Navigation Course

Purpose

To provide information on map reading, course plotting, and GPS use.

Maps

- A map is a graphic representation of a portion of the earth's surface drawn to scale, as seen from above. It uses colors, symbols, and labels to represent features found on the ground.
- A map provides information on the existence, the location of, and the distance between ground features, such as populated places and routes of travel and communication. It also indicates variations in terrain, heights of natural features, and the extent of vegetation cover.
- Maps are categorized by scale and type.
  - **Scale.** Because a map is a graphic representation of a portion of the earth's surface drawn to scale as seen from above, it is important to know what mathematical scale has been used. You must know this to determine ground distances between objects or locations on the map, the size of the area covered, and how the scale may affect the amount of detail being shown. The mathematical scale of a map is the ratio or fraction between the distance on a map and the corresponding distance on the surface of the earth. Scale is reported as a representative fraction with the map distance as the numerator and the ground distance as the denominator.
  - ***Representative fraction (scale) = map distance ÷ ground distance***
    - ***Example 1:250,000 or 1:10,000***
  - The larger the number after 1:, the smaller the scale of the map.
  - The smaller the number after the 1:, the more detailed the map may be

Map Information

- **MARGINAL INFORMATION ON A MILITARY MAP**
- a. **Sheet Name (1)**. The sheet name is found in bold print at the center of the top and in the lower left area of the map margin. A map is generally named for the settlement contained within the area covered by the sheet, or for the largest natural feature located within the area at the time the map was drawn.
- b. **Sheet Number (2).** The sheet number is found in bold print in both the upper right and lower left areas of the margin, and in the center box of the adjoining sheets diagram, which is found in the lower right margin. It is used as a reference number to link specific maps to overlays, operations orders, and plans. For maps at 1:100,000 scale and larger, sheet numbers are based on an arbitrary system that makes possible the ready orientation of maps at scales of 1:100,000, 1:50,000, and 1:25,000.
- c. **Series Name (3)**. The map series name is found in the same bold print as the sheet number in the upper left corner of the margin. The name given to the series is generally that of a major political subdivision, such as a state within the United States or a European nation. A map series usually includes a group of similar maps at the same scale and on the same sheet lines or format designed to cover a particular geographic area. It may also be a group of maps that serve a common purpose, such as the military city maps.
- d. **Scale (4).** The scale is found both in the upper left margin after the series name, and in the center of the lower margin. The scale note is a representative fraction that gives the ratio of a map distance to the corresponding distance on the earth's surface. For example, the scale note 1:50,000 indicates that one unit of measure on the map equals 50,000 units of the same measure on the ground.

Map Information cont.

- e. **Series Number (5).** The series number is found in both the upper right margin and the lower left margin. It is a sequence reference expressed either as a four-digit numeral (1125) or as a letter, followed by a three- or four-digit numeral (M661; T7110).
- f. **Edition Number (6)**. The edition number is found in bold print in the upper right area of the top margin and the lower left area of the bottom margin. Editions are numbered consecutively; therefore, if you have more than one edition, the highest numbered sheet is the most recent. Most military maps are now published by the DMA, but older editions of maps may have been produced by the US Army Map Service. Still others may have been drawn, at least in part, by the US Army Corps of Engineers, the US Geological Survey, or other agencies affiliated or not with the United States or allied governments. The credit line, telling who produced the map, is just above the legend. The map information date is found immediately below the word "LEGEND" in the lower left margin of the map. This date is important when determining how accurately the map data might be expected to match what you will encounter on the ground.
- g. **Index to Boundaries (7).** The index to boundaries diagram appears in the lower or right margin of all sheets. This diagram, which is a miniature of the map, shows the boundaries that occur within the map area, such as county lines and state boundaries.
- h. **Adjoining Sheets Diagram (8).** Maps at all standard scales contain a diagram that illustrates the adjoining sheets. On maps at 1:100,000 and larger scales and at 1:1,000,000 scale, the diagram is called the index to adjoining sheets. It consists of as many rectangles representing adjoining sheets as are necessary to surround the rectangle that represents the sheet under consideration. The diagram usually contains nine rectangles, but the number may vary depending on the locations of the adjoining sheets. All represented sheets are identified by their sheet numbers. Sheets of an adjoining series, whether published or planned, that are at the same scale are represented by dashed lines. The series number of the adjoining series is indicated along the appropriate side of the division line between the series.

Map Information cont.

