COURSE TITLE

CARTOGRAPHY AND COMPUTER AIDED DESIGN

Chapter one

INTRODUCTION TO CARTOGRAPHY

Cont’d

- At the end of this chapter, you will able to :
  - Define cartography and map
  - Know the scope of cartography
  - Understand process of cartography and mapping
  - Identify advantages and dis advantages of map
  - Explain characteristics of map
  - List marginal information of map
  - Describe map projections and coordinate system

Introduction to cartography and mapping

- Cartography is about the making and study of maps in their all aspects. It is the artistic and scientific foundation of map making
- “Cartography is the art, science and technology of making maps, together with their study as scientific documents and works of art.”
- It is one of the branches of graphics for it is an efficient way of manipulating, analyzing, and expressing ideas, forms, and relationships that occur in two- and or three-dimensional space.
- In broad sense , cartography includes any activity in which the presentation and use of maps is a matter of basic concern.

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- This may include:
  - Teaching the skills of map use involving map reading, analysis & interpretation
  - Studying the history of cartography
  - Maintaining map collections with associated cataloguing & bibliographic activities
  - Collection, organization, and manipulation of data and
  - Design & presentation of maps, charts, plans, and atlases.
  - Cartography is concerned with the philosophical and theoretical basis of the rules of map making including the study of map communication.

Cont'd

- All these involves highly specialized procedures and trainings.
- But all of them deal with maps.
- It is the unique character of the map as a central intellectual object that unites all cartographers.
- ***Cartographer* is a person who makes map.**

The Scope of Cartography

- **Cartography** is like a drama played by two actors, the **map maker** and **map user**, with two stage properties- the **map** and the **data domain** (all information that can be put on a map).
- The **map maker** selects information from the **data domain** and puts it into map format.
- The **map user** then observes and responds to this information.

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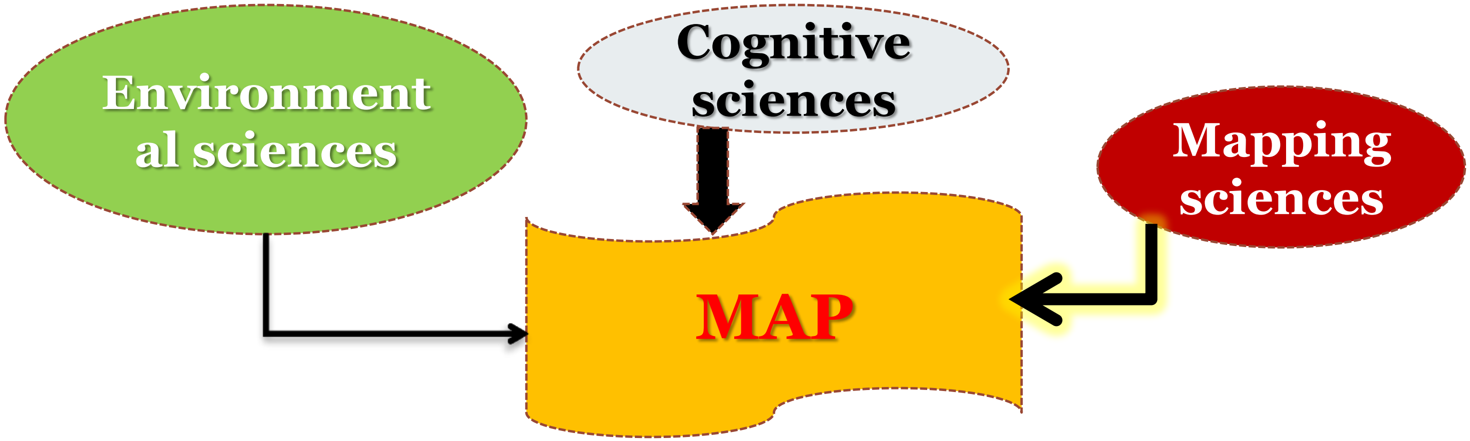
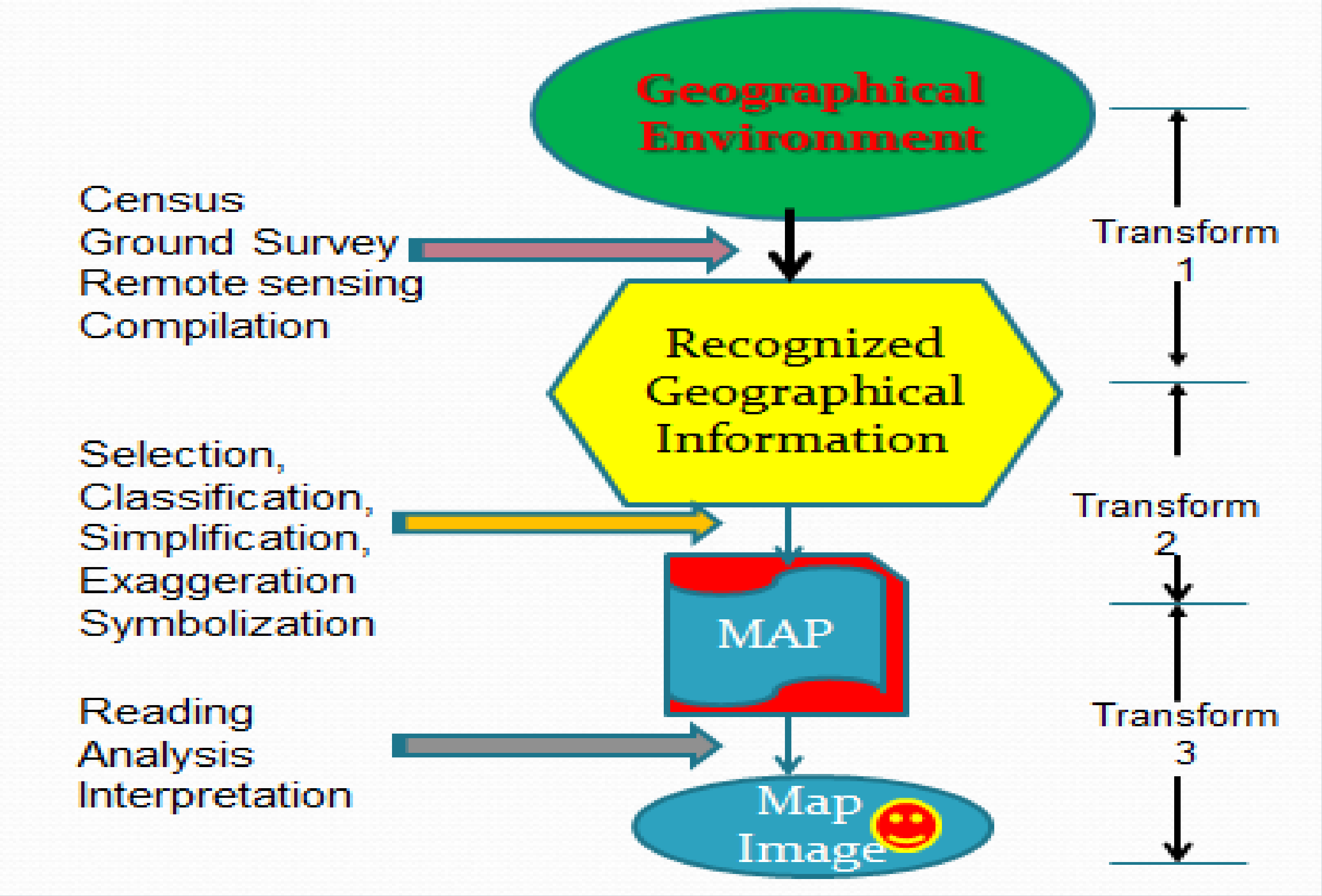
- There are **four** process in cartography:
  - Collecting & selecting the data for mapping
  - Manipulating (processing) & generalizing the data, designing and construction of the map
  - Reading or viewing the map
  - Responding to or interpreting the information

