❖ What is Map?

- The map is a primary language of Geography.
- This geographic form of spatial data abstraction is composed of different grid system, projections, and symbol libraries, methods of simplification and generalization, and scale.
- Knowledge about cartographic methods will increase a portion of our spatial vocabulary that we have called **graphicacy**.
- An improved level of graphicacy will assist us in all four subsystems of the GIS tool kit.
- As we produce output from our GIS, we will have a batter fill for how best to display the result of analysis because we will be familiar with cartographic methods and its design criteria.

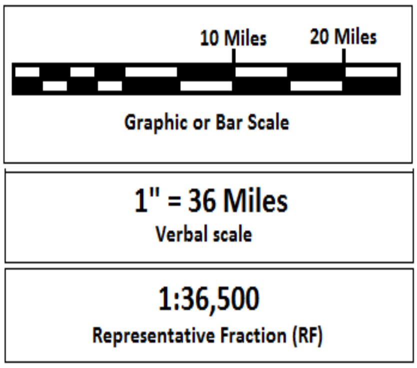
❖ Abstract Nature of Map :-

- The map is a model of spatial Phenomena.
- It is an abstraction: it is not a version of reality that is meant to show every detail of a study area.
- Although this may sound rather evident, at times we have all either ignored or forgotten this simple fact.
- There are limits to what we can do with cartographic skills. The primary reason for our misinterpretation of the limits of maps to display reality is that they are among the most elegantly designed graphical instruments created to communicate spatial data.
- Maps come in wide verity of forms and subject matters.
- The two primary types are the **general reference map** and the **thematic maps**.
- We have seen already, most of what we will deal with in GIS has to do with thematic maps, although at times reference maps are used as input to GIS.
- Primary to permit the disassembly from the more complex map of selected data.
- Although we will largely limit our discussion to thematic maps, much of what is covered in his chapter can be readily applied to the reference map.

❖ Map Scale :-

- The maps are always the **reduction** of reality. Although it might be intellectually appealing to envision a map that physically covers our entire study area, such a map would require us, once again, to explore a planet on foot.
- A primary purpose of any thematic map is to allow us to view important detail, for a large region at a single glance without the destruction of extraneous details.
- The amount of reduction is primarily a function of the level of detail we need to examine our area.
- If we are looking at a very small area (e.g. 20 hectares) we are not required to reduce the reality as much as we would if we were looking at a study area of 1000 hectares.
- ***Scale*** *is the term commonly applied to the amount of reduction found on maps.*
- It can more easily be defined as: “*Scale is a ratio of distance on map to the same distance as it appears on the map”*.
- For example, a map legend might indicate that 1 inch on the map is equal to 63,360 inches it is called ***Verbal Scale***.

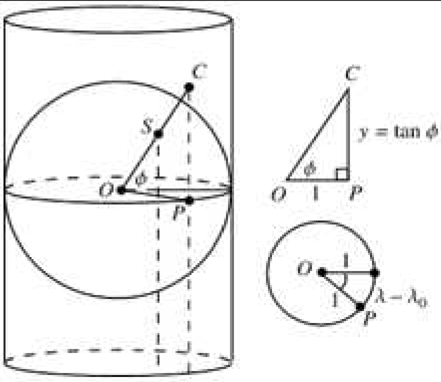
- This common method of expressing scale is the advantage of being easily understood by most map users.
- Another common method is **Representative fraction (RF)**, in which both the map distance and ground distance are given in the same unit, as a fraction there by eliminating the needs to include unit to measure.
- Experience map users most often prefer the RF Method.
- However you are really hearing the shorthand version of the verbal scale, and your contact is trying to say that the map scale is 1 inch = 600 feet. This translates into a RF of 1:7200.
- Actual area measures may be illustrated on the map.
- A graphic scale device can be place on the map during the input, and as the map scale change on output, so will the scale bar itself.
- The scale at which you input the data may differ from the scale at which you display the result.



