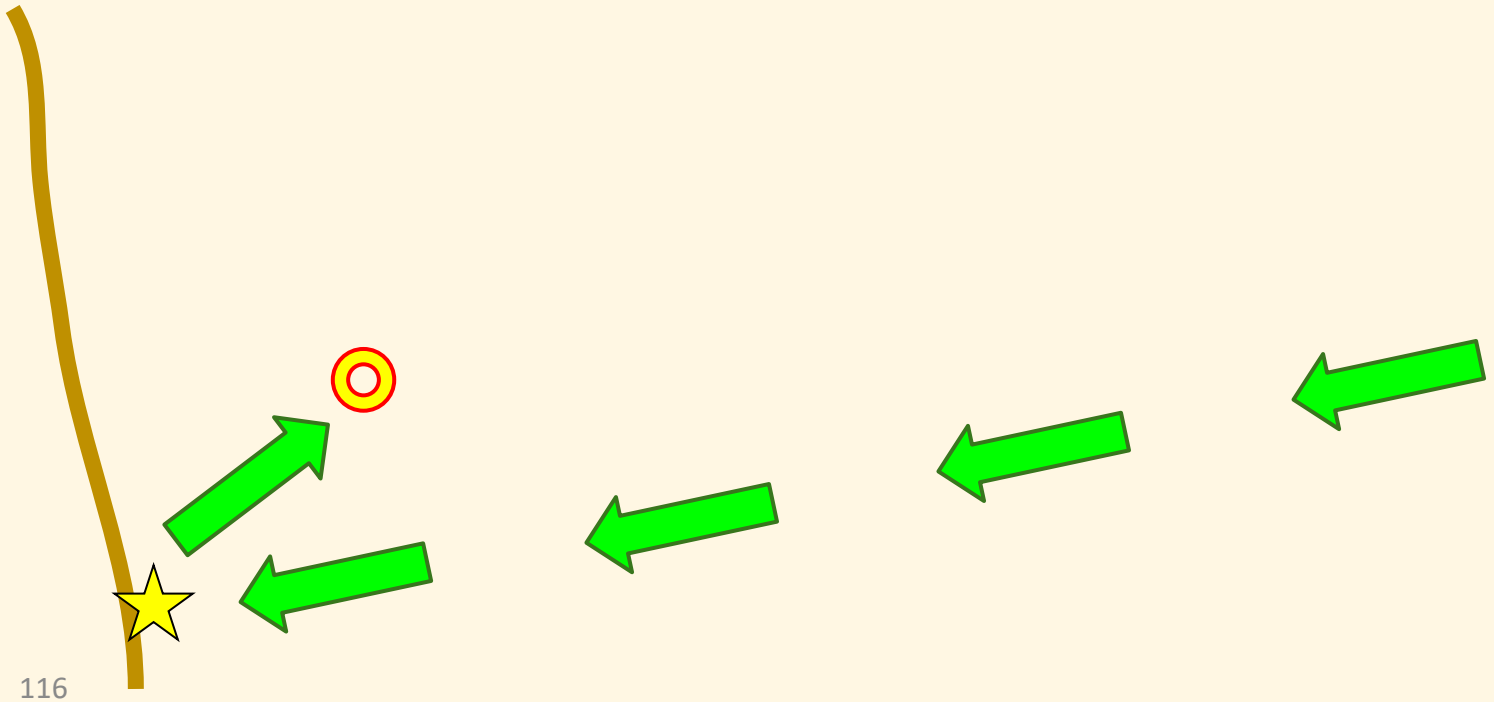
Additional Techniques

Attack Points - a feature recognizable on the map and in the field near your objective to help guide you to the objective.