- **To master this processes a cartographer must also should know about human thought and communication (cognitive science) & the disciplines associated with environmental features being mapped.**



- **Geographers are the primary users of maps but they are not the only ones.**
- **People in the sciences, engineering, and humanities also see the map as a valuable way to organize & express ideas.**

Information Transformation in Cartography



History of cartography

- Cartography is in the midst of revolution in technology.
- Technological revolutions are not new in the history of cartography.
- But the contemporary one goes beyond the normal upheaval.
- It is caused by a universal use of electronics and, computers.
- The use of computer technology in cartographic process is referred to as digital cartography (contrasts to analogue/traditional cartography).
- The revolution is not only influencing the highly technical field of cartography but also affecting the relation b/n mapping and society in general.

Cartography yesterday

- Analogue maps provided in the past two important functions:

i) Served as a storage medium of spatial information needed by humans.

ii) Provided a picture of the world to help us understand the spatial patterns, relationships, and complexity of the environment in which we live.

Cartography today

- The computer revolution in cartography preserves the basic elements of cartographic science and Satisfy each of the former functions; Besides digital cartography provides two other distinct products:

  i) The digital database is replacing the printed map as the storage medium for geographic information;

  ii) Cartographic visualizations on many different media now satisfy the second function served previously by printed maps.

- Today the computer hardware available to cartographic scientists is capable of replacing all analogue methods used previously in cartography.

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- Software algorithms can nearly replicate all standard methods; however some of the more subjective analogue techniques, such as feature generalization and geographic name placement, are still rather crudely replaced by computer software.

Cartography tomorrow

When the revolution is through the science of cartography will have been transformed.

- Maps will not disappear, but they will take on new forms and encourage new uses/users.
- Many new cartographic visualization is envisioned in the future.
- Likewise individual access to and use of very large spatial database will become common place.
- The revolution has already run through punched cards and magnetic tapes as media of choice, and we are now using floppy disks, CD-ROMs, cassette tapes, optical disks and flash disks to store and convey digital spatial data.
- Undoubtedly, newer media will soon be discovered and existing media will be perfected.

Implication of changes

i) Cartographers are losing the control they exercised in the past.

When the print media was the sole product, cartographers were controlling graphic presentation of every bit of spatial information. But now with the emergence of digital cartography and GIS, cartographers are losing the control they exercised in the past because with digital technology , users can select the information they want to include in a visualization.

ii) Thus , as the expertise of cartographers will be confined to codifying the mapping software and data structures available to non-professionals, the non-professionals role will be shifting to the earlier map preparatory stage. The map user s on the other hand are taking on more of the actual map production assignment.

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iii) Professional cartographers placed a high importance on scale.

"Always compile a map from larger to smaller scales." They follow the same advice in digital cartography. But, individual users may adhere to it or not.

iv) Many users of digital spatial data can be accommodated by a file collected at one scale and used for visualization at a range of scales including large scales.

v) Such change in technology will generate new requirements for data and greater knowledge on the part of new users, which thus demand an expanded emphasis on cartographic education.

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vi) The need for data standardization.

Local units will feed data to central (state, national, global) coordinating organizations. Such organizations must be responsible for setting data standards and distribution.

Standards are needed for data quality, data exchange, hardware and software interoperability, and data collection procedures. Hence, knowledge of data model, features, attributes and data set lineage are some of the concepts cartographers must learn.

vii) The need to reorganize cartographic institutions. To efficiently provide the two principal cartographic products- the database & visualization- cartographers will have to reorganize cartography institutions.

The fundamental problems of traditional cartography

The shortcoming of traditional cartography are:

i) Set the map's agenda and select characteristics of the object to be mapped. This is the concern of map editing. Traits may be physical, such as roads or land masses, or may be abstract, such as toponyms or political boundaries.

ii) Represent the terrain of the mapped object on flat media. This is the concern of map projections.

iii) Eliminate characteristics of the mapped object that are not relevant to the map's purpose.

Reduce the complexity of the characteristics that will be mapped. This is also the concern of generalization.

iv) Orchestrate the elements of the map to best convey its message to its audience. This is the concern of **map design**.

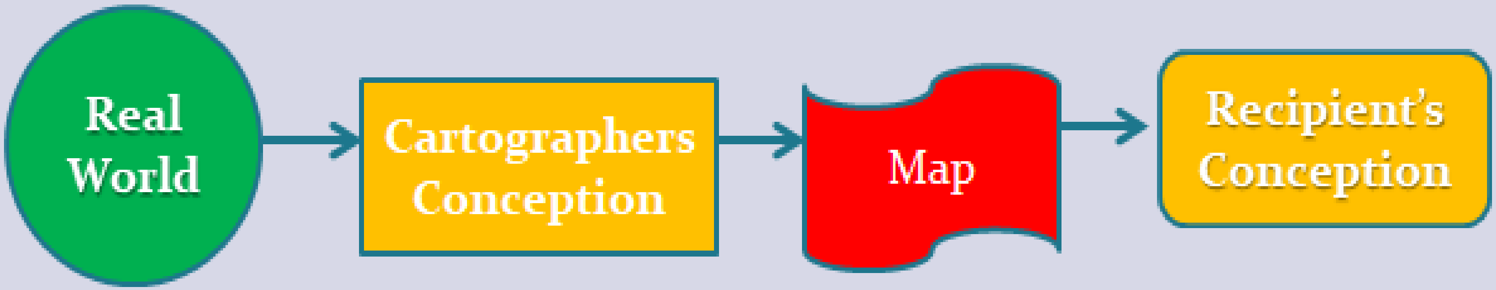
Cartographic Communication System

In the realms of maps communication takes place between the cartographer and the map user via the map. Thus, maps are medium of communication. In the cartographic communication process:

- the real world is the source,
- the encoding is the symbolism of the map and
- the signal is the two dimensional graphic pattern created by the symbols.