❖ Map Projections :-

- Maps, as we have seen, are the reduction of reality, designed to represent not only its features but also its shapes and spatial configurations as well.
- The use of globes (પૃથ્વી) is traditional method to representing the Earth's shape.
- Although globes preserve the majority of earth's shape and illustrate the spatial configuration of continent sized features, they are very difficult to carry in one's pocket, even at extremely small scale (1:100, 00,000).
- Most of the thematic map encounter in the practice, as in GIS analysis, is of considerably large scale (1:1,000) depending on the level of details.
- A globe of this size would be difficult and expensive to produce even more difficult to carry around or to spare out on a digitizing table as a input of GIS.
- As a result, cartographers have developed a set of techniques called a Map Projection designed to depict with reasonable accuracy the spherical earth on two-dimensional media.
- The process of creating the map projection was originally envisioned as positioning a light source inside a transparent globe on which opaque (અપારદર્શક) earth features were placed then projecting the features outline onto a two-dimensional surface surrounding the globe.
- Different ways of projecting called as a ***Projection Family***.
    1. Cylindrical fashion
    2. As a clone
    3. As a flat piece of paper
- Projections are not absolutely accurate representation of geographic space. Each will impose its own types and amount of distortion on the map document.
- **Preserving direction** (*azimuthal*), a trait possible only from one or two points to every other point.

- **Preserving shape locally** (*conformal* or *orthomorphic*)
- **Preserving area** (*equal-area* or *equiareal* or *equivalent* or *authalic*)
- **Preserving distance** (*equidistant*), a trait possible only between one or two points and every other point
- **Preserving shortest route**, a trait preserved only by the gnomonic projection
- Analytical operation will detect which projection should be used so that the important characteristic of our map must remain preserve.
- ***It is impossible to preserve all these properties at the same time when performing the map projection***.
- The process of map projection as it is mathematically produced is twofold:



Cylindrical Map Projection

- **First** scale change convert the actual globe to a reference globe based on the desired scale then the reference globe is mathematically projected onto the flat surface.
- *When we reduce the scale from its actual globe to its reference globe, we would change the representative fraction (RF) to reflect this scale change. The RF for the reference globe is called* ***Principal Scale*****.**
- Principal scale is calculated by dividing the earth's radius by the radius of the globe.
- When we moved to spherical reference globe to two-dimensional map, however the scale factor will necessary be changed, because the flat surface and the spherical surface are not completely compatible.
- While projecting the reference globe to the flat map counterpart, we would note that the ***Scale Factor (SF)***, defined by Actual Scale divided by the Principal Scale, ***should remain 1.0 at every location on reference globe***.

1. **Orthomorphic Map Projection :-**

    - When we working with the globe, the cardinal direction of the compass fond on its side will always occur at 90^o of one another.
    - In other word east will always occur at 90^o angle to north.
    - This property of maintaining a correct angular correspondence can be preserve on map projection as well.
    - The projection that retain this property of angular conformity is called ***Conformal*** or ***Orthomorphic Map Projection***.
    - Because of SF is always remain 1.0 in every direction for every point on the reference globe, conformal projection permit us to mathematically arrange the stretch and compression, so that within the projected map, the SF is keep the same direction.
    - This type of projection result in a distortion of area, means if area measures made on the map, they will be incorrect.

2. <u>Equidistance Map Projection</u> :-

- <u>If our purpose is in protecting a map to accurately measure a distance we must select a projection that preserves distan</u>ce. Such projections called Equidistance Projection require us to keep the scale of the map constant.
- It must also be the same as the principal scale on the reference globe. There are two ways in which this can be done.
  i. The first maintain a scale factor of 1.0 along one or more parallel lines called **Standard Parallels**. Then distance measured along these lines will be accurate representation of real distance.
  ii. The second approach is to maintain a scale factor as 1.0 in all direction from either one or two points. Distance measure from these starting points will be then accurate representation of true distance.