Additional Techniques

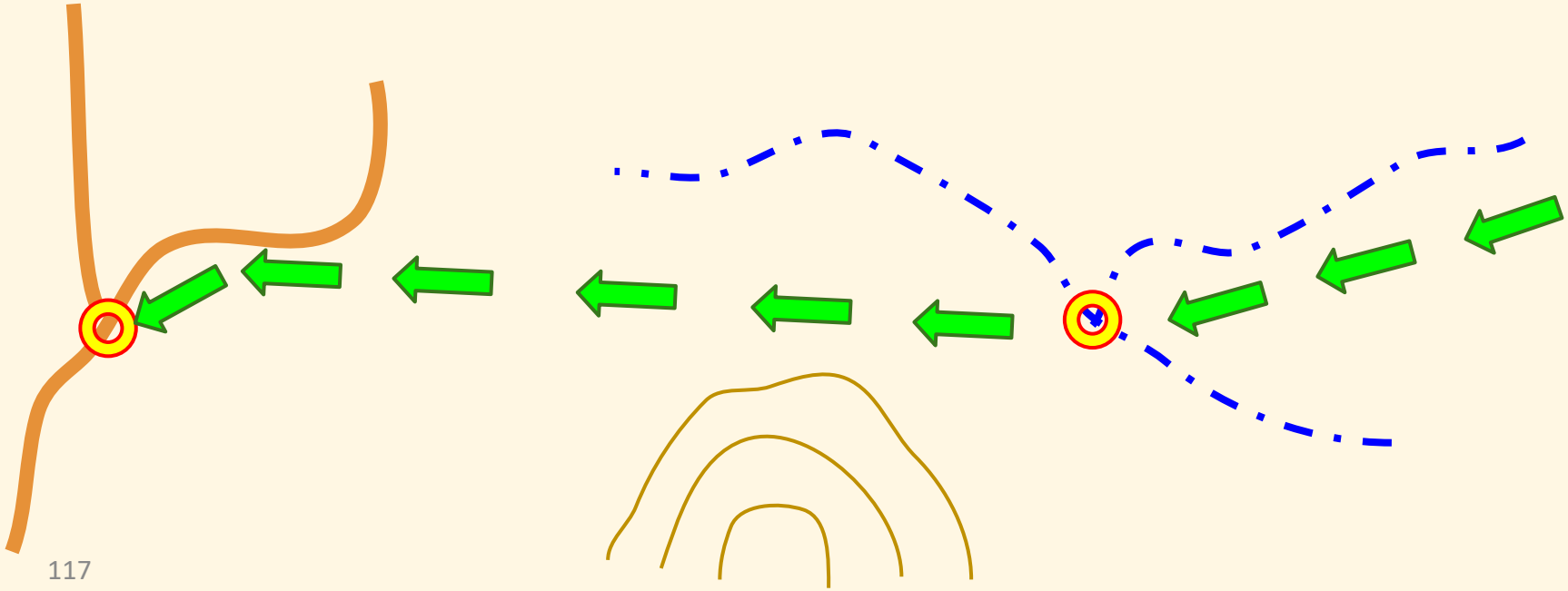
Catch Feature - a feature past your objective to let you know you've gone too far. If you've aimed off to the south (as shown), you know the objective is to the north of your original course.



Additional Techniques

Checkpoint - a location, visible on the map and in the field, along your route to verify that you're on course.

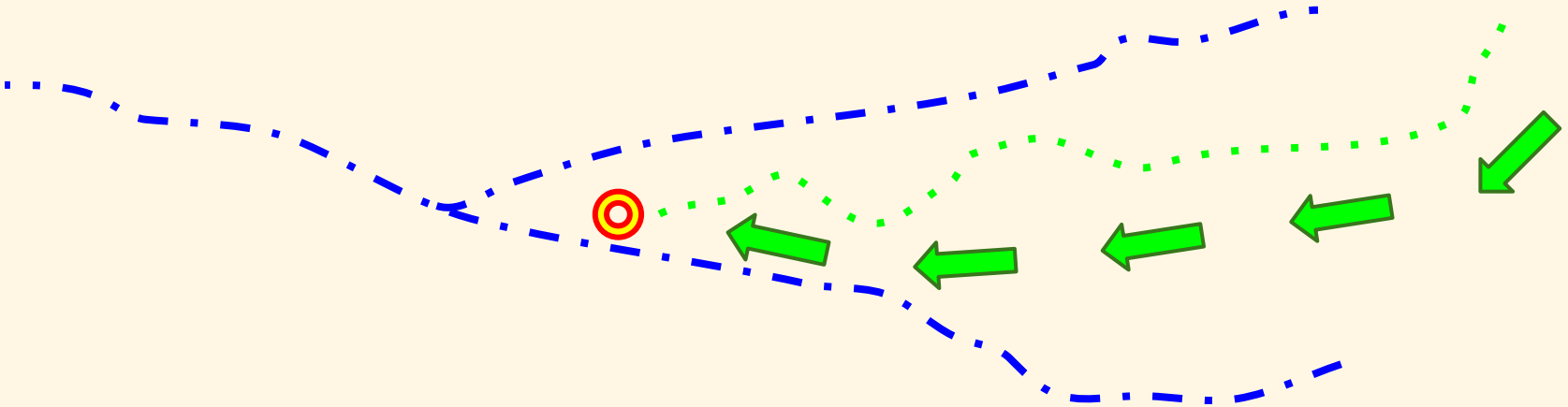
Examples: Trailheads, junctions (trail, road, or stream), structures, benchmarks, terrain



