National Association for Search and Rescue

FUNDAMENTALS OF Search and Rescue

Chapter 10

Navigation

Objectives (1 of 3)

- Define the following terms or concepts:
  - Determining distances
  - Contour lines
  - True north
  - Grid north and magnetic north

Objectives (2 of 3)

- Demonstrate the use of the UTM (Universal Transverse Mercator) Grid System to determine the coordinates for a given point.
- Describe the procedures used to obtain a back azimuth.
- Describe how to take bearing in the field and transfer it correctly to the map, and obtain a bearing on the map and transfer it correctly to the field.

Objectives (3 of 3)

- Describe techniques used to navigate during daylight hours while wearing a 24-hour pack.
- List three advantages and three limitations of GPS (Global Positioning System) units as employed during search operations.

Global Mapping

- Geographic mapping
- Geographic Coordinate System (latitude and longitude)
- Universal Transverse Mercator (UTM)
- Universal Mapping System (UMS)
- Township and Range
- San Diego Mountain Rescue Team (SDMRT)

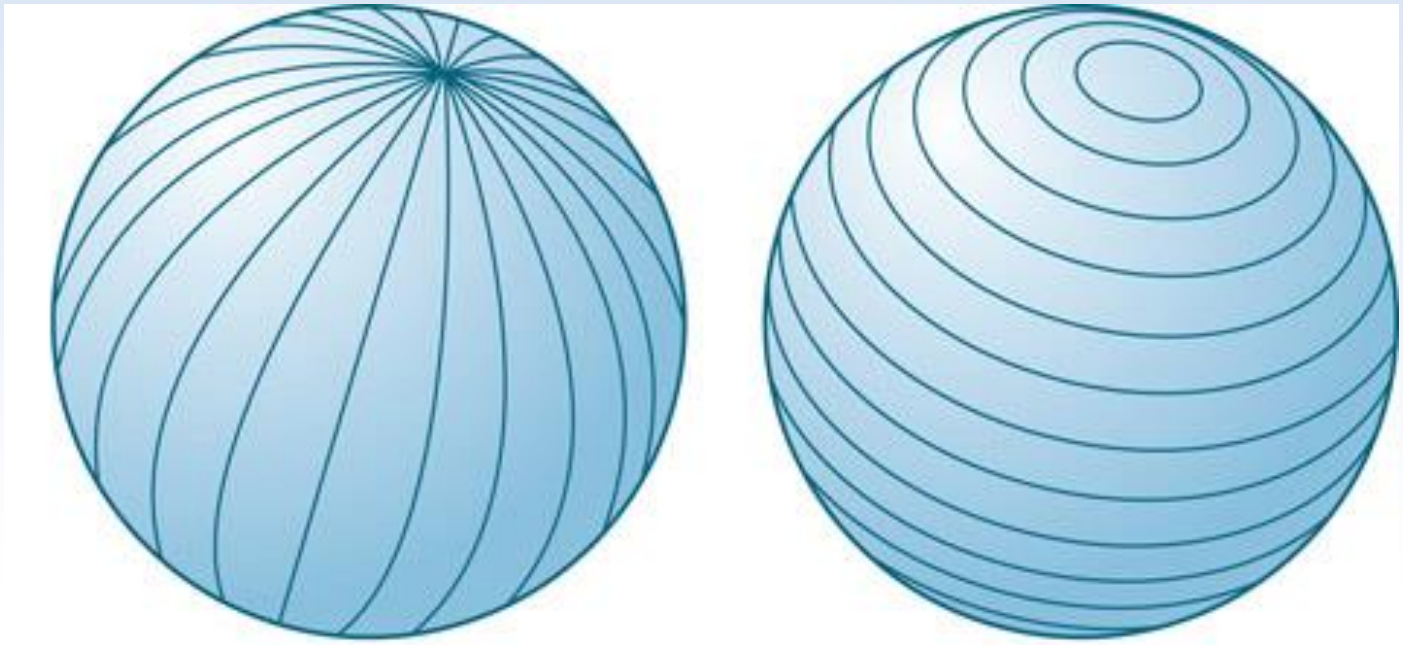
Geographic Mapping (1 of 2)

- Uses specific known geographic locations
- Good for use as reference points
- References can be measured in travel distances.