3. <u>Equal Area Map Projection :-</u>

- General reference and the educational maps most often require the use of equal area projection, but our interest is in analysis.
- As the name implies, these maps are best used when calculation of area are dominate.
- ***<u>For example</u>*** if your interest is in the calculation of the changing percentage of a land cover type over a time or if you are trying to analyze the particular land area to determine whether it is large enough to be consider for a shopping mall, equal area projection is best. When considering the use of an equal area projection, you will need to take into account the size of the region involved as well as the distribution and amount of angular deformation.
- **Two types of equal area projection :**
  i. Albert's Equal Area Projection
  ii. Lambert's Equal Area Projection

❖ Grid System for Mapping :-

- Grid and coordinate system is necessary to reckon the distance and direction on the earth.
- The geographic coordinate system based on Latitude and Longitude is useful for locating objects and features when they are confined to the spherical earth or its reference globe.
- Because we will most often operate with two-dimensional maps projected from this reference globe, however we also need one or more coordinate systems that correspond to the distortions introduced though that process. These reference systems, called **<u>Rectangular Coordinates</u>** or **<u>Plane Coordinates</u>**, allow us to locate objects correctly on the flat maps.

1. <u>Rectangular Coordinate System</u> :-

- It is also the one that most of us learned when working with the graphs and number lines. It consists of two lines **abscissa** and an **ordinate**.

- ***Abscissa***: it is a horizontal line that contains equally spaced numbers starting from 0, called the origin and extending as far as we wish to measure the distance in either of two directions.
- The values are positive if we move to the right to the 0.
- The values are negative if we move left to the 0.

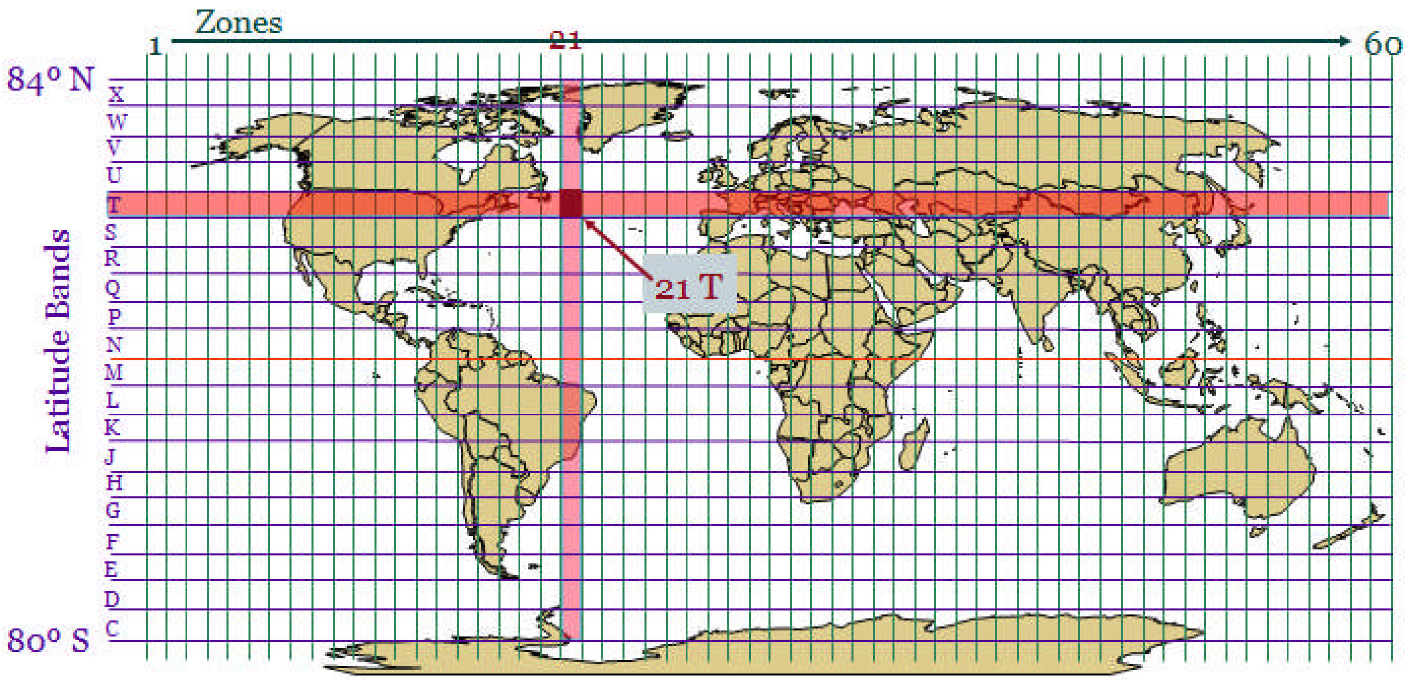
- ***Ordinate*:** It allows to move vertically from the same point of origin in a positive or negative Y direction.
- Together the X and Y coordinates allows us to locate any point or feature by combining the value of X and Y.