Additional Techniques

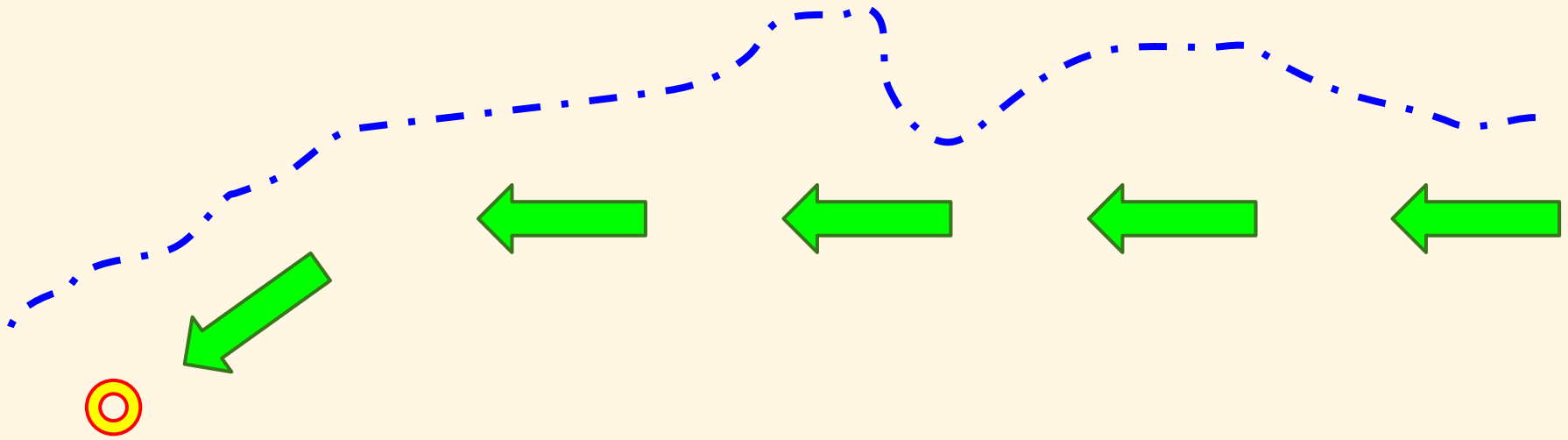
Funneling - using two linear features as left and right boundaries as you approach your target.

Best if these linear features converge to reduce the size of the target area.



Additional Techniques

Handrail - using a linear feature or terrain as a guide, keeping the feature to your right or left.



Course Outline

Maps

Reading a 7.5 Minute Topo Map

Coordinate Systems

Pace Counting

Compass

GPS

GPS

- How a GPS receiver may be used
- How a GPS receiver determines a location
- Limitations of a GPS in the wilderness, including signal errors
- Advantages and disadvantages of navigating by a GPS versus a map and compass
- How user's movements and location can be documented
- Importance of GPS datum matching the map datum

Objectives

Searcher must be able to:

- State location in format required by Command Post
- Recognize when the receiver is not operating properly
- Determine the current location
- Obtain location information from a GPS and correlate it to a topographic map

Uses of a GPS Receiver

- **GPS** systems are extremely versatile and can be found in almost any industry sector. They can be used to map forests, help farmers harvest their fields, and navigate airplanes on the ground or in the air. **GPS** systems are used in military **applications** and by emergency crews to locate people in need of assistance.

- Current location
- Tracking
- Marking waypoints (CP, clues, LZ, hazards, etc)
- Navigating to waypoints
- Compass

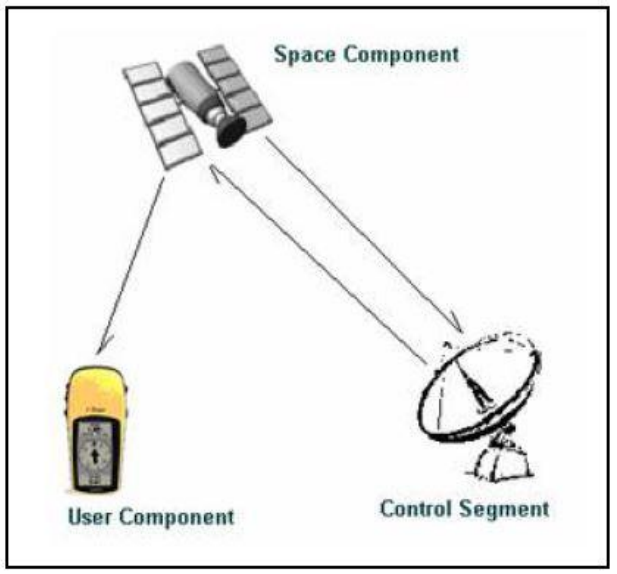
How a GPS Determines Location

- About 30 satellites orbiting the earth at an altitude of 20,000 km.
- Wherever you are on the planet, at least four GPS satellites are 'visible' at any time.
- Once the GPS has information on how far away at least three satellites are, your GPS receiver can pinpoint your location using a process called trilateration.
- The more satellites there are above the horizon the more accurately your GPS unit can determine where you are.
- https://youtu.be/3zRlbboMvb0

Global Positioning System

- GPS is a navigation system with three major components:
- **Space component** - satellites that transmit information.
- **Control component** - ground stations that monitor/adjust satellites.
- **User component** - GPS receiver.

In order for GPS to work satellites must provide accurate information to GPS receiver. GPS receiver must have line of sight to satellites. GPS receiver should be able to see at least 5 satellites.