- The signal consists of the light rays transmitted through the channel space to the decoder, which is the eye-mind mechanism of the recipient.
- Noise is anything in the signal or channel that interferes with the transmission, such as distracting graphic patterns on the map or poor lighting, which decreases visibility.

Model of Cartographic Communication System



❖Any thing that adversely interferes with map communication and distract graphic patterns on the map such as poor lighting which lowers visibility and lack of map use/reading skills, and poor drawing are called Noise.

Sources and possible noises in a cartographic communication process.

Sources of possible noises	Examples of possible noises
Data Collection	▪Collects incomplete or wrong data
	▪Use of wrong concepts
	▪Making wrong generalization e.g. in classification
Map editor	▪Makes wrong choice of data
	▪Wrongly defined purposes
	▪Includes too much or too little information
Cartographic designer	▪Selecting wrong visual variables
	▪Design wrong symbols ▪ Poor lay out
	▪Applies overpowering lettering
Cartographic draftsman	▪Produces poor line quality
	▪Places text incorrectly
Reproduction Specialist	▪Produces poor quality products
	▪Produces low quality printing
Map user	▪Does not detect all relevant information
	▪Had no adequate background knowledge
	▪Gives wrong interpretation to information

Types of Cartographic/geographic data: by shape

- Based on their shape cartographic data are classified in to three shapes: point, line and area.
- Point data: Points are used represents zero-dimensional features
- Points represent geographic features that have no area or length, or features that are too small for their boundaries to be apparent for a given map scale.
- However every object in reality takes up space and no geographic feature can really have any length or width. Instead, you can use points to represent geographic features on maps and GIS.

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- They are used to represent real-world objects, such as water valves, electrical transformers, survey benchmarks, and street lights.
- **Line data**: is used to show the geometry of linear features such as roads, rivers, contours, footpaths, flight paths and so on.
- Similarly, polylines used to store a road network should be connected at intersections.
- Because in reality comes from different direction should cross each other forming intersection, except in ring road
- In some applications you can set these special rules for a feature type (e.g. roads) and the GIS will ensure that these polylines always comply with these rules.

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- Areal feature: are most often represented by closed polygons.
- These polygons are formed by a set of connected lines, either one line with an ending point that connects back to the starting point, or as a set of lines connected start-to-end.
- Note that there is no uniformly superior way to represent features.
- Some feature types may appear to be more "naturally" represented as points, e.g., sample pits as points, roads as lines, and parks as polygons.
- However, in a very detailed data set, the sample pit may be represented as circles, and both edges of the roads may be drawn and the roads represented as polygons

What is map?

- The answer to the question, “what is a map?” is that “ maps are neatly drawn, bird’s eye views of the earth’s surface or beyond”. They are drawn/graphical representation of features of the earth’s surface or beyond.
- A map is “a graphic depiction of all or part of a geographic realm in which the real-world features have been replaced by symbols in their correct spatial location at a reduced scale.” (Clarke, 2001)
- A map is “a symbolized image of geographic reality, representing selected features or characteristics resulting from the creative efforts of cartographers and designed for use when spatial relationships are of special relevance.” (ICA, 1995)

What Purposes Maps Serve?

i) Cartography is concerned with reducing the spatial characteristics of a large area- a portion or all of the earth, or another celestial body- and **put it in a map form to make it observable**.

- As microscopes and telescopes used to enlarge microscopic things and enable to see objects found at great distance, respectively, a map **extends our normal range of vision**.

- A map enables us see the broader spatial relations that exist over large areas or the details of microscopic particles.

-This is the **fundamental function** of maps i.e. cartography **helps to bring a reality which is extensive into view**.

ii) Maps are carefully designed instruments for **recording, calculating, displaying, analyzing, and understanding the interrelation of things**.

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iii) Regardless of variation in the type and size all maps have the same goal **of communicating spatial relationships and forms or patterns.**

- Maps clearly preserve the locational attributes of spatial information, i.e. they show the relationship between one feature and another.

-They show not only the features and their location but show also extent and spatial limits of phenomena; they are used to measure distances, direction and area

- They are used to determine **spatial patterns formed by many features on the surface of the earth.**

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iv) **Maps show** not only information about physical and cultural features but also show **distributions of more abstract features- trade flow, use of communication, extent of political influence, or areas occupied by peoples of various races, languages, or religion.**

v) **Maps provide a major source of historical documentation and are used for regional planning and property assessment purposes.**

- Large scale or detailed map of a small region, can depict its landforms, drainage, vegetation, settlement patterns, roads, geology, or host of other detailed distributions, communicates the relationships necessary to plan and carry on many types of work such as building a road, a house, a flood-control system, or almost any other construction requires prior mapping.

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- Small scale or less detailed maps of larger areas showing floodplain hazards, soil erosion, land use, population character, climates, income, and so on, are indispensable to understanding the problems and potentialities of an area.
- Highly abstract maps of the whole earth indicate generalizations and relationships of broad earth patterns with which we may study the course of past, present, and future events.

vi) These and others can **assist researchers in the generation of hypotheses** as to why the existing spatial patterns emerged?

- What are driving forces behind such spatial relationships/patterns and what would be the trend?

Types of map

maps can be categorized in different ways based on scale , objectives and subject matter.

- **Based on scale**
  - Scale is a ratio between the dimensions of the map and those of reality (ground).
  - It shows the amount of reduction made in size when one goes from the reality (ground) to map size.
  - When a small sheet of paper is used to show a large area such as a map of Africa or even the world on a sheet the size of a page, the map is described as being **small-scale map**.
  - If a map of one page size of a book used to show only a small part of reality, e.g. less than one square kilometer area; it would be described as a **large scale map**.

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- There is no consensus on the quantitative limits of the terms small, medium, and large-scale;
- There should not be reason why there should be for the terms are relative.
  - But most cartographers would agree:
  - Reduction ratio of 1:50,000 or less (e.g. 1:25,000) would be a **large-scale map**;
  - Maps with ratios of between 1: 50000 and 1:1,000,000 would be considered **medium-scale maps;**
  - Maps with a scale of 1: 1,000,000 and or beyond would be referred to as **small-scale maps.**

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- ## Based on Function

Based on function and purpose maps serve one can recognize three main classes of maps:

1) **General Reference Maps:**

- The main objective is to show the locations of a variety of different features such as water bodies, coastlines, boundaries, roads, contour lines, etc.
- They are supposed to serve a general purpose; they can be used people of different background- engineers, agriculturalists, geographers, planners, etc. general purpose map also divided into two parts.

1.1) Large-scale general reference maps of land areas are called topographic maps.

- They are usually made by public agencies such as EMA, using photogrammetric methods, and are issued in series of individual sheet.

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- They are required for site location and other engineering purposes;
- Great attention is paid to their accuracy in terms of positional relationships among the features mapped;
- They have the validity legal documents and are the basis for boundary determination, tax assessments, transfer of ownership, and other such functions that require great precision.