Geographic Mapping (2 of 2)

- Requires little or no training
- Easily learned
- Best suited for novices
- A good backup for more sophisticated mapping systems

Geographic Coordinate System



Latitude and Longitude (1 of 4)

- One method to identify points on a curved surface of the Earth
- System of reference lines
  - Parallels of latitude
  - Meridians of longitude

Latitude and Longitude (2 of 4)

- On most modern maps, meridians and parallels appear as curved lines.
- Important properties are shown with minimum distortion
- Map projection
  - System used to portray a part of the round Earth on a flat surface

Latitude and Longitude (3 of 4)

- Grid system that covers entire globe
- Longitude (meridians) run north-south.
- Latitude (parallels) run east-west.
- Practice is required to accurately describe a point in the field.

Latitude and Longitude (4 of 4)

- Not as effective for ground personnel who require accuracy
  - Better for use with aircraft and boats
- Works well for all-around, general use when exchanging information between ground and air units

Longitude

- Any point is measured by an angle in degrees up to 180 in either direction.
- Prime meridian
  - Considered zero as the angular distance east or west
- The International Date Line
  - At 180-degree
  - Connects with the prime meridian

Latitude

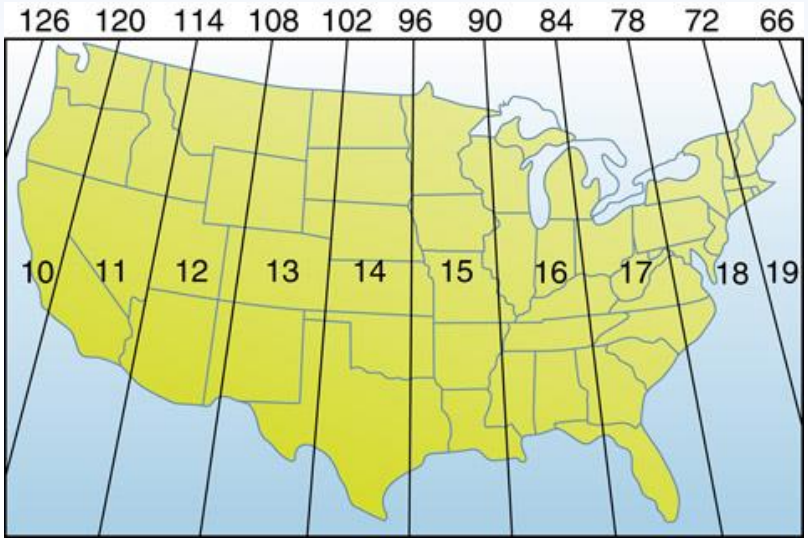
- Latitude starts at the equator,which is considered zero.
- Lines of latitude are parallel to the equator.
- Latitude lines are referred to as parallels.
- Angular distance is measured in degrees with 90 being the maximum at each pole.

Universal Transverse Mercator (1 of 6)

- Special grid for military use
- The world is divided into 60 north-south zones.
- Each zone covers a strip 6° wide in longitude.

Universal Transverse Mercator (2 of 6)

- Zones are numbered consecutively with Zone 1 between 180° and 174° west longitude and progressing eastward to Zone 60, between 174° and 180° east longitude.



Universal Transverse Mercator (3 of 6)

- Coordinates are measured north and east in meters.
- One meter equals 39.37 inches, or slightly more than 1 yard.
- Northing values are measured continuously from zero at the equator in a northerly direction.

Universal Transverse Mercator (4 of 6)

- The Equator was assigned an arbitrary false northing value of 10,000,000 meters.
- Central meridian through the middle of each 6° zone is assigned an easting value of 500,000 meters.
- Grid values to the west of this central meridian are less than 500,000; to the east, more than 500,000.

Universal Transverse Mercator (5 of 6)

- UTM grids lines
  - Shown on all USGS quadrangle maps
  - Indicated at intervals of 1,000-meters
  - Indicated by either blue ticks in the margins of the map or with full grid lines
- The 1,000-meter value of the ticks is shown for every tick or grid line.

Universal Transverse Mercator (6 of 6)

- On a 7.5-minute map, each tick is represented by four numbers.
  - Superscript numerals: 1,000,000- and 100,000-meter grids
  - Last two numerals: 10,000- and 1000-meter grids
- $^{49}98$ = 4,998,000 meters north of the Equator

Universal Mapping System (1 of 5)

- Devised in Washington State in the mid 1960s
- Widely used prior to handheld GPS devices
- Designed to help air and ground operations in communicating locations
- UTM and geographic coordinate systems have almost completely supplanted UMS.