- Te **digitizer**, the device we use to input the geographic coordinate in to GIS, are based on this **Cartesian Coordinate System.**
- Maps of this type are most likely to illustrate only small portion of the earth's surface. Each of large scale maps are uses their own coordinate system to ensure a degree of accuracy of measurement.
- By tradition, when reading maps using rectangular coordinates, we give the X value first and Y value second.
- When amp is oriented with north at top, the normal situation, the X value, is called an ***easting*** because it measure the distance east of the origin or starting point.
- In like manner the Y value is called ***northing***, because it measure the distance north of the origin.
- As you can see, there is no southing or wasting. Instead the origin is placed so that all values are positive. It allows us to read first right and then up from the origin, a process called ***reading right-up***.
- In some cases the size of the area will require us to construct a number of **false origins** to ensure that the each portion of the earth is accurately represented on a flat surface.

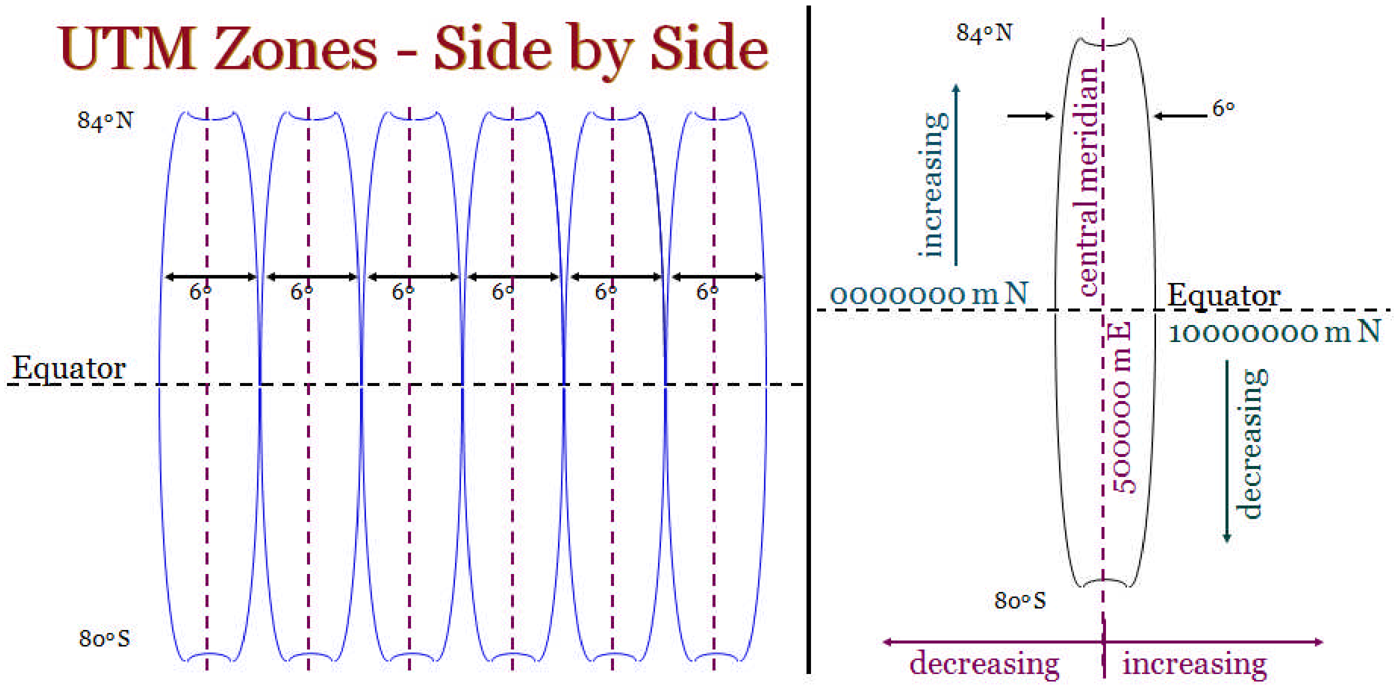
2. Universal Teraserver Mercator :-

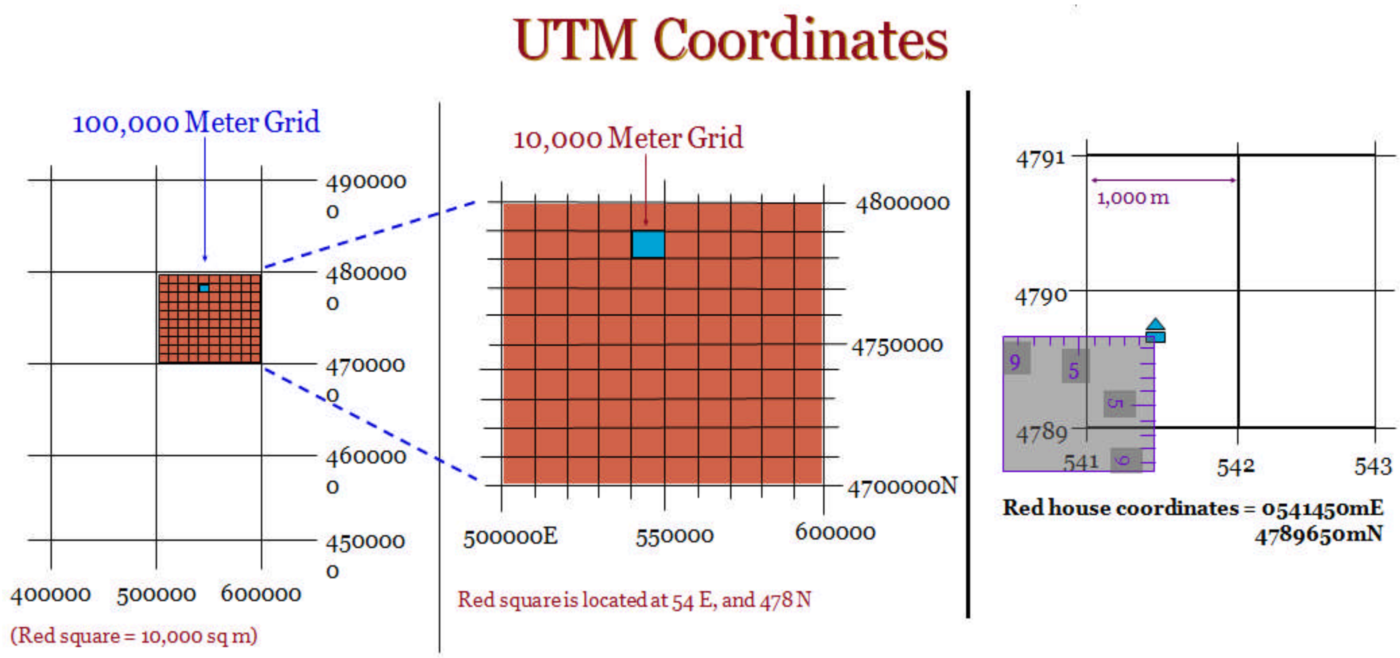
- It is a rectangular coordinate system derived from latitude and longitude.
- ***UTM divide the earth from 84º North and 80º South***.
- ***The earth is divided into 60 UTM zones***.
- ***Each zone is divided by 6º***. **(6^0 Per Zone * 60 Zones = Total 360^0)**
- These zones are numbered starting from 180º west meridian in a eastward direction.
- Sixty zones allow the earth to be projected onto maps with minimal distortion.
- UTM uses false values (easting and northing) to derive coordinates.
- ***Coordinates are expressed in meters***.