1.2. Small-scale general reference maps are typified by the maps of states, countries, and continents in atlases.

- Such maps show similar phenomena to those on large-scale general reference maps;
- But because they must be greatly reduced & generalized, they cannot attain the detail and positional accuracy of large-scale maps

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2) Thematic Maps

- Thematic maps are also referred to as **special purpose or single topic maps**.
- The show and concentrate on the distribution of a **single attribute** or the relationship among several.
- They range from satellite cloud cover images to shaded maps of election results.
- Thematic maps are typified by maps of precipitation, temperature, population distribution, atmospheric pressure, average annual income, cadastral maps, vegetation map, soil map, etc.

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- They are referred so if they focus attention on the structure of the distribution rather than on location.
- Otherwise such maps may be regarded as general reference maps rather than thematic if they focus on location.
- Thematic maps may not be only small in scale, they can be large in scale.
  - For example: there is demand for maps to show the structure of individual phenomena at a level of detail suitable for making site-specific decisions like decision on ownership, fixing tax, etc. Hence, such maps need to be relatively large scale.

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3) **Charts**

- These are maps especially designed to serve the needs of navigators, nautical and aeronautical, are called charts.
- Charts differ from other classes of maps in that they are to be ***worked on*** while others maps are to be ***looked at***.
- On charts, navigators plot their courses, determine positions, mark bearings, and so on.
- Note that navigators also use general reference maps.

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- Marine equivalent of the topographic map is the ***bathymetric map***.
- Although not called a chart, the familiar road map is really a 'chart' for it is used to navigate on land.
- It supplies information about routs, distances, road qualities, stopping places, and hazards, as well as incidental information such as regional names and places of interest.

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- **Based on Subject Matter:** maps are classified by their subject matter in the following ways.

i) Cadastral maps

Cadastres were drawings that accompany the official list of property owners and their land holdings, while Cadastral map shows the geographic relationships among land parcels.

ii) **Engineering Maps (Plans)**

- They are closely allied with cadastral maps except they are more general in nature.
- Plans are in a category of large-scale maps.
- They are detailed maps, sometimes called plans or engineering maps;

Cont’d

- They are used to showing buildings, roadways, boundary lines visible on the ground, administrative boundaries;
- They are used for guiding engineering projects, such as bridges or dams, and as aid to estimating the construction costs of such projects.

iii) **Flood Control Maps:** are used to provide information about areas subject to flooding. They are derived from topographic maps

- Detailed and accurate terrain information is critical to determining such areas of risk.

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iv) Landscape map: is another type of map derived from topographic maps;

- It provides detailed site information and planting plans for gardens and parks.
- You may sketch a map of this type for own use or may need to interpret landscaping plans prepared by landscape architect.
- There is no limit to the number of type of maps grouped according to their subject matter;
- There are soil maps, geological maps, climatic maps, population maps, transportation maps, economic maps, statistical maps, cadastral maps, and so on without end.

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- . **Based on the definition that follows:** "a map is any concrete or abstract image of the distributions and features that occur on or near the surface of the earth or other celestial bodies"; **maps may be classified as either real maps or virtual maps.**

  1) Real (paper) map is any tangible map product that has a permanent form and that can be directly viewed.

  - This is paper map.

  - In the digital world such products are often referred as a "hard copy".

  - Conventionally drawn or printed products, items that were traditionally called maps.

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2) **Virtual maps** are related to real maps in one way or another and have qualities that allow them to be converted into real maps. They are divided into three types:

a) **Images** that can be directly viewed but that are not permanent; images projected in computer screen of a cathode-ray tube (CRT).

- Such an image is real enough, while the computer is turned on and the information it shows similar or identical to that of real map except it . the image vanishes when it is turned off

b) **Mental images** are the conceptual equivalent of a conventional printed map. These are maps that we have in our minds. they provide us with an awareness of the location of places. r/ships b/n places in terms of direction and distance, the size & characteristics of regions, etc.

Cont'd

- They are called " the environmental image, the generalized mental picture of the exterior physical world held by individual.

- They are "quite unlike (real) maps… because they are personal, fragmentary, in complete and presumably, frequently erroneous."

- They can be converted into a more conventional real map by sketching its image on paper.

c) **Digital Map** are maps produced by computers (in GIS environment or from RS data) and stored in computer memory in digital form.

Differences between paper maps and digital maps: paper map

- ***They can be bought physically on physical stores***: Paper maps are printed on physical papers and can be available for purchase on physical stores on your way home.
- ***Storage requires physical space***: Storage of paper maps requires that you keep them in a dedicated place in your house or in your suitcase since it can be physically handled.
- ***Paper maps can be accessed offline***: Paper maps are printed on paper that can be stored anywhere and can therefore be accessed from anywhere. You do not need a computer or internet connection to access it.

Cont'd

- ***Mostly uses symbols to represent features and routes***: Paper maps mostly rely on symbols to represent features or routes that are physically seen on land. You therefore need to interpret the symbols when reading paper maps.
- ***Cannot be updated easily***: Paper maps are printed on paper and can therefore not be updated on the same paper. This means that you cannot make any changes on the map based on the changes in landforms.
- ***It is static***: Paper maps are static representations of features on land at the time when the representations were created. One cannot modify to see the previous version of the area.

Cont'd

- ***Paper maps cannot represent all features at the same time***: paper maps usually make a representation of one aspect of the land at a time, For instance, a map could represent the rivers only or the geographical area of a place.
- ***Paper maps are limited to specific area based on the scale of the map***: Paper maps are representations that are limited on a specific area of the land and not the entire geographical location.
- ***It requires skills to interpret because of the symbolic representation of features***: Paper maps do not show objects but use symbols instead. Which means special skills are required to interpret the symbols when reading the map.

Cont'd

- ***Good at showing boundaries and for data analysis***: Paper maps are ideal for showing boundaries of an area and for analysis of data.
- ***It is important for use as data storage and for comparison of change in landforms***: Since they are static, paper maps are ideal for use as data storage for reference purposes when showing changes in land forms

Digital map

- ***They can be downloaded for free***: Digital maps are not sold in physical shops but instead they are available online and can be downloaded for free.
- ***Storage requires digital space***: Digital maps do not require physical space for storage. They are stored in digital format and therefore require digital space.
- ***Digital maps must be accessed online***: Digital maps cannot be accessed anywhere else besides online. One therefore requires an internet connection to access them online.
- ***Shows all features including time and the actual building***: Digital maps do not depend on symbols to represent features. Instead, they show the actual features and the time.

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- ***Can be easily updated***: Digital maps are mostly real time representations of an area and can therefore be updated easily because the changes will be updated automatically.
- ***It is dynamic***: Digital maps are dynamic which means one can choose to view the previous versions of the represented area unlike paper maps.
- ***Digital maps can represent all features at the same time***: Digital maps can be used to represent all features of a given area at the same time. They allow filtering for specific features but can also show the entire area.
- ***Digital maps are not limited to any area***: Digital maps are not limited to show only a specific area based on scale. They can be widened to show the entire area.