Universal Mapping System (2 of 5)

- Uses letters and numbers to describe points
- Tied into Sectional Aeronautical Charts (1:500,000)
- Used by Civil Air Patrol and USAF
- Also keyed into 15-minute topo maps that have been abandoned by the USGS

Universal Mapping System (3 of 5)

- Example: *SFO 123 B 4567*
- “SFO” designates the three-letter name of the Sectional Aeronautical Map.
- “123” represents a 15-minute quad.
- “B” represents the upper right quadrant (A is upper left, C is lower left, and D is lower right).

Universal Mapping System (4 of 5)

- “4567” represents measurements made from the corner of the 7.5-minute quad, horizontally first, then vertical.
- “45” represents 4.5 miles horizontally from the upper right corner.
- “67” represents 6.7 miles vertically from that point.
- The entire designation describes an areas 1/10th of a square mile.

Universal Mapping System (5 of 5)

- Difficult to teach and apply in the field, especially if not used often
- Possibly a consequence of attempting to adapt an air search system to ground SAR operations
- Some swear by its effectiveness.

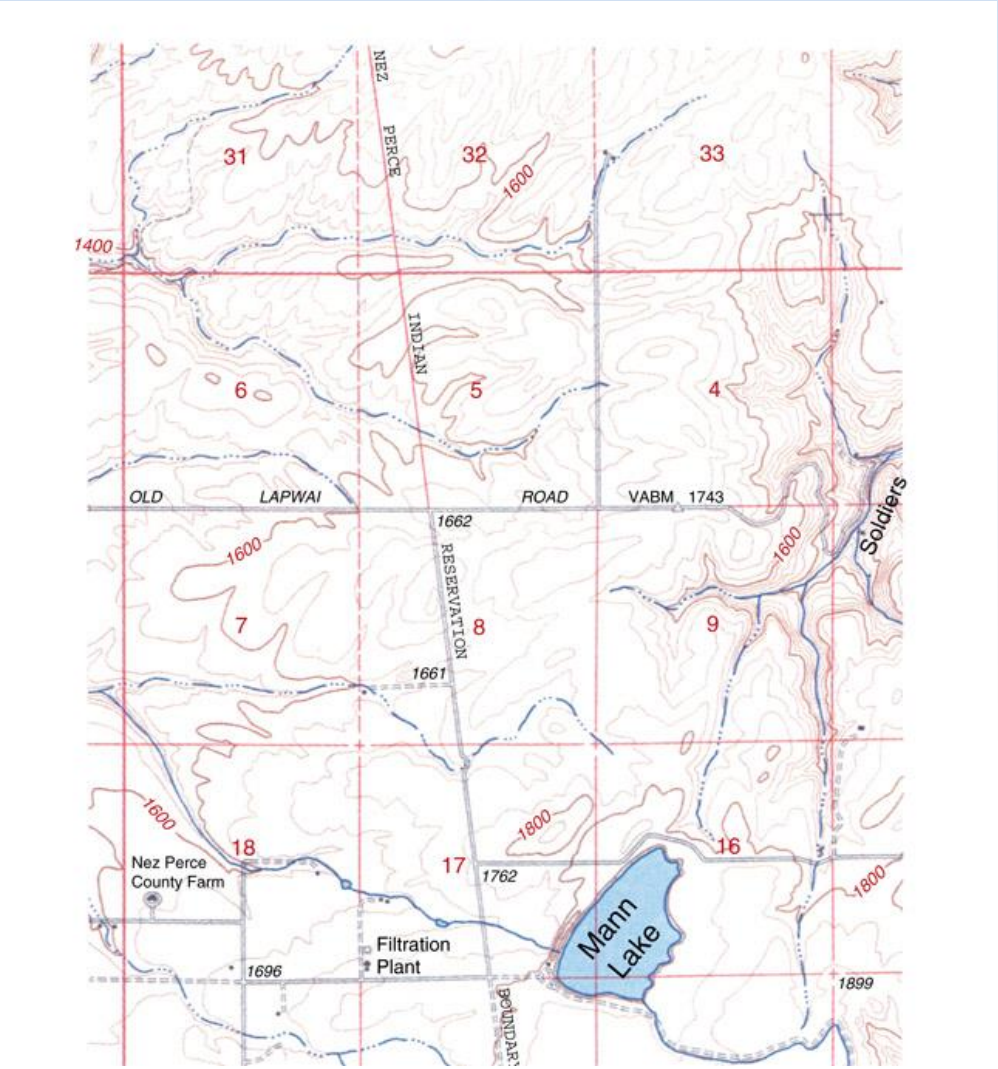
Township and Range (1 of 3)

- In 1785, the U.S. Public Land Survey was started with territories northwest of the Ohio River as a test area.
- The land was divided into townships 6 miles square with boundaries running north, south, east, and west.
- Townships were to be subdivided into 36 numbered sections of 1 sq. mile (640 acres) each.