- i. **Elevation Guide (9).** This is normally found in the lower right margin. It is a miniature characterization of the terrain shown. The terrain is represented by bands of elevation, spot elevations, and major drainage features. The elevation guide provides the map reader with a means of rapid recognition of major landforms.
- j. **Declination Diagram (10).** This is located in the lower margin of large-scale maps and indicates the angular relationships of true north, grid north, and magnetic north. On maps at 1:250,000 scale, this information is expressed as a note in the lower margin. In recent edition maps, there is a note indicating the conversion of azimuths from grid to magnetic and from magnetic to grid next to the declination diagram.
- k. **Bar Scales (11).** These are located in the center of the lower margin. They are rulers used to convert map distance to ground distance. Maps have three or more bar scales, each in a different unit of measure. Care should be exercised when using the scales, especially in the selection of the unit of measure that is needed.
- l. **Contour Interval Note (12)**. This note is found in the center of the lower margin normally below the bar scales. It states the vertical distance between adjacent contour lines of the map. When supplementary contours are used, the interval is indicated. In recent edition maps, the contour interval is given in meters instead of feet.
- m. **Spheroid Note (13).** This note is located in the center of the lower margin. Spheriods (ellipsoids) have specific parameters that define the X Y Z axis of the earth. The spheriod is an integral part of the datum.
- n. **Grid Note (14).** This note is located in the center of the lower margin. It gives information pertaining to the grid system used and the interval between grid lines, and it identifies the UTM grid zone number.

Map Information cont.

- o. **Projection Note (15).** The projection system is the framework of the map. For military maps, this framework is of the conformal type; that is, small areas of the surface of the earth retain their true shapes on the projection; measured angles closely approximate true values; and the scale factor is the same in all directions from a point. The projection note is located in the center of the lower margin. Refer to DMA for the development characteristics of the conformal-type projection systems.
  - (1) Between 80° south and 84° north, maps at scales larger than 1:500,000 are based on the transverse Mercator projection. The note reads TRANSVERSE MERCATOR PROJECTION.
  - (2) Between 80° south and 84° north, maps at 1:1,000,000 scale and smaller are based on standard parallels of the lambert conformal conic projection. The note reads, for example, LAMBERT CONFORMAL CONIC PROJECTIONS 36° 40' N AND 39° 20' N.
  - (3) Maps of the polar regions (south of 80° south and north of 84° north) at 1:1,000,000 and larger scales are based on the polar stereographic projection. The note reads POLAR STEREOGRAPHIC PROJECTION.
- p. **Vertical Datum Note (16).** This note is located in the center of the lower margin. The vertical datum or vertical-control datum is defined as any level surface (for example, mean sea level) taken as a surface of reference from which to determine elevations. In the United States, Canada, and Europe, the vertical datum refers to the mean sea level surface. However, in parts of Asia and Africa, the vertical-control datum may vary locally and is based on an assumed elevation that has no connection to any sea level surface. Map readers should habitually check the vertical datum note on maps, particularly if the map is used for low-level aircraft navigation, naval gunfire support, or missile target acquisition.
- q. **Horizontal Datum Note (17).** This note is located in the center of the lower margin. The horizontal datum or horizontal-control datum is defined as a geodetic reference point (of which five quantities are known: latitude, longitude, azimuth of a line from this point, and two constants, which are the parameters of reference ellipsoid). These are the basis for horizontal-control surveys. The horizontal-control datum may extend over a continent or be limited to a small local area. Maps and charts produced by DMA are produced on 32 different horizontal-control data. Map readers should habitually check the horizontal datum note on every map or chart, especially adjacent map sheets. This is to ensure the products are based on the same horizontal datum. If products are based on different horizontal-control data, coordinate transformations to a common datum must be performed. UTM coordinates from the same point computed on different data may differ as much as 900 meters.

Map Information cont.