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- ***May not require special skills since it shows the real life object***: Interpreting digital maps is easier than paper maps since the features are real representations of the real world objects.
- ***Good at showing area overlays from various angles***: Digital maps do not only show 2D representations of an area. They can be used to show the 3D angle of the area and also show the area overlays.
- ***Cannot be used to show changes in land forms because it is always up to date***: Digital maps are always up to date and may therefore not be ideal for use to show changes in land forms.

Basic Characteristic of Maps

1. All maps are concerned with two elements of geographical features: location and attributes.

- Locations are positions in 2-dimensional space (x,y), while attributes are qualities or magnitudes (e.g. temperature, elevation, language, population size, etc.)

2) All maps are reduced representation (reductions) of a reality.

- The geometric r/ship between dimension on map and the reality is called scale.
- Because of limitation of map space the scale sets a limit on the information that can be included on a given map.

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3) All maps involve geometric transformations called map projection.

4) All maps are abstractions (generalization) of reality.

- Maps portray only the information that has been chosen to fit the use of map.

5) All maps use signs to stand for elements of reality.

- The meanings of the signs make up the symbolism (language) of cartography.

Map elements

- Title ... which tells about the type of the map.
- Legend ... which has all information to read the map.
- Scale ... with what measurements can be done.
- Direction Indicator ... to determine the map orientation.
- Inset/Locator Map ... which give additional Information.
- Projection Info ... which gives type of projection.
- Graticule ... with what coordinates can be read.
- Information of Data Source, Author

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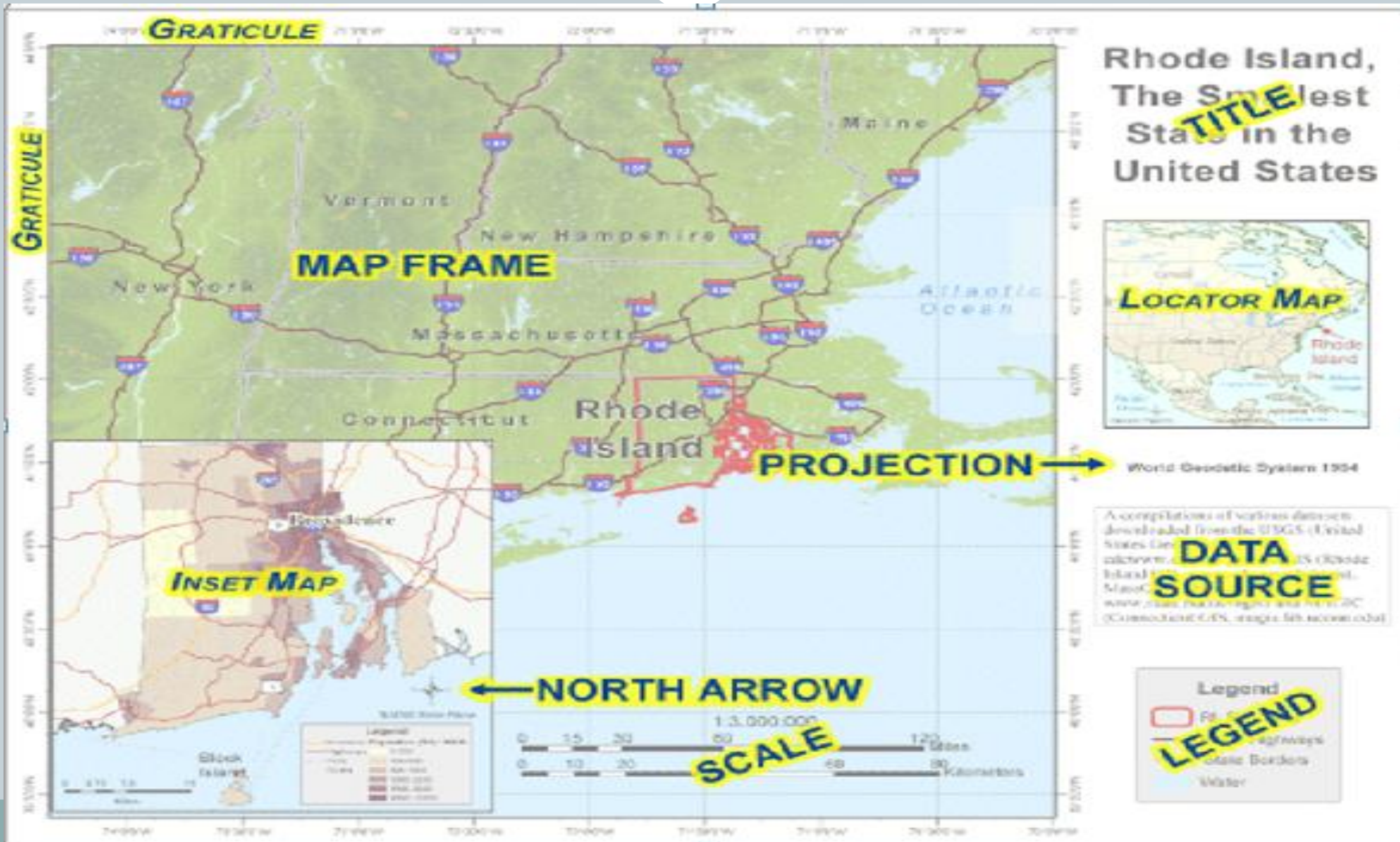
GRATICULE
GRATICULE
Rhode Island, The Smallest State in the United States
TITLE
Maine
Vermont
New Hampshire
MAP FRAME
New York
Massachusetts
Atlantic Ocean
Connecticut
Rhode Island
LOCATOR MAP
Rhode Island
PROJECTION
World Geodetic System 1984
DATA SOURCE
INSET MAP
Providence
NORTH ARROW
Block Island
1:3,000,000
SCALE
Miles
Kilometers
Legend
LEGEND
State Borders
Water

Basic Steps of Map Making

1. Collecting and selecting data for mapping
2. Manipulating and generalizing the data
3. Designing and constructing the map
4. Printing a first draft
5. Viewing, reading and analyzing the first draft
6. Implementing of important comments and corrections in the map
7. Printing the final map

Advantage and disadvantages of maps

Advantages:

- Quickly Summarize & Explanation of spatial relations
- Easier to visualize and to understand spatial patterns
- Solve complex Problems and important for decision making

Disadvantages:

- Cannot show everything, since maps are simplified
- Too much information is not necessarily good
- Misunderstandings can be misleading

Map projection and coordinate system

<u>Coordinate system</u>

- ***Coordinate*:** is a set of numbers that designate **location in a given reference system**, such as, x, y in a plane coordinate system or x, y, z in a three dimensional coordinate system.
- **Coordinate pairs** represent location on the earth's surface relative to other locations.
- ***A Coordinate System*** is a reference system used to measure horizontal and vertical distances on a plan metric (flat surface) map.

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- A coordinate system is used to define **a location on the Earth**.
- It is created in association with a map projection, datum, and reference ellipsoid and describes locations in terms of distances or angles from a fixed reference point.