Township and Range (2 of 3)

- Surveys were not completed.
- System is not applicable to many parts of the U.S.
- Should not be used for navigation
  - Lines do not always run true north/south or true east/west as originally intended.

Township and Range (3 of 3)



San Diego Mountain Rescue Team (1 of 3)

- Simple, fast, and easy to learn
- The SDMRT system will work on any map.
- Useless without a map so it cannot be strictly considered a method of absolute navigation.

San Diego Mountain Rescue Team (2 of 3)

- First: Identify the map to be used by scale and quadrant name.
- Second: Use a measuring device to measure the point from the nearest border.
- Coordinates are read by indicating distance in inches from the left map margin and from the bottom margin.
- “Read Right Up”

San Diego Mountain Rescue Team (3 of 3)

- Take measurements from map margin and not the edge of the map.
- Map edge is not used because large variances exist from one map to another.
- Can be used on any map as long as it has a border and the user has some type of measuring device.

Topographical Maps (1 of 10)

- Portray the shape and elevation of the terrain
- Show graphic representation of selected manmade and natural features to scale

Topographical Maps (2 of 10)

- USGS publishes topo maps in a variety of scales.
  - Most popular for land SAR is the 7.5-minute map.
- 7.5-minute maps have quadrangle dimensions of 7.5 minutes.
- Available as digital files on CD-ROM computer disk

Topographical Maps (3 of 10)

- USGS maps are supposed to be updated every 5 to10 years, but often it is longer.
- They accurately depict terrain and relief (elevation and slope).
- Manmade features may differ.

Topographical Maps (4 of 10)

- Top of the map is always true north.
- Vertical lines of longitude point north and south.
- Horizontal lines of latitude point east and west.
- Space outside the margin line identifies and explains the map.

Topographical Maps (5 of 10)

- Identified in the upper right margin by quadrangle name, state or states in which it is located, series, and type
- Usually named after a prominent, immoveable place or landmark within the mapped area

Topographical Maps (6 of 10)

- “Series” refers to the area mapped in terms of minutes or degrees.
- “Type” is either topographic or plenimetric.
- Title block in lower right margin shows quandrangle name, state name, and geographic index number.

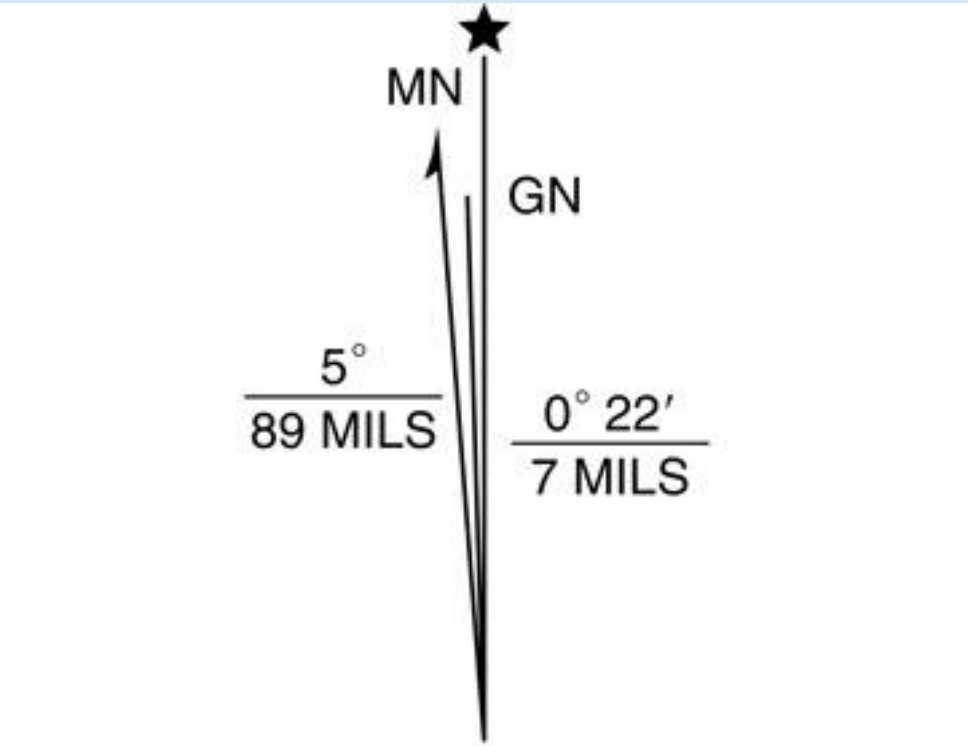
Topographical Maps (7 of 10)