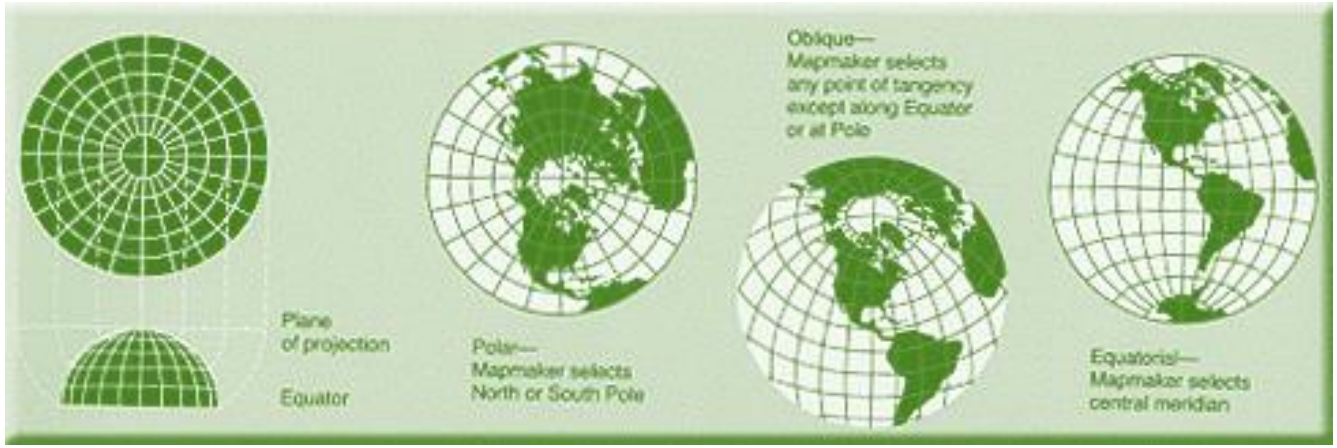
- r. **Control Note (18).** This note is located in the center of the lower margin. It indicates the special agencies involved in the control of the technical aspects of all the information that is disseminated on the map.
- s. **Preparation Note (19).** This note is located in the center of the lower margin. It indicates the agency responsible for preparing the map.
- t. **Printing Note (20).** This note is also located in the center of the lower margin. It indicates the agency responsible for printing the map and the date the map was printed. The printing data should not be used to determine when the map information was obtained.
- u. **Grid Reference Box (21).** This box is normally located in the center of the lower margin. It contains instructions for composing a grid reference.
- v. **Unit imprint and Symbol (22).** The unit imprint and symbol is on the left side of the lower margin. It identifies the agency that prepared and printed the map with its respective symbol. This information is important to the map user in evaluating the reliability of the map.
- w. **Legend (23).** The legend is located in the lower left margin. It illustrates and identifies the topographic symbols used to depict some of the more prominent features on the map. The symbols are not always the same on every map. Always refer to the legend to avoid errors when reading a map.

Maps cont.

- Topo cadastral Maps
  - Topographic Information
    - Large Scale detail, quantitative representation of relief using contour lines
    - Represents cultural information
    - Natural and man made features of terrain
  - Cadastral Information
    - Property boundaries
- General Reference Maps
  - Atlas maps – political boundaries
- Planimetric Maps– flat
- Thematic or Topical Maps
  - Information on single subject – cell coverage
- Road Maps

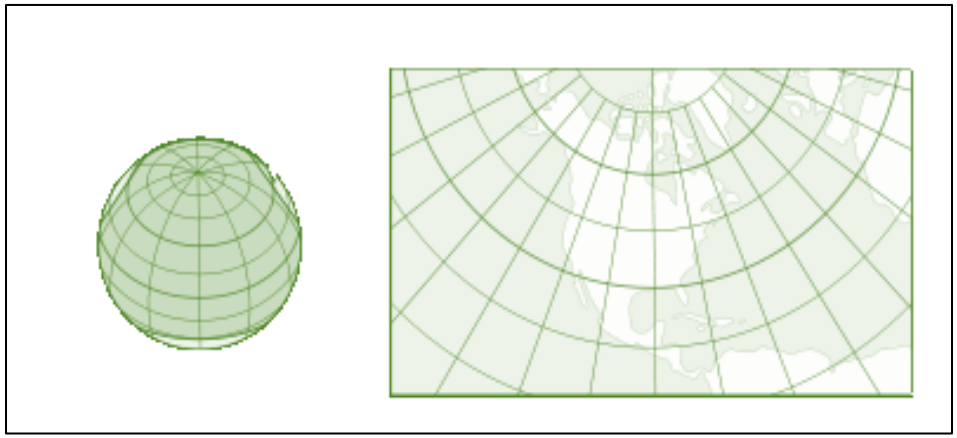
Map Projections

- Projection is a method used to project the earth's curved surface on a flat surface – this creates various distortions
- There are three main groups of projections
  - Azimuthal
    - When projected from the center of the globe with the normal aspect, the typical grid appearance for azimuthal projections shows parallels forming concentric circles, while meridians radiate out from the center. If the imaginary projecting light source is inside the globe a gnomonic projection results, if the light is antipodal a stereographic, and if at infinity, an orthographic.