Global Positioning System

Variety of GPS receiver manufacturers and models. Each manufacturer and model are slightly different.

Critical to learn about model that SAR team members plans to use.

- Read owner's manual.
- Practice before using on SAR missions.
- Configure pages, units, data fields, and settings

Global Positioning System

Standard GPS Features

- Waypoints (location, elevation, notes)
- Tracks
- Routes (series of waypoints)

Additional features

- Multi-GNSS Receiver (uses multiple GPS systems)
- Phone/App connectivity/weather
- Touchscreen
- Camera
- Radio & dog collar connectivity
- Add aerial imagery & scanned base maps
- Altimeter, barometer, compass
- Additional SD card memory for detailed maps

Global Positioning System

- When a GPS is turned on it begins searching for satellites.
- After acquiring signals from 3 satellites it displays 2-D location - horizontal information, no elevation information.
- Once 4 or more satellites are received it displays 3-D location - horizontal and elevation information.
- 2-D location information unreliable. Wait for 3-D location fix (lock).

New GPS systems from other countries are becoming available for all users with a compatible GPS unit. This gives faster and better quality lock in challenging terrain or canopy.

- United States: NavStar (GPS), Russia: GLONASS, European Union: Galileo
- Turn on WAAS correction

GPS Limitations

- Needs clear view of the sky
- Does not work indoors or inside vehicles
- Signal Errors
  - Lack of satellites
  - Ionospheric interference (when GPS passes through the ionosphere or electromagnetic fields)
  - Multipath Errors (Physical barriers, such as terrain or canyon walls) can reduce reception

- https://youtu.be/1vUVXN3iRYw

Global Positioning System

GPS allows:

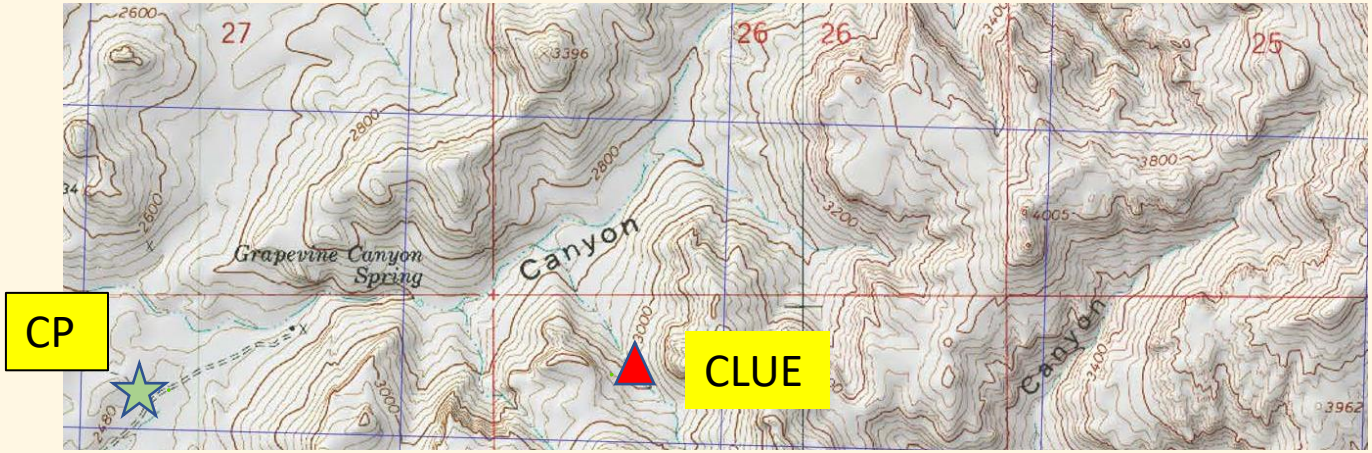
- Locations to be marked accurately.
- Users to navigate accurately in most types of weather, in the dark, and in flat featureless terrain.
- Conversion between coordinates
- You to report to command the area you've searched

GPS does NOT:

- Tell you the terrain along your path of travel
  - topo base maps may help, but are an additional cost
- Tell you the most efficient route, on trail or off

Waypoints

- A saved point location with specific coordinates
- Current location can be saved in a GPS device and marked for reference
- These can be added, edited, saved, or deleted
- Can be used to document CP, LZ, clues, etc