- Geographic coordinates are shown:
  - At all four map margin corners
  - Along the margin lines at 2.5-minute intervals for 7.5-minute maps
- Credit legend is located in the lower left margin.
  - Due to the infinite data, credit legends cannot be rigid.

Topographical Maps (8 of 10)

- Magnetic declination for the year of filed survey or revision
  - Determined to the nearest 0.5 degree from the latest isogonic chart
  - Shown by a diagram centered between the credit legend and bar scale
- The declination diagram indicates the angular relationship between true north, grid north, and magnetic north.

Topographical Maps (9 of 10)



UTM GRID AND 1979 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

Topographical Maps (10 of 10)

- Center of the lower margin contains:
  - Publication scales expressed as a ratio
  - Bar scales in metric and imperial units
  - Contour-interval statement
  - Vertical datum
  - Depth-curve sounding statement
  - Shoreline and tide-range statements
  - Map accuracy statements

Road Symbols (1 of 2)

- Legend is placed in the lower right margin.
- Tailored for each map to include only classes of roads and route markers that are shown in the body of the map
- Trails are not included in the legend unless there are no roads on the map.

Road Symbols (2 of 2)

Colors on the Map

- Brown: Contour lines
- Green: Vegetation
- Blue: Water
- Black: Manmade objects
- Red: Roads and built-up areas
- Purple: New changes or updates on the map

Contour Lines

- Represent relative elevation
- Each contour line connects all points at the same elevation above sea level.
- Three types:
  - Index
  - Intermediate
  - Supplementary

Index Contour Lines

- Every fifth line is darker.
- Have numbers superimposed on them indicating the elevation along that particular line