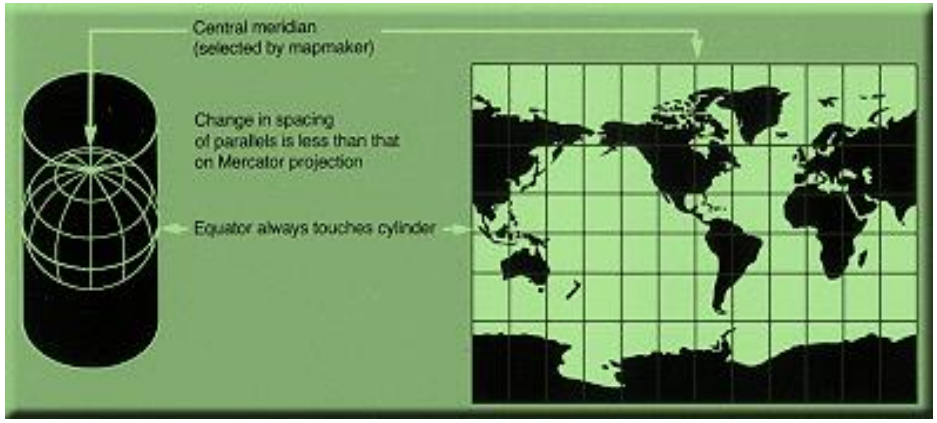
Map Projections cont.

Conic **Lambert conformal conic projection (LCC)**



Cylindrical

- The Mercator projection shows courses of constant bearing as straight lines.