UTM Grid Overlay
60 Zones, and 20 Latitude Bands



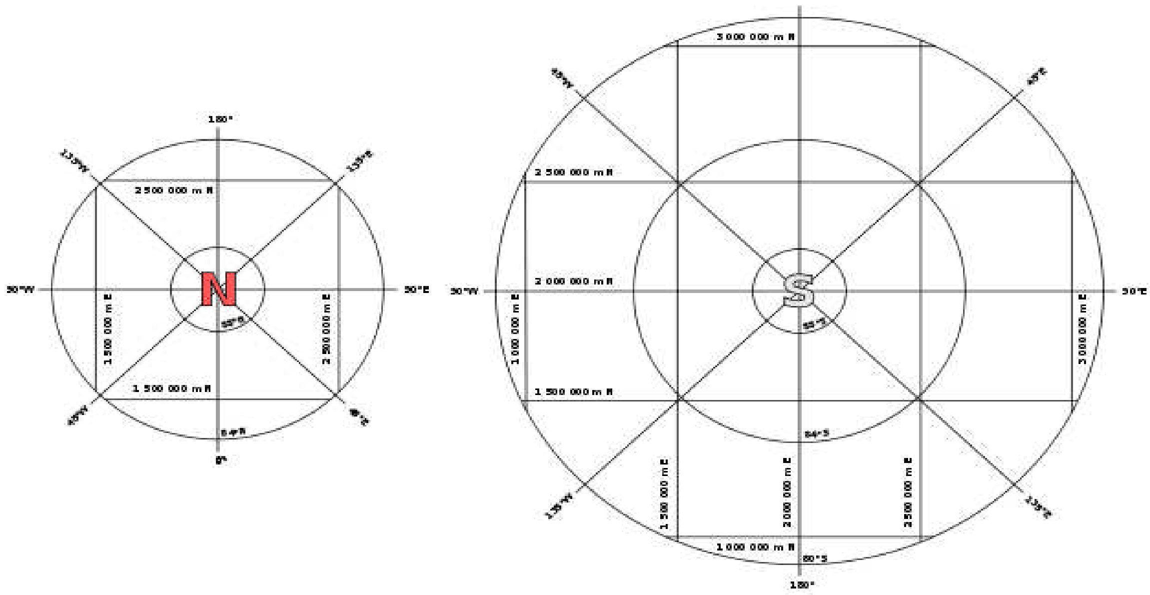
UTM Zones - Side by Side





3. Universal Polar Stereographic (UPS) Grid :-

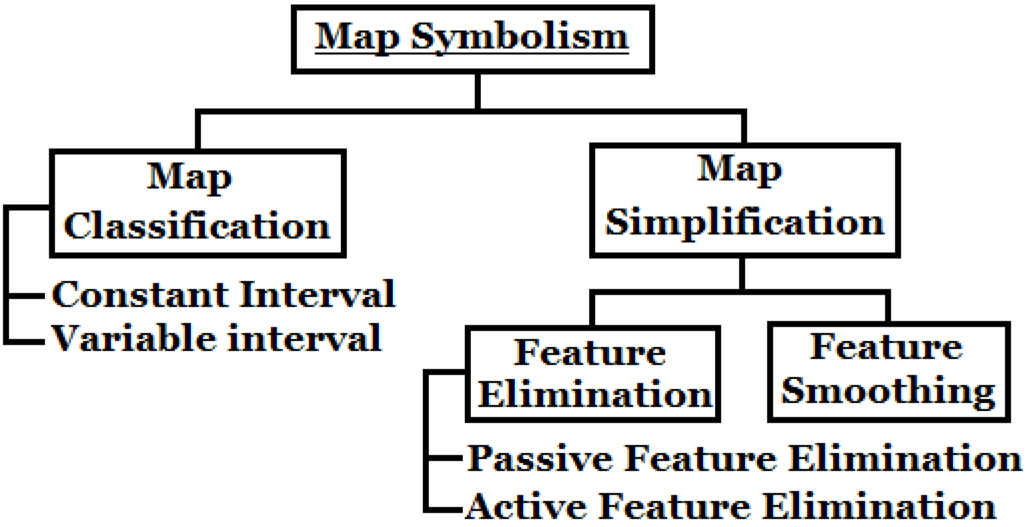
- **The Universal Polar Stereographic (UPS)** coordinate system is used in conjunction with the Universal Transverse Mercator (UTM) coordinate system to locate positions on the surface of the earth.
- Like the UTM coordinate system, the UPS coordinate system uses a metric-based Cartesian grid laid out on a conformally projected surface.
- UPS covers the Earth's Polar Regions, specifically the areas north of 84° N and south of 80° south, **which are not covered by the UTM grids.**



4. Public Land Survey System (PLSS):-

- Commonly used plane or rectangular grid system in United State is the US Public Land Survey System (PLSS) establish in 1785 as a method of Land Subdivision.

- As a land subdivision, it is not formally tied to any particular Map Projection; it was meant as a tool for recording ownership of land.
- The Public Land Survey System (PLSS) is a method used in the United States to survey and identify land parcels, particularly for titles and deeds of rural, wild or undeveloped land.
- *Its basic units of area are the* **township** and **section**. It is sometimes referred to as the **rectangular survey system**.
- **Township** and their smaller, square-mile **section** are located within a large grid of vertical and horizontal lines.
- The horizontal lines called baselines, allows measurements of township lines, whereas the vertical lines, called **principal meridians**, measure the longitudinal bounds of land through measurement called **ranges**.