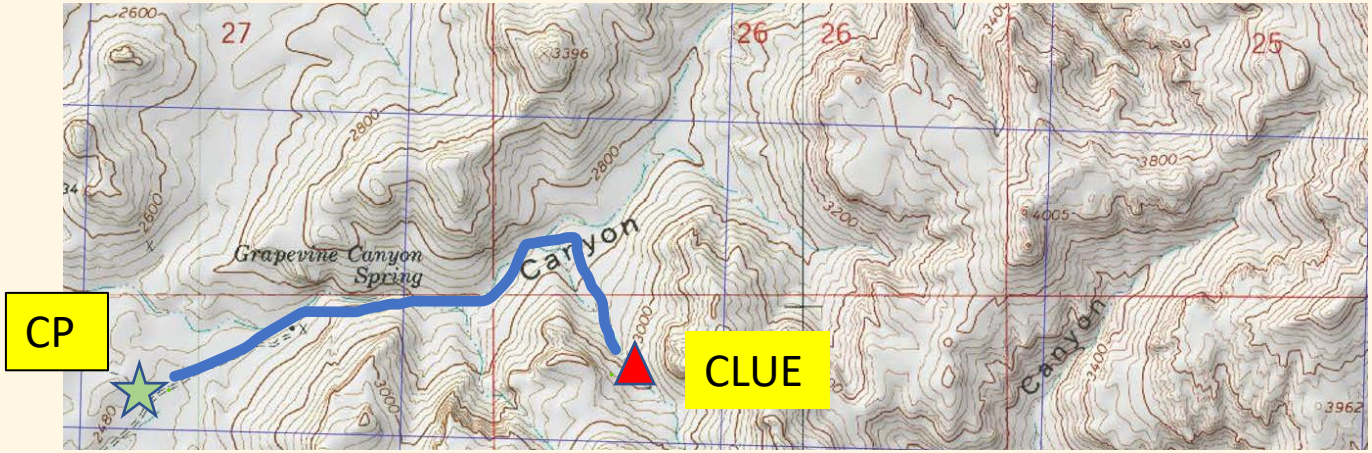


Routes

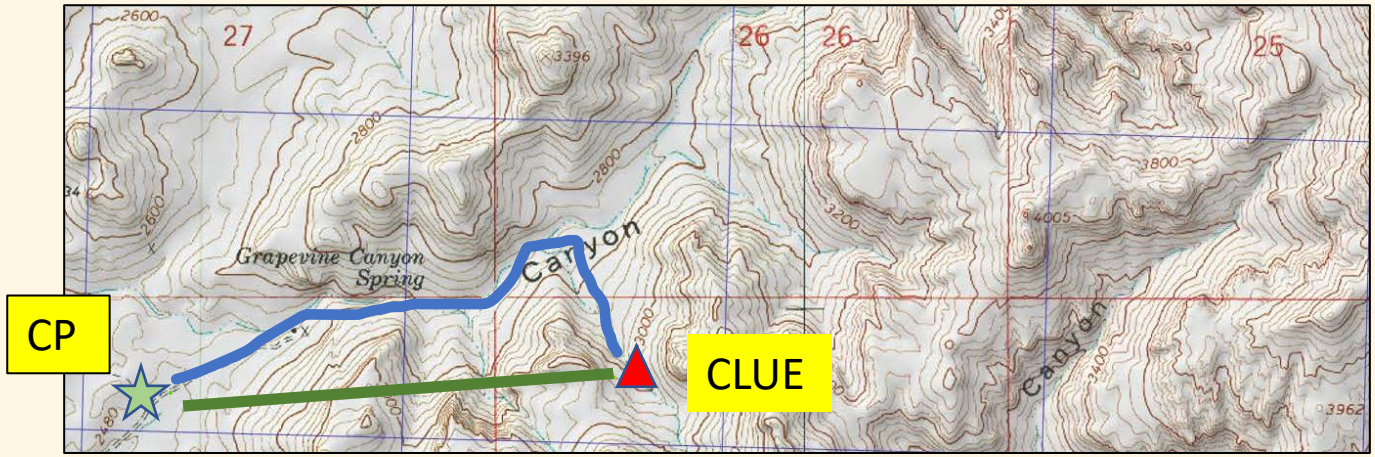
- Some GPS devices are able to route between two points. Most commonly found in GPS receivers designed for navigation.
- Uses digital road network to navigate.
- Inaccuracies are higher in rural areas compared to urban areas.
- A route is a path between two or more waypoints in a specific order