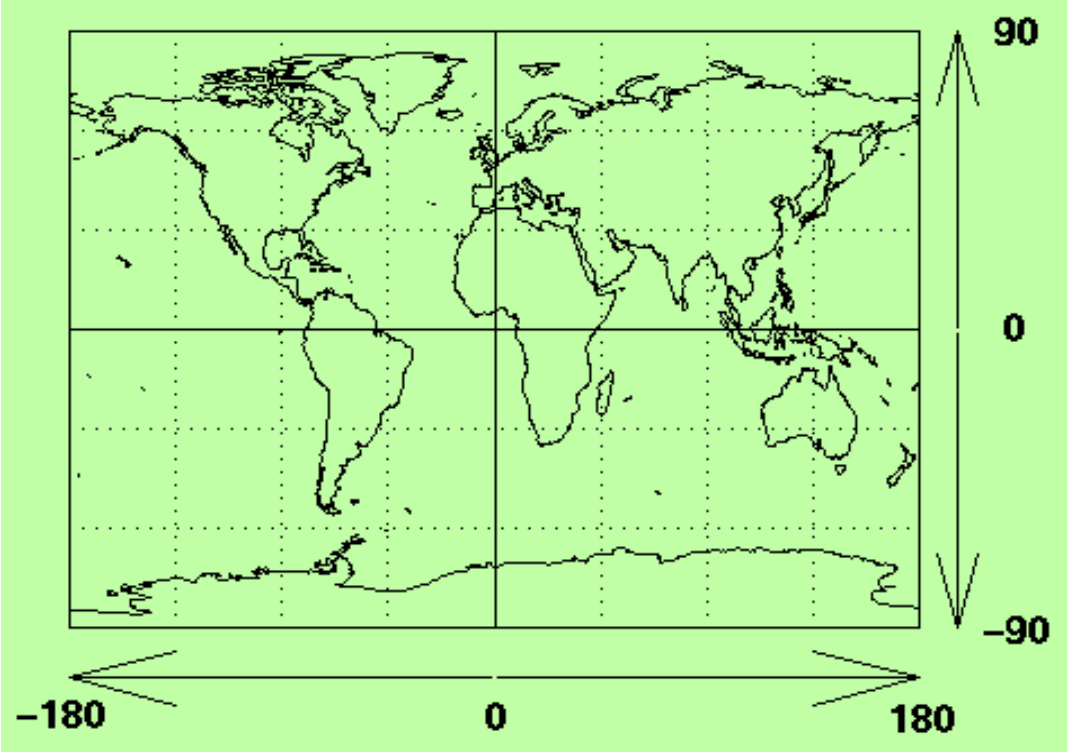
Longitude and Latitude

- Meridians of Longitude
  - Longitude is measured from the Prime Meridian (which is the longitude that runs through Greenwich, England), with positive values going east and negative values going west.
  - Run up and down on a map
  - The E or the W following a longitude measurement indicate whether the degrees are measured east or west of the prime meridian.
- Parallels of Latitude
  - Latitude is measured from the equator, with positive values going north and negative values going south.
  - Run from left to right on a map
  - The N or S following a latitude measurement indicate whether the degrees are measured north or south of the equator.
- Meridians and parallels intersect at right angles to form the global grid.
- Every point on the earth's surface may be located exactly by reference to the grid.

Longitude and Latitude cont.

Units of Measurement

- Geographic coordinates are expressed in angular measurement. Each circle is divided into 360 degrees, each degree into 60 minutes, and each minute into 60 seconds. The degree is symbolized by ° , the minute by ’, and the second by ”.



Longitude and Latitude cont.

- At any point on the earth, the ground distance covered by **one degree of latitude** is about 111 kilometers (69 miles); one second is equal to about 30 meters (100 feet).
- The ground distance covered by **one degree of longitude** at the equator is also about 111 kilometers, but decreases as one moves north or south, until it becomes zero at the poles.