- The PLSS is often portrayed on projected maps together with other rectangular grid systems; the square sections are often offset east and west to account for converging meridians as we moved away from the equator.
- All grid systems rely on accurate measurements of earth's size.
- *Such measurements, in turn, are dependent on some reliable starting point from which to begin. This starting point is generally referred to as a* ***datum***.
- The datum allows geodetic scientist and surveyors to compare their earth measurement not only among themselves using a common datum but also to other ordinate system based on other datums.
- Datums are based on the somewhat nonspherical shape of the earth known as an ***ellipsoid***.
- In North America, the first datum was devised in 1866, based on reference points along the earth surface, which characterized the earth's ellipsoid as heaving an equator axis of 6,378,206.4 meters and a polar axis 6,356,538.8 meters.
- These values resulted in a fitness ratio of 1/297 by using the following formula :
- $f = 1 - \frac{b}{a}$ Where: a = the equator axis, b = the polar axis.
- Although the simpler fitness ratio 1/297 was already adopted as the international standard, the original was used or the 1927 **North American Datum (NAD27)** because a substantial amount of mapping in the United State had already taken place using the order standard.
- Unlike the previous example, the newer datum has been established that are based on estimates of the center of earth. in 1983, for example, a new datum was established for the United State **North American Datum (NAD83)** it become the standard **Geodetic Reference System (GRS80)**. A modified version of GRS80, developed by U.S. military in 1984 resulted in the **World Geodetic System (WGS84)**.