Types of coordinate system

Geographic Coordinate Systems

- A reference system using **latitude and longitude to define the location of points on the surface of the earth.**
- Coordinates are expressed in degrees, minutes and seconds.
- Position coordinates are based on an angular distance from a known reference point.
- LATITUDE measures the position of a given point in terms of it's *angular distance* from the equator.
- That is, latitude is an indicator of how far north or south of the equator a given point is situated.

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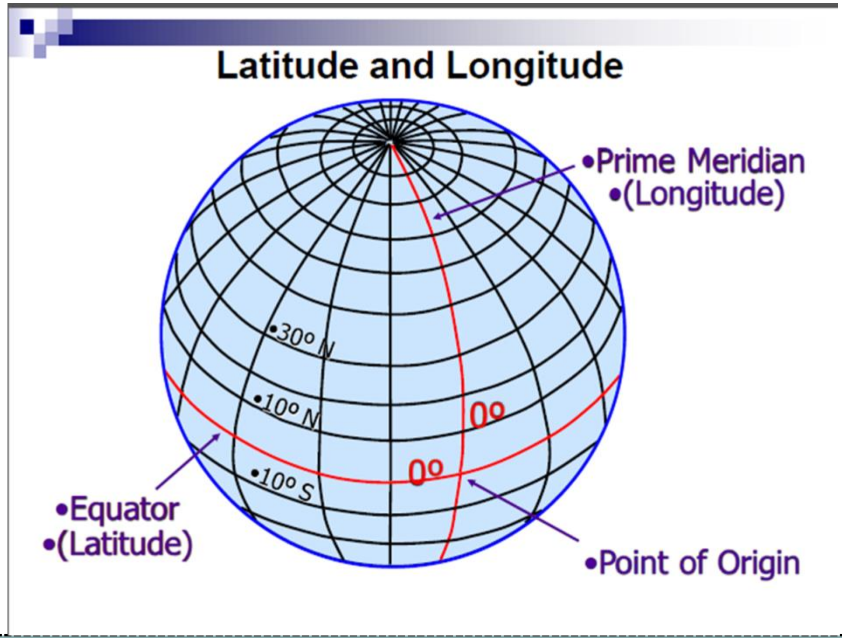
- All points north of the equator are designated as **north latitude** (*northern hemisphere*), all points south of the equator are designated as **south latitude** (*southern hemisphere*).
- Angle from equator: latitude
- Angle east of Greenwich: longitude



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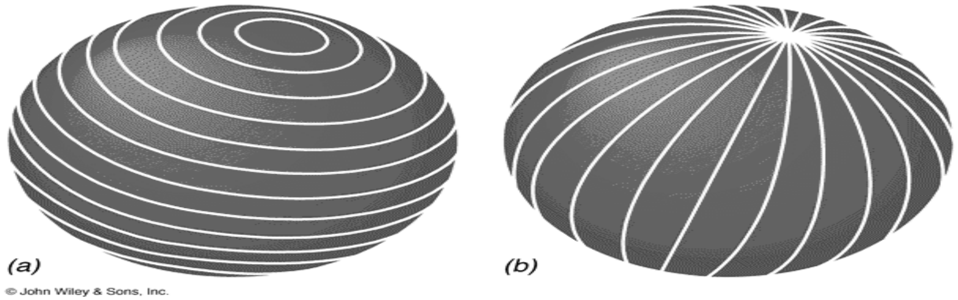
- The equator is 0º latitude, and the north and south poles are at 90º angles from the equator.
- **Longitude**
- **Longitude lines (also called "meridians") run north-south and meet at the poles.**
- **It measures distance east and west of the Prime Meridian, from 0 degrees at the Prime.**

a: PARALLELS
b: MERIDIANS



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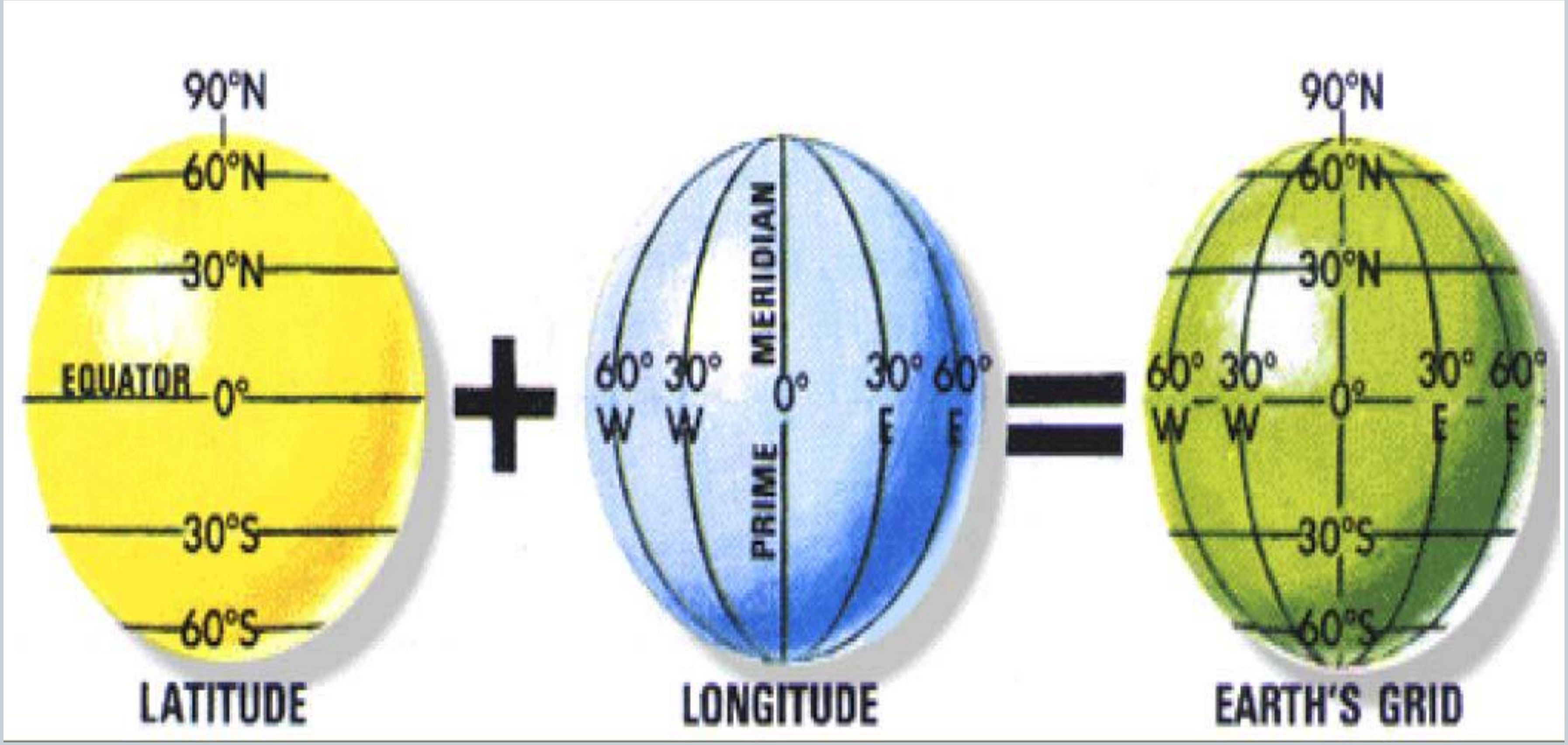