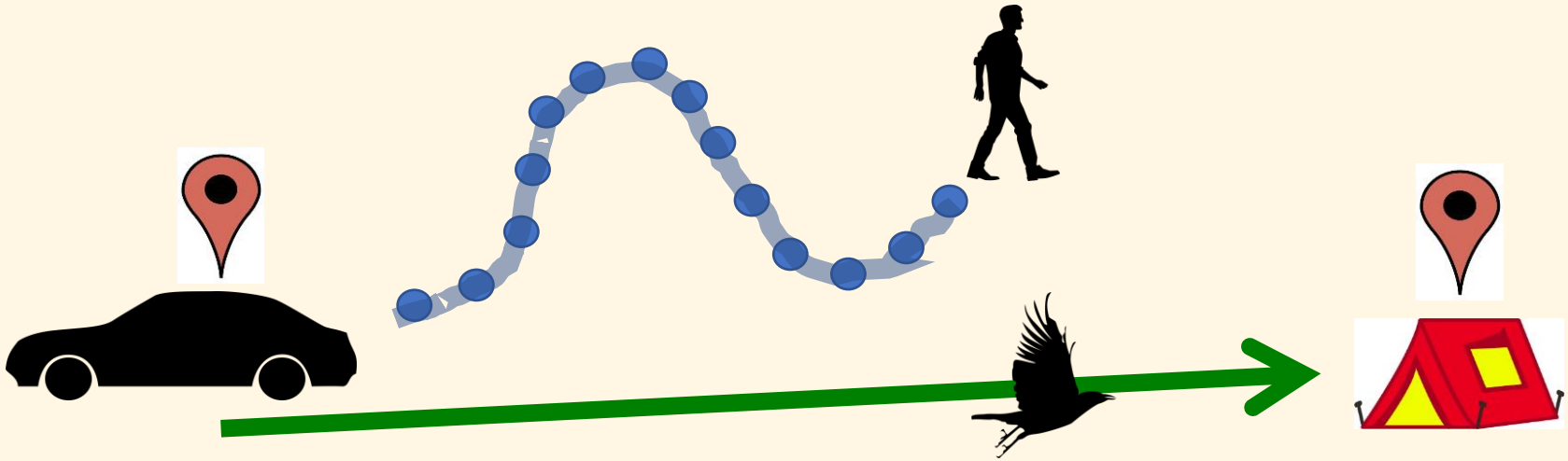
Tracks

- GPS receivers can store tracks
- Tracks are a series of point locations created along your path as you move. When saved, they get converted to a line that can be navigated forward and backward