❖ Map symbolism:-

- Maps are not exact reality but rather abstraction.
- We have observed that geographic objects occur as points, lines, polygons, and surfaces, and we have also seen that they can be described by four different levels of measurements.
- When we move to cartographic abstraction, we need to represent all these objects by careful selection, no matter what their measurement level.
- S that the result will physically fit on the space provided and the reader can understand what is being presented.
- We now have some sample set of symbols that corresponds to point, line, polygon, and surface at all level of measurement.
- Lines can be used to illustrate the surface. This may add some confusion for ***two reasons***:
  1. The invoice may tend to misinterpret lines as one-dimensional feature rather than as a symbol of surface. This form of confusion is easily overcome by continued familiarity with map feature and symbols as more and more maps are encountered.
  2. The second problem is that of interpreting the lines themselves as a accurate representation of point evolution values.
- The GIS analyst should examine the map carefully before proceeding with data encoding based on symbol manipulation.
- When mapping area under the communication purpose, we want to **group the areas into meaningful** as well as visual applying the aggregation. The many common methods of grouping or aggregation are collectively called **Class Interval Selection (CIS) or Map Classification**.

1. Map Classification :-

- Among these methods of class interval selection we find several categories that merit examination. *Constant and Variable Intervals*.

- **Constant Intervals :-**
  - ✓ This group of methods include heaving the same number of areas within each category or the same number of data point for each class, or simply dividing the range of values from start to finish into an equal number of classes. Each of these constant interval methods has its own characteristics.
  - ✓ Some will produce well balanced output; other will be more convenient; and still others will ensure that all classes will have data.

- **Variable Intervals :-**
  - ✓ These approaches produce maps that are less intuitive but may be highly useful for isolating certain high or low values, or for highlighting variations in values.
  - ✓ This method can be systematic, including arithmetic, logarithmic or the data into natural grouping used to determine where the class interval will be designated.

2. Map Simplification :-

- Of course, symbolism and classification are not only cartographic compilation methods to be noted.
- The **Graphical or Map Simplification** that takes place on the map as this classified data and their symbols are transferred to paper.
- This process present a particular problem during GIS input, but it is also measured the subsequent measurement and other analysis.
- Simplification goes further then classifying the data we will find on a map or then determining the types and levels of abstraction for the symbols used.
- Instead, simplification **eliminated** some features that are not wanted, or **smoothes**, aggregate or further modify the feature on map. Two basic methods are used:

  - **Feature Elimination.**

    - ***Passive feature Elimination :-***
      - When we observe a portion of a earth, we use our geographic filter to make decision about which feature we will note and which we will ignore. The importance of the features during the data gathering process is determined before we begin, and it is largely controlled by our reason for gathering the data in the first place.
      - The selection of object for investigation will act as a passive process of feature elimination on our map, because only the features selected will be placed in the database or map document.

    - ***Active feature Elimination :-***
      - Unlike the passive feature elimination, active feature elimination can be used in data collection and cartographic database development as well.
      - When we select certain electromagnetic radiation bands for remote sensing, we are actively eliminating certain portion from our data set.

Prepared By: Ajay A. Ardeshana, Lecturer of MCA, GARDI VIDYAPITH, Rajkot.
Email: ajay.24021985@gmail.com **Mobile:** +91-95588 20298

- The sampling schemas we discussed earlier also actively promote selectivity by eliminating large portion of the object that could be collected.
- We also perform the active feature elimination on the map or digital cartography.
- In all these cases a set of rules are formulated to determine which are selected and which are not. **Whichever set technique is applied, the result is a less detailed output**.

- **Feature Smoothing.**

  - Another useful method of simplification is smoothing.
  - This method abstract the detailed geometric objects into objects reduced in detail.
  - Important geometric features are retained by representing a given detail as a simplified geometric shape.
  - On map showing a coastal regions, boundaries, sinuous streams, or islands, we may generalize the lines that represent these regular features so that their existence is recorded but their spatial details are minimized to fit on the document.
  - GIS Input from these maps will result in less then satisfactory measures of length, shape, area or other geometric properties.