Intermediate Contour Lines

- Lighter brown lines
- Fall between index lines
- Are not numbered

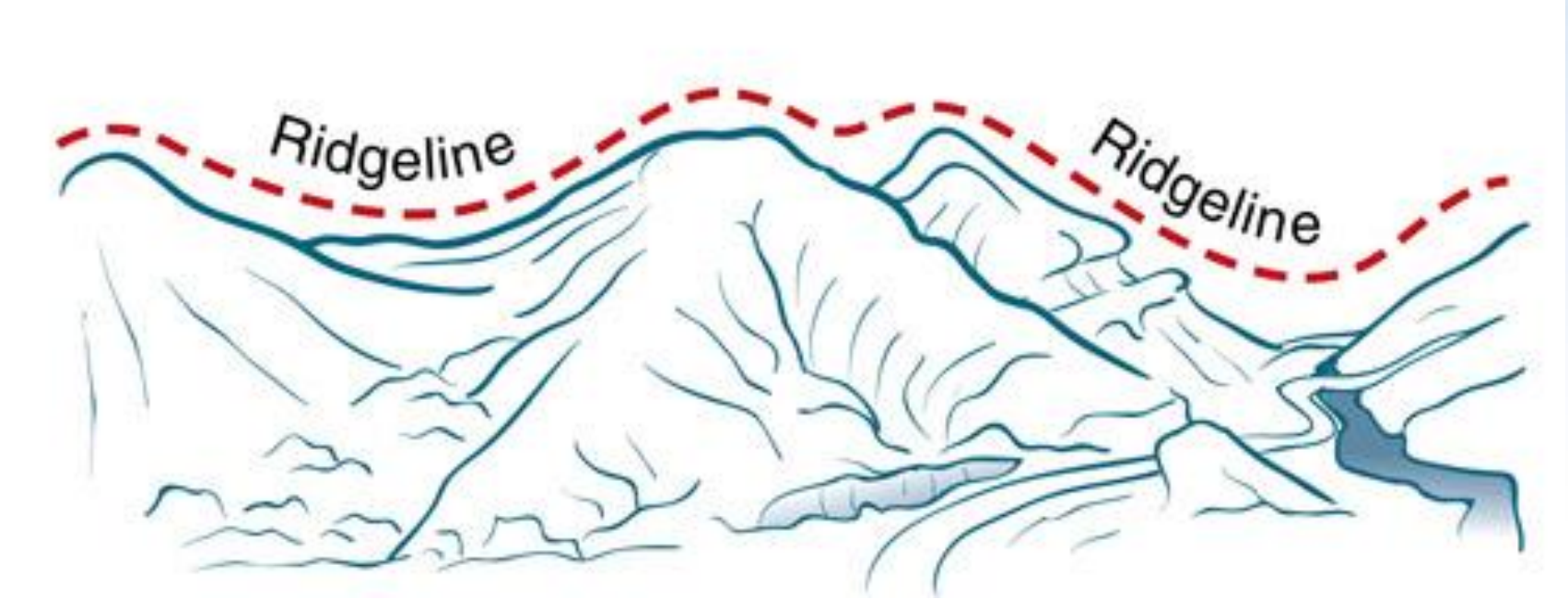
Supplementary Contour Lines

- Dashed lines that may be used when:
  - The terrain is very flat
  - There are large distances between contour lines
- Shows a difference in elevation that is half of the elevation of the contour lines between which it falls

Terrain Features (1 of 5)

- Terrain features evolve from a complex landmass known as a “ridgeline. ”
- A ridgeline:
  - Is a line of high ground
  - Usually has variations in elevation along its top
- A “ridge” is simply one of the terrain features that may arise from a ridgeline.

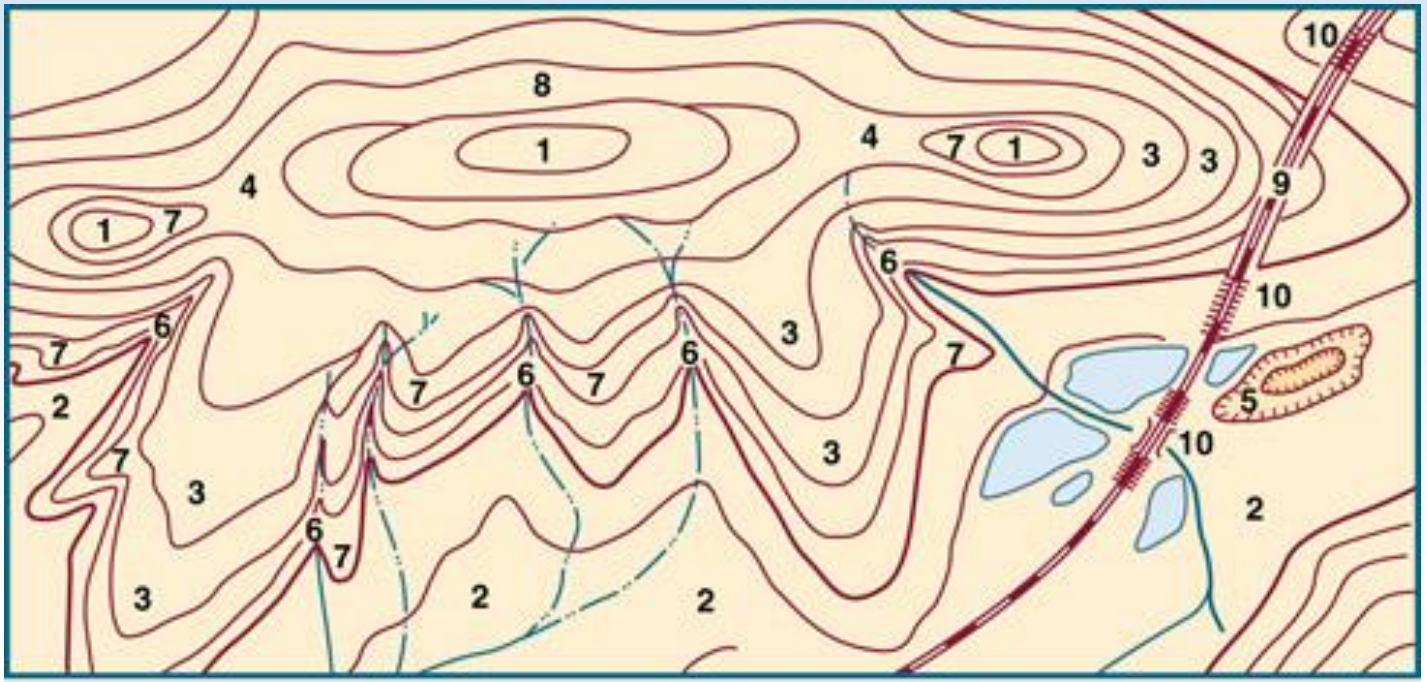
Terrain Features (2 of 5)