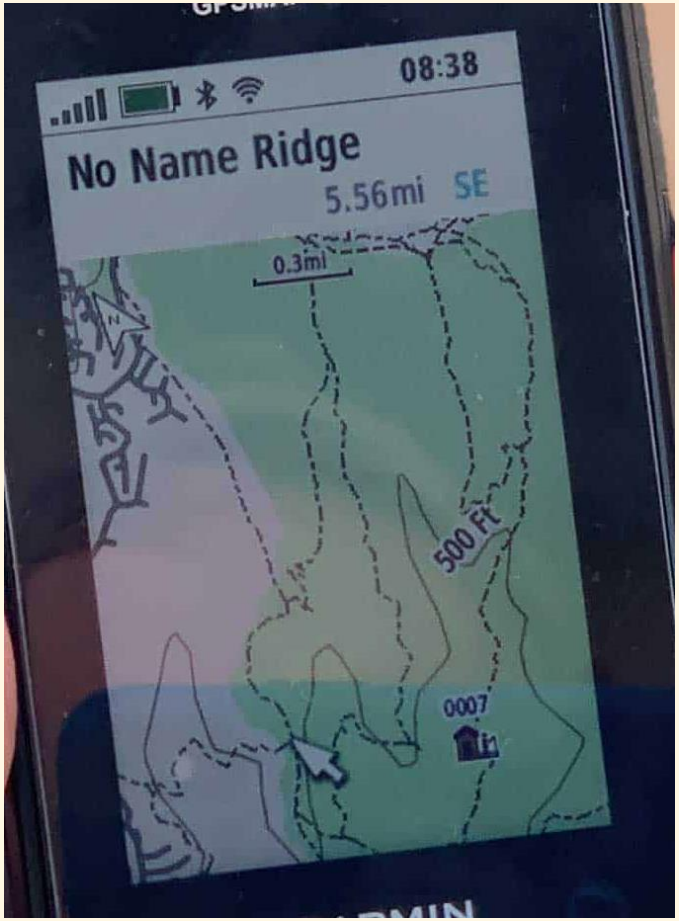
2D vs 3D





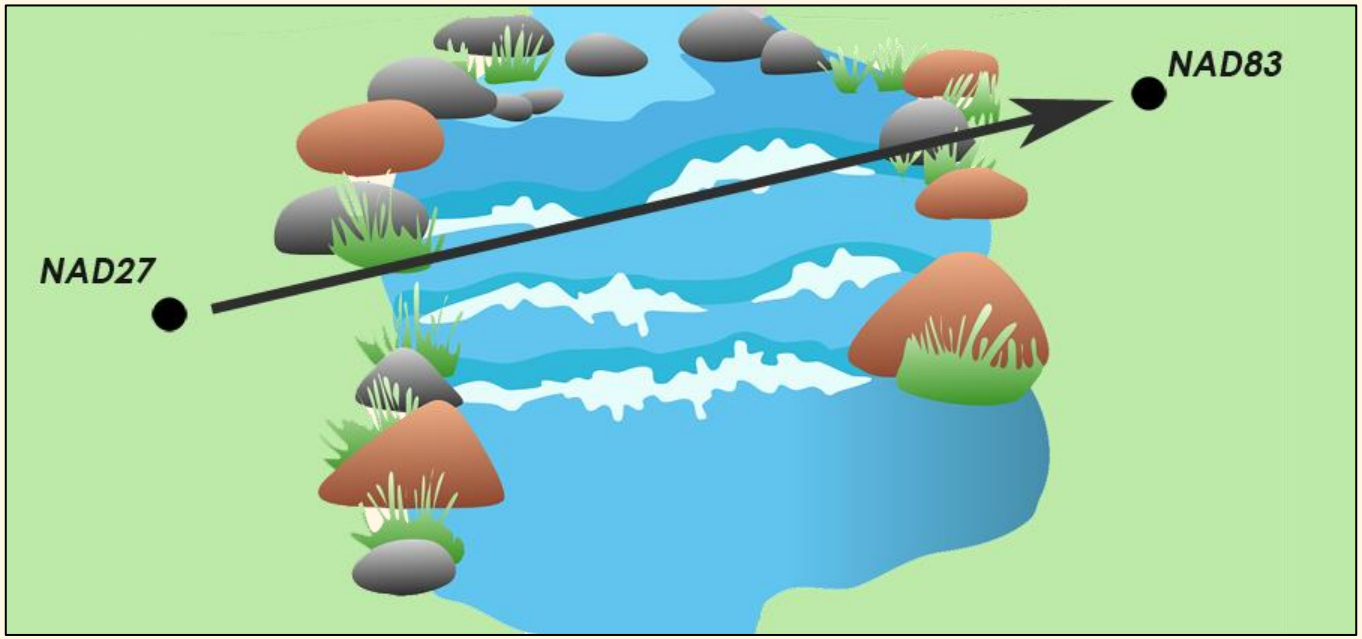
GPS Display


Grand Canyon National
368.46 mi NE
0.2mi
2600 Ft
Colorado Ri
3000 Ft
River Trail
3200 Ft
3500 Ft
Tonto Trail


08:38
No Name Ridge
5.56mi SE
0.3mi
500 Ft
0007

Datums

- Errors caused by using different datums
- GPS Datum needs to match map datum



GPS Pros/Cons

- Pros
  - Preload many maps
  - Easily track and store waypoints
  - Quickly determine location
- Cons
  - Battery life – need spare batteries
  - User curve
  - User errors
  - Signal errors
  - Device could break

Map and Compass Pros/Cons

- Pros
  - Handheld (still works without a battery or signal)
  - Details may be more defined on maps
  - Able to handwrite on the map

- Cons
  - Must calibrate for magnetic deviation
  - Errors with map and compass are significant the further you navigate

GPS Knowledge

Competence required to use GPS on SAR mission:

1. Be familiar with the GPS receiver and its operation.
2. Adjust settings (distance units, azimuth display)
    1. Change coordinate formats
    2. Change map datums
3. Assess satellite page for position condition for accuracy
4. Take coordinates in one format/datum, enter, save, and convert to another format/datum.

GPS Knowledge

Competence required to use GPS on SAR mission:

5. Mark a Waypoint
    1. From current position or from coordinates provided.
    2. Edit waypoint information (name, coordinates, symbol, notes)
    3. Set up a "Go to" waypoint
6. Use tracks
    1. Save tracks after completing an assignment
    2. Clear tracks before starting an assignment
7. Have cables to upload/download GPS information to computer.

GPS Review

GPS should not be used alone. Must be used in conjunction with map and compass skills. **Cautionary notes:**

- GPS is delicate instrument, can break and needs batteries.
- Satellite signals can bounce off canyon walls
- 2-D navigation mode can be relatively unreliable
- GPS needs a good sky view for best operation.
  - Using multiple GPS systems helps this, i.e. GPS+GLONASS
- Cold temperatures can affect the LCD display.
- GPS receivers do not calculate slope distance (terrain).
- Ensure that everyone understands what coordinate format and datum are being used.
- Biggest error in GPS operation is human.
- READ THE MANUAL and PRACTICE

GPS: Standard Procedures

- Turn on GPS and allow it to locate your position upon arrival at ICP. Check battery level!
- Clear tracks:
  - Before starting to search your assignment
- Mark waypoints for ICP, vehicle, and/or LZ
- Save tracks:
  - Upon completing or leaving assignment
  - Identifiable name: UNIT ID/NAME
- **Don't let tracks record travel to/from assignment**

Review

Map Review

- What are the two main scales of maps?