90°N
60°N
30°N
EQUATOR 0°
30°S
60°S
LATITUDE
PRIME MERIDIAN
60° W
30° W
0°
30° E
60° E
LONGITUDE
90°N
60°N
30°N
60° W
30° W
0°
30° E
60° E
30°S
60°S
EARTH'S GRID

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Projected Coordinate Systems

- A Projected coordinate system (PCS) is a two-dimensional planar surface.
- However, the Earth's surface is three-dimensional. Transforming three-dimensional space onto a two-dimensional surface is called **projection**.

- Reference systems, called *rectangular coordinates* or *plane coordinates*, allow us to locate objects correctly on flat maps (Two-dimensional maps projected from reference globe).

Cont’d

- It is based on a sphere or spheroid geographic coordinate system, but it uses **linear units of measure for coordinates**, so that calculations of **distance and area are easily done in terms of the same units**.

- The **latitude and longitude** coordinates are **converted to x and y coordinates on the flat projection.**
- The x coordinate is, usually, the eastward direction of a point and the y coordinate is, usually, the northward direction of a point.
- The centerline that runs east and west is referred to as the x-axis and the centerline that runs north and south is referred to as the y-axis.

Map projection

- The shape of the Earth is represented as a sphere. It is also modeled more accurately as an oblate spheroid or an ellipsoid.
- A globe is a scaled down model of the Earth.
  - It can represent size, shape, distance and directions of the Earth features with reasonable accuracy.
  - It is not practical or suitable for many applications.
  - It is hard to transport and store; for example you cannot stuff a globe in your backpack while hiking or store it in your car's glove compartment.

Cont'd

- Globes are not suitable for use at large scales, such as finding directions in a city or following a hiking route, where a more detailed image is essential. They are expensive to produce, especially in varying sizes (scales).
- measuring terrain properties is difficult on curved surface, and it is not possible to see large portions of the Earth at once.

- Maps do not suffer from the above shortcomings and are more practical than globes in most applications. Historically cartographers have tried to address the challenge of representing the curved surface of the Earth on a map plane, and to this end have devised map projections.

Cont'd

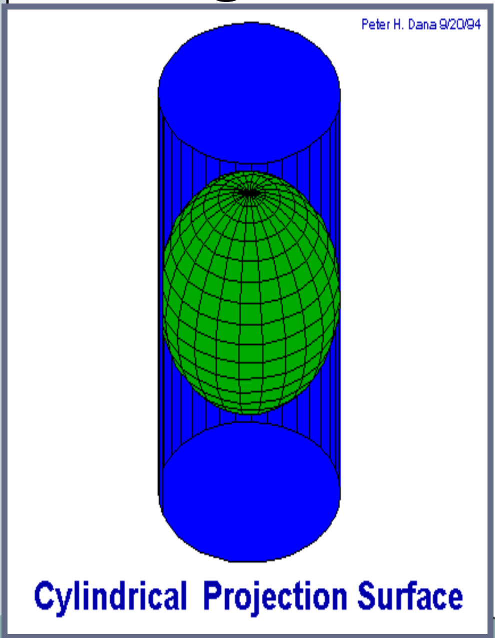
- **map projection** is the transformation of Earth's curved surface (or a portion of) onto a two-dimensional flat surface by means of mathematical equations. During such transformation, the angular geographic coordinates (latitude, longitude) referencing positions on the surface of the Earth are converted to Cartesian coordinates (x, y) representing position of points on a flat map.
- **Types of projection:** Base on developable surface

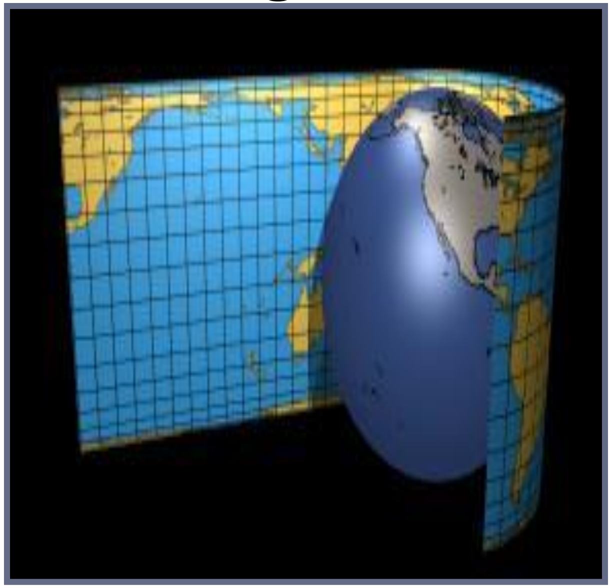
✓ developable surface is a geometric shape that can be laid out into a flat surface without stretching or tearing. The three types of developable surfaces are cylinder, cone and plane, and their corresponding projections are:

I. Cylindrical projection
II. Planner or azimuthal Projection
III. Conical Projection

Cylindrical projection

- The reference spherical surface is projected onto a cylinder wrapped around the globe. The cylinder is then cut lengthwise and unwrapped to form a flat map.
- evenly spaced network of straight, horizontal parallels and straight vertical meridians (grid like)