Terrain Features (3 of 5)

- A total of ten natural or manmade features may arise from a ridgeline.
- Each feature has unique and notable characteristics.
- These features fall into two categories:
  - Major terrain features
  - Minor terrain features

Terrain Features (4 of 5)



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

Terrain Features (5 of 5)

- Major features:
  - Hills
  - Saddles
  - Valleys
  - Ridges
  - Depressions
- Minor features:
  - Draws
  - Spurs
  - Cliffs
  - Cuts/Fills

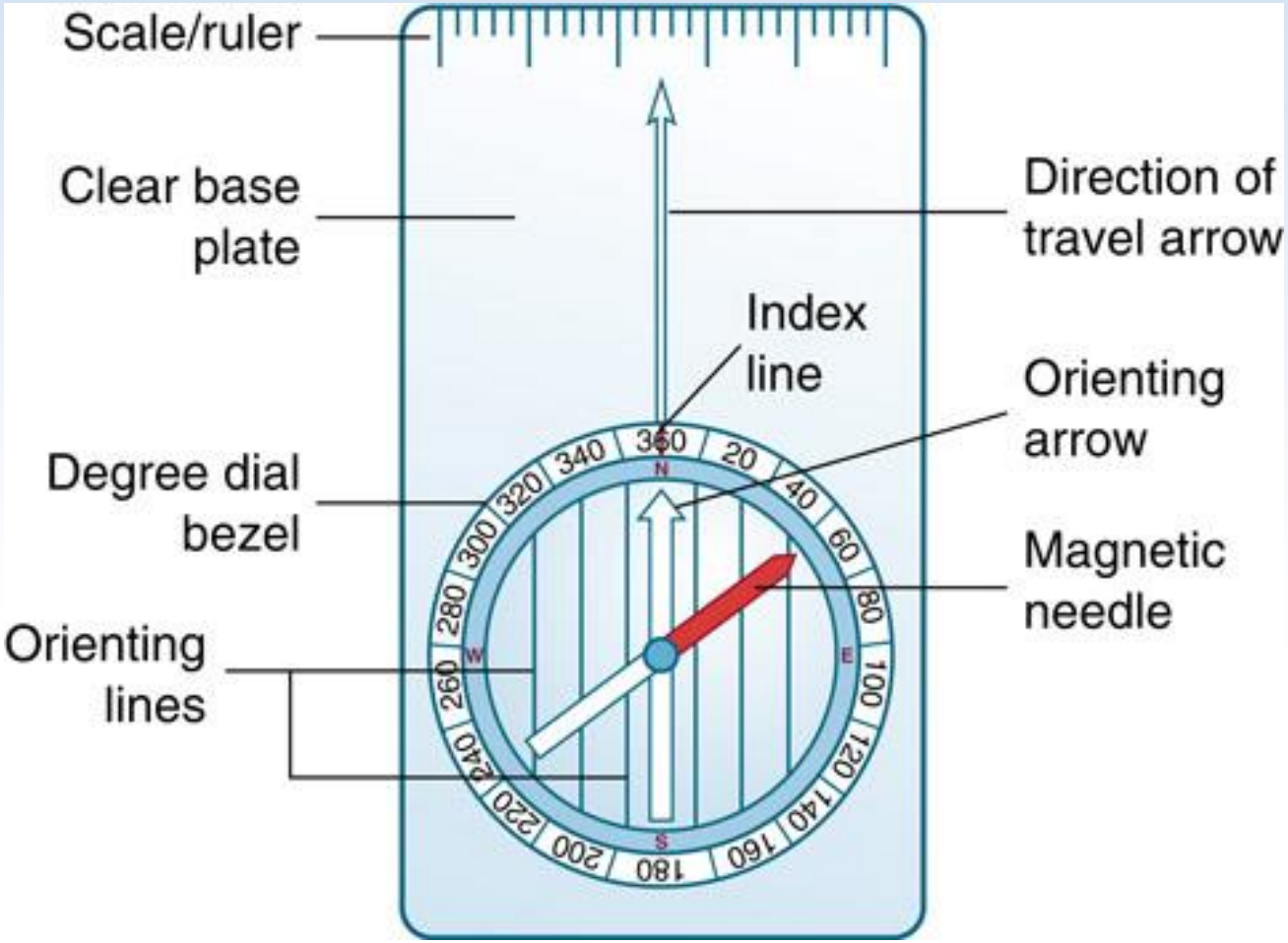
Compass Types

- Two styles of compasses:
  - Orienteering
  - Lensatic
- The orienteering style is preferred for SAR.
- All compasses have similar basic features.