  Small Scale and Large Scale

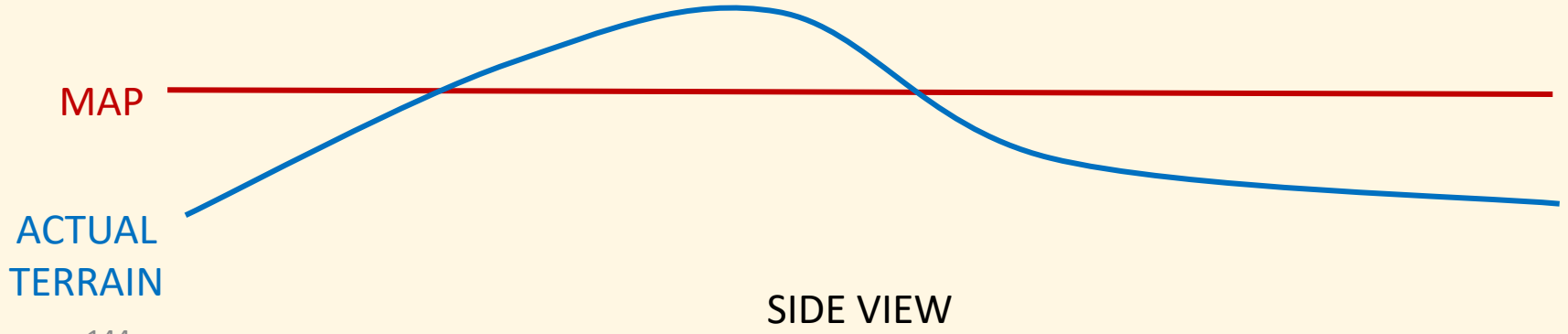
- Difference between large and small scale maps?

  Small Scale shows a large area and
  Large Scale shows a small area

- Contour lines: What indicates drainages?

  The shape of "V"s

- Which is longer map distance or real distance?



Map Review

- Where is the map datum on a USGS topo map?

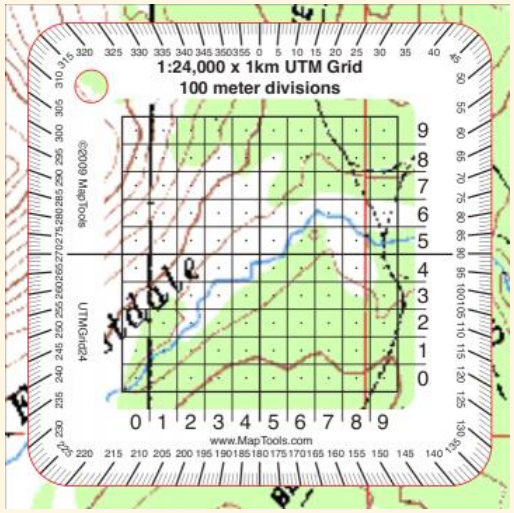
  Generally, lower-left corner

- What are two ways locate your position on a map?

  Triangulation, plot coordinates or by terrain features

- A ___ ___ is placed on a map to get UTM coordinates, to a 10 meter accuracy.

Map Tool



Compass Review

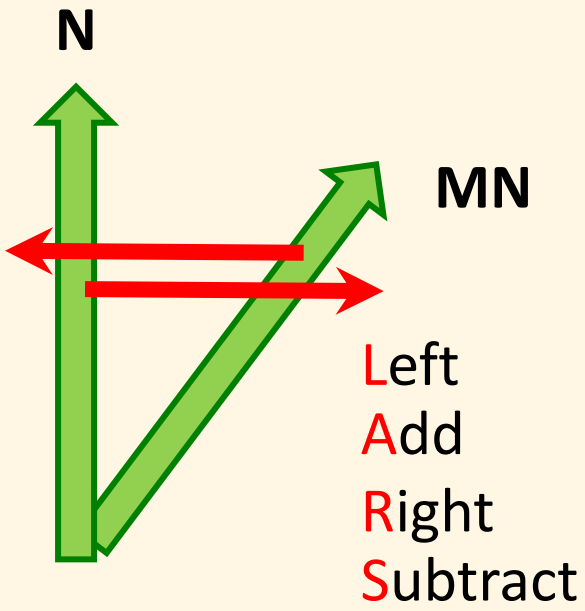
- Azimuths are read on a compass at the _____ _____.
  Index Mark
- How is the baseplate used when determining an azimuth? **Align the baseplate to the direction of travel, then orient the bezel to map north**
- What are some items that affect the magnetic needle on a compass?

Radios
Batteries
Vehicles
Magnets
Power lines
Fences
Belt buckles
Knives, Guns
Rings, Jewelry

Compass Review

- What is the current declination in Kingman? **11°**

- When transferring an azimuth from map to field you will ____ ___° from the azimuth.
  Subtract 11°
- When transferring an azimuth from field to map you will ____ ___° to the azimuth.
  Add 11°



Compass Review

- What is a method of finding your position on a map using at least two landmarks?

  Resection (or triangulation)

- Intentionally aiming to the left or right of the objective is called _____?

  Aiming Off - Intentionally aiming to the left or right of the objective, then following a linear feature to the objective. It's easier to hit a linear feature than a point.

GPS Review

- What can affect or block a GPS signal?
  - **Need clear view of sky**
  - **Does not work indoors**
  - **Signal errors**
- What location should be marked before starting every SAR mission?
  - **Command Post**
- When you are ready to start your SAR assignment you must **Clear tracks** and **record tracks**.

Evaluation

- Be sure to have:
  - 24-hour pack
  - Compass
  - Pencil
  - GPS Receiver

- Meet at 35.16474, -114.06080 and go East 100 yards