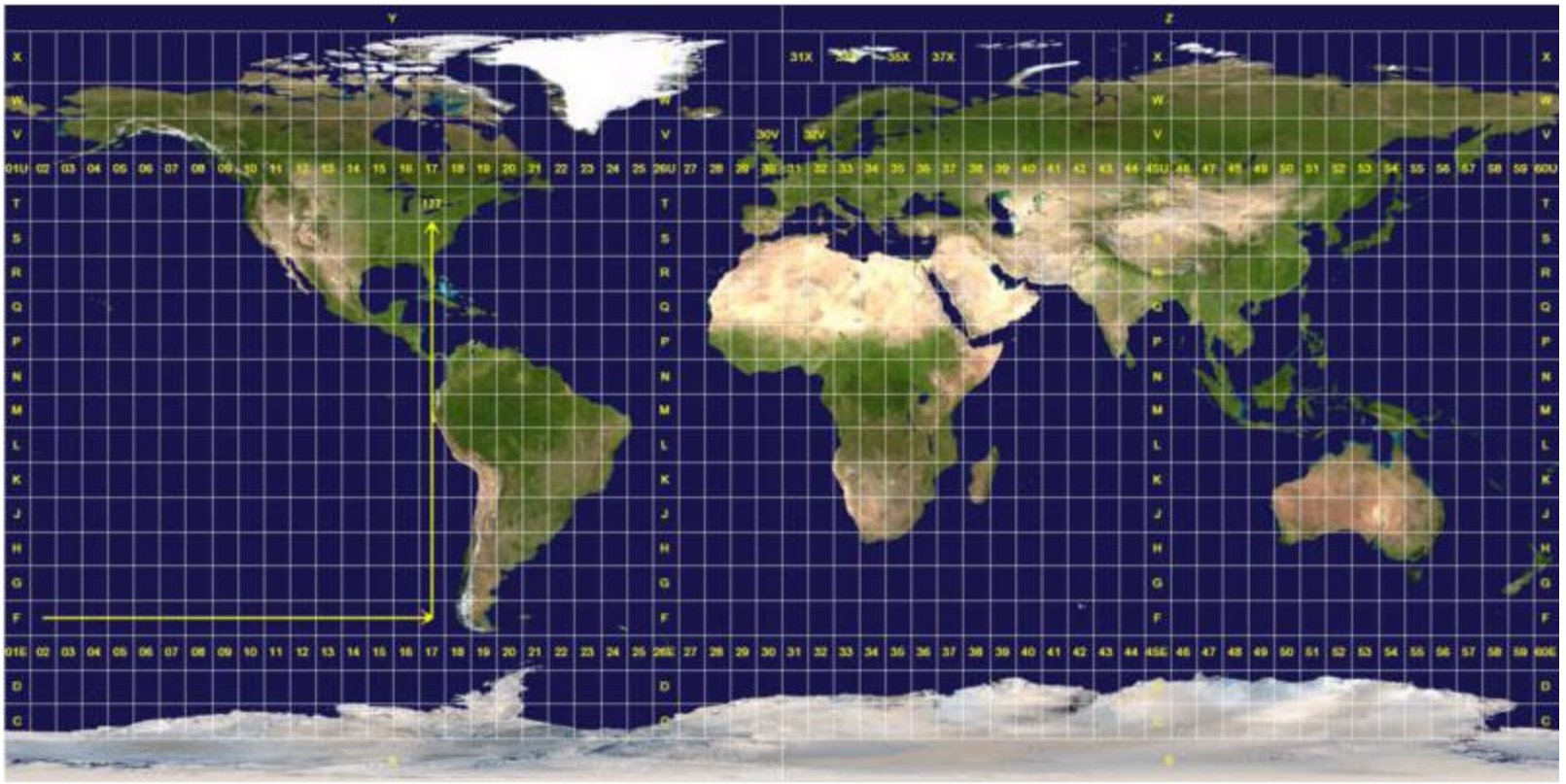
Geodetic Datums

- A geodetic datum is a reference from which measurements are made.
- A datum is a set of reference points on the Earth's surface against which position measurements are made, and (often) an associated projection model of the shape of the earth to define a geographic coordinate system.
- Horizontal datums are used for describing a point on the earth’s surface, in latitude and longitude or another coordinate system.
- The most common reference Datums in use in North America are North American Datum 27 and 83 or NAD27, NAD83, and World Geodetic System 84 or WGS84, which is used by Global Positioning Systems or GPS.

Grids

- **Universal Transverse Mercator Grid**. The UTM grid has been designed to cover that part of the world between latitude 84° N and latitude 80° S, and, as its name implies, is imposed on the transverse Mercator projection.
- Longitude zones are six degrees wide. They are numbered from 01 at 180° west, increasing towards the east until 60 at 180° east.
- Latitude zones are 8° high. They are lettered from C to X, omitting the letters "I" and "O", beginning at 80° south.
- The letters A, B, Y and Z are used in the polar regions by the Universal Polar Stereographic grid system.
- A grid reference is read "right, up", as indicated by the arrows. A reference is always written with the longitude zone first. In this example, "17T".