Compass Characteristics

- Base plate or base
- Bezel, dial, ring, or compass housing
- Bearing/orienting lines
- Magnetic needle
- Direction of travel arrow
- Index line or lubber line
- Sighting mirror

Orienteering Compass



Navigating with a Compass (1 of 2)

- Good compass posture:
  - Stand still with arms comfortably at sides.
  - Elbows bent so that both hands can hold the compass directly in front of body
  - Hold compass at either chest-level or belt-level.

Navigating with a Compass (2 of 2)

- Ensure that direction of travel arrow is pointing in the same direction as your toes.
- Toes must be pointing in the same direction as the direction of travel arrow
- When you move the compass to a specific heading, move your entire body as a solid extension.
- Hold the compass level so that the needle may move freely to settle on a direction.

Following a Heading

- Point your toes in direction you wish to travel and sight a prominent object in the distance.
- Close your eyes for several seconds, open them, and confirm you can find the object.
- Reconfirm your heading to object, lower the compass, and start walking.

Using a Map and Compass Together (1 of 3)

- The compass is used primarily as a protractor and ruler.
- 360-degree dial, in association with the orienting lines in the base of the bezel, serve as the protractor.
- Straight sides of the base serve as a straight edge.
- The magnetic needle can be completely ignored.

Using a Map and Compass Together (2 of 3)

- To determine the heading from one point to another on the map:
  - Place the compass on the map so that one edge of the base plate touches both the starting point and the destination.
  - Make sure that the direction of travel arrow is pointing in the correct direction of travel.

Using a Map and Compass Together (3 of 3)

- Turn the dial ring until the orienting arrow, with the arrow pointing north, is parallel to the nearest north-south meridian.
- The heading from the starting point to the destination is now indicated on the dial ring.
- Scales on bottom margin can be used to measure distance on the map.

Magnetic Declination

- The angle between the direction the magnetic needle points (magnetic north) and true north
- The magnetic needle on a compass only points to true north when the compass is along the “Agonic” line.
- East of this line, a compass needle will point west of true north (west or negative declination).
- West of this line, a compass needle will point east of true north (east or positive declination).

Magnetic Declination

- If you know the magnetic declination of the area in which you will be navigating, you have four options:
  - Ignore it.
  - Adjust for it on the compass.
  - Adjust for it by drawing magnetic meridians on the map.
  - Adjust for it mathematically.

Ignore it

- When using a compass without a map
- When operating on the Agonic line

Adjust the Compass

- Some compasses can be adjusted for declination.
- Offsets the orienting arrow and index line in the base of the bezel to compensate for declination when the compass is used as a protractor with a map
- Once adjusted, the orienting arrow in the bezel is no longer parallel to the orienting lines.

Draw Magnetic Meridians

- Prepare the map by adding magnetic north lines to it .
- Adding these lines requires a protractor, long straight edge, and the angle of declination.
- Not recommended for SAR due to difficulty in accomplishing this manually.
- Added lines may make map more difficult to read.

Mathematical Correction

- Must know if the declination is east or west.
- Look at the declination diagram at the bottom margin of the map.
  - If “MN” is to left of the star, declination is west.
  - If “MN” is to right of the star, declination is east.
- Determine if you are going from map to compass or compass to map.

Tally (1 of 2)

- Distance can be measured by knowing the length of one's stride and multiplying it by the number of strides walked
- A stride, is equivalent to 2 steps, or the distance between where one foot strikes the ground and where the same foot strikes the ground again

Tally (2 of 2)

- Strides will vary depending on leg length, terrain, weather, darkness, fitness, and many others
- Valuable skill in several situations in SAR – estimating distance when a mapped object or area is a known distance from a starting point. Also, being able to estimate how far a clue was found from the start of a search might be valuable during debriefing

Global Positioning System (1 of 2)

- A space-based radio navigation system consisting of satellites and a network of ground stations
  - Use for monitoring and control
  - A minimum of 24 GPS satellites orbit the Earth.
- The principal behind the GPS is the measurement of distance between the receiver and the satellites.

Global Positioning System (2 of 2)

- Limitations
  - Requires line-of-sight to the satellites and will not work in all terrains.
  - Should not be used as sole navigation device
  - Less than perfect accuracy
  - Human error
  - Position display can easily be misread.
  - Typical battery life is 4-6 hours.