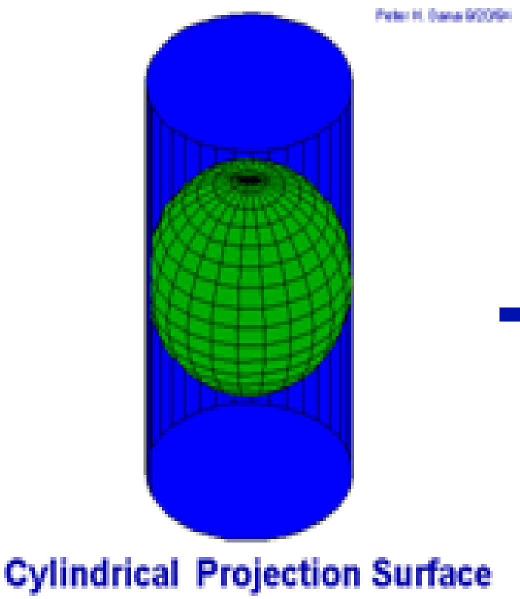


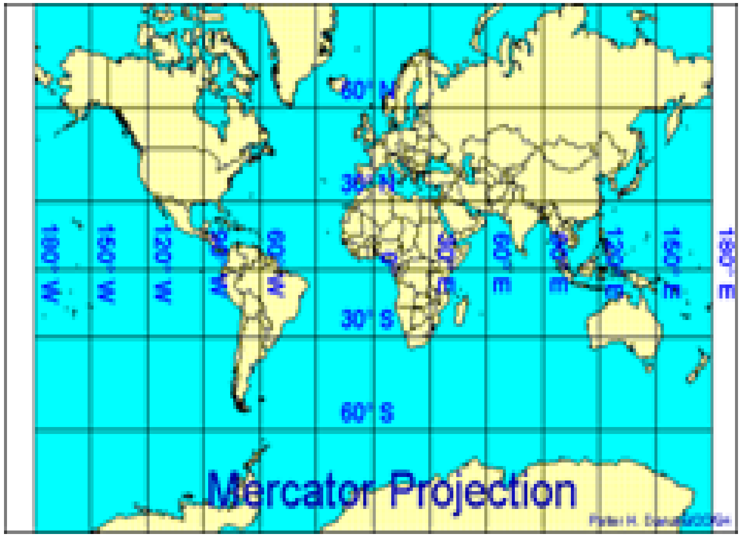
Cont'd

- The Mercator projection is one of the most common cylindrical projections,
- equator is usually its line of tangency.
- Meridians are geometrically projected onto the cylindrical surface, and parallels are mathematically projected.
- This produces graticular angles of 90 degrees.
- The cylinder is "cut" along any meridian to produce the final cylindrical projection.

Cont'd

- The meridians are equally spaced, while the spacing between parallel lines of latitude increases toward the poles





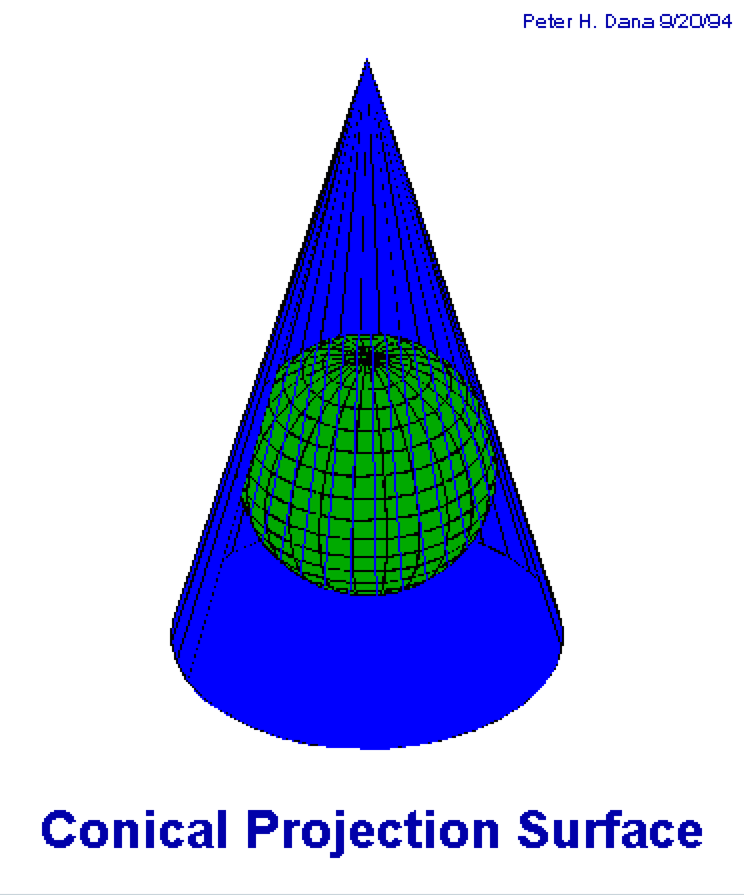
$$x = \lambda R$$

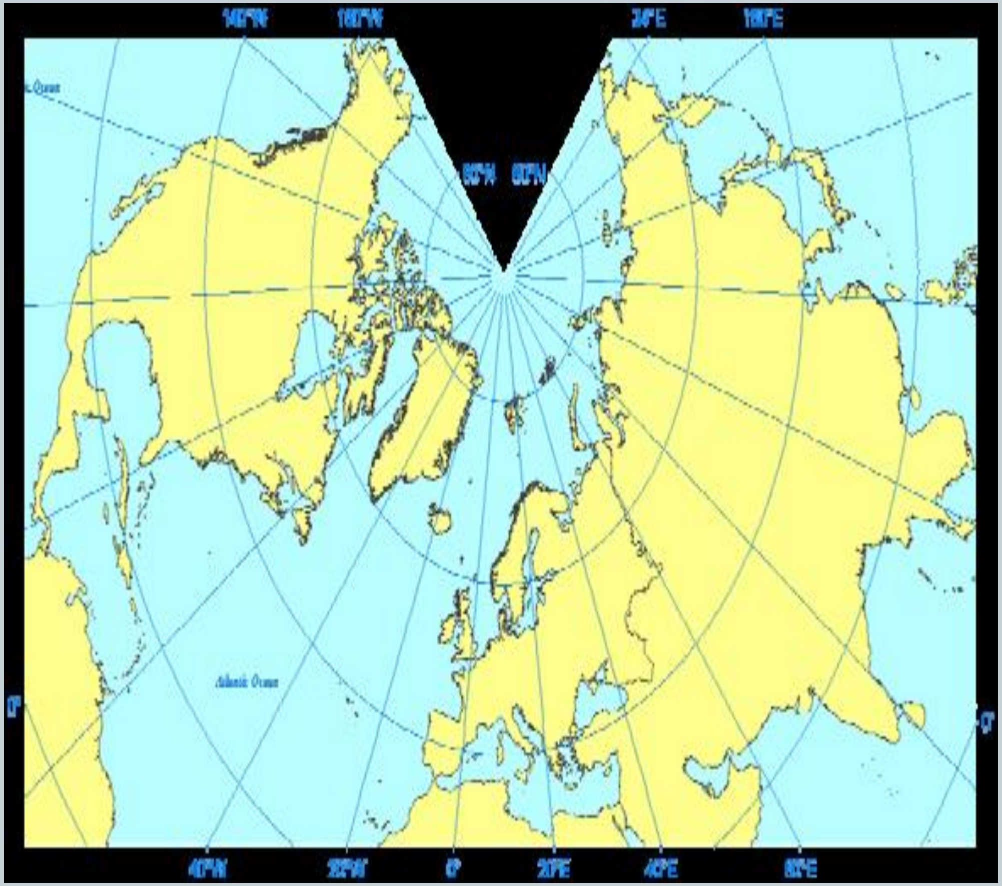
$$y = 2R \tan(\varphi / 2)$$

CONICAL PROJECTION

- Resulted from projecting a spherical surface onto a cone.
- Normally shows just one semi hemisphere in middle latitudes.
- Very popular for maps of East-West oriented land masses
- **Example: Lambert Conformal Conic**

Cont’d