Universal Transverse Mercator Grid

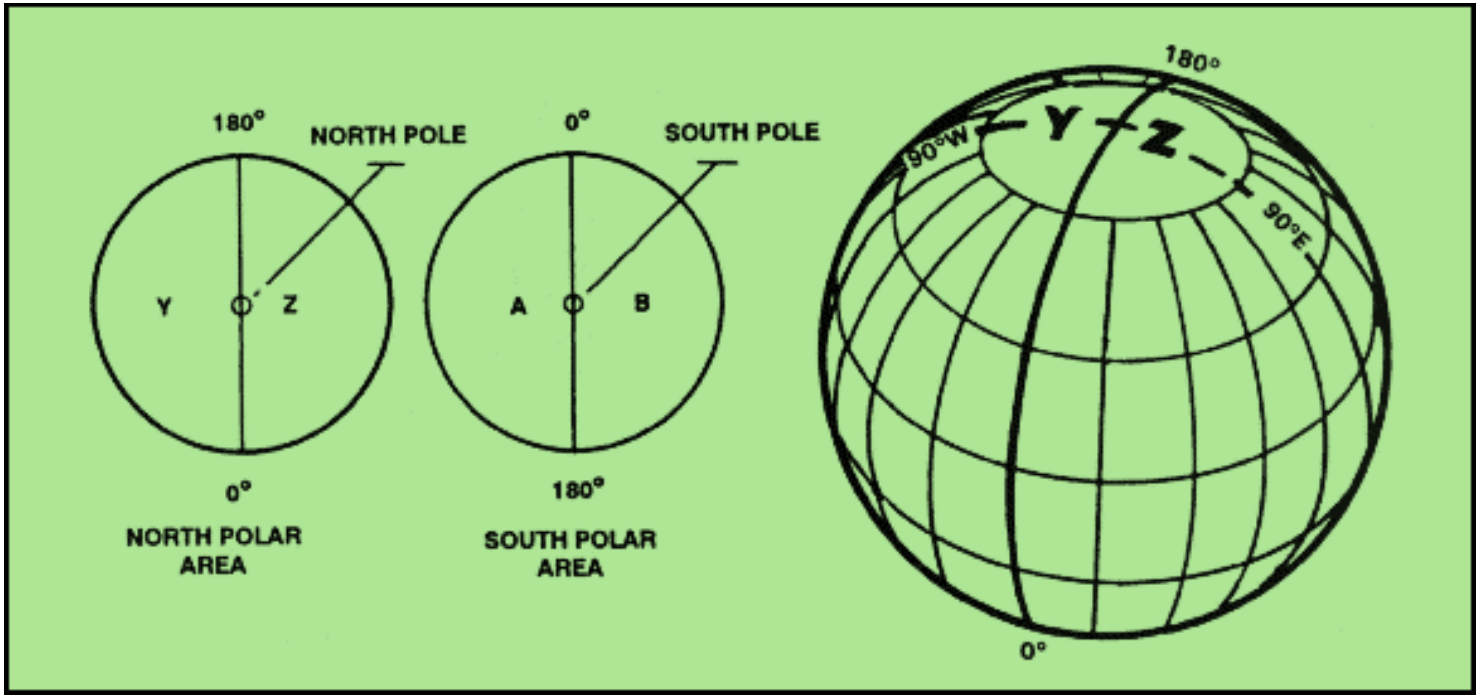


Universal Transverse Mercator Grid

- Each of the 60 zones (6 degrees wide) into which the globe is divided for the grid has its own origin at the intersection of its central meridian and the equator). The grid is identical in all 60 zones.
- Base values (in meters) are assigned to the central meridian and the equator, and the grid lines are drawn at regular intervals parallel to these two base lines. With each grid line assigned a value denoting its distance from the origin, the problem of locating any point becomes progressively easier.

Grids cont.

- **Universal Polar Stereographic Grid**. The UPS grid is used to represent the polar regions.



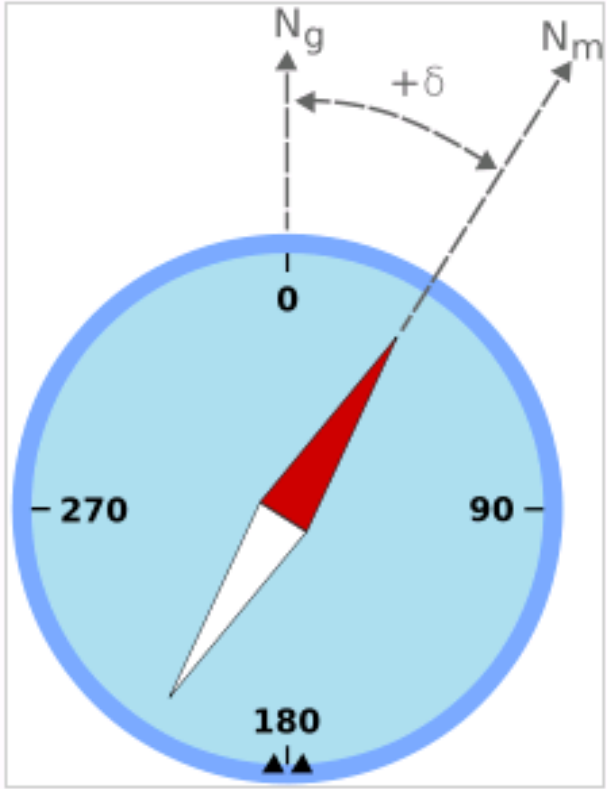
Universal Polar Stereographic Grid.

- ***North Polar Area***. The origin of the UPS grid applied to the north polar area is the north pole. The "north-south" base line is the line formed by the 0-degree and 180-degree meridians; the "east-west" base line is formed by the two 90-degree meridians.
- (2) ***South Polar Area***. The origin of the UPS grid in the south polar area is the south pole. The base lines are similar to those of the north polar area.

Compass Bearings

Magnetic Declination

- **Magnetic declination** is the angle between magnetic north (the direction the north end of a compass needle points) and true north.
- The declination is positive when the magnetic north is east of true north.
- Magnetic declination varies both from place to place, and with the passage of time.
- As a traveler cruises the east coast of the United States, for example, the declination varies from 20 degrees west (in Maine) to zero (in Florida), to 10 degrees east (in Texas), meaning a compass adjusted at the beginning of the journey would have a true north error of over 30 degrees if not adjusted for the changing declination.



Example of magnetic declination showing a compass needle with a "positive" (or "easterly") variation from geographic north.

Compass Bearings cont.

- When navigating by following a compass bearing, one must always correct for magnetic declination.
- Global Positioning Systems
  - READ YOUR OWNER”S MANUAL ☺
  - Carry spare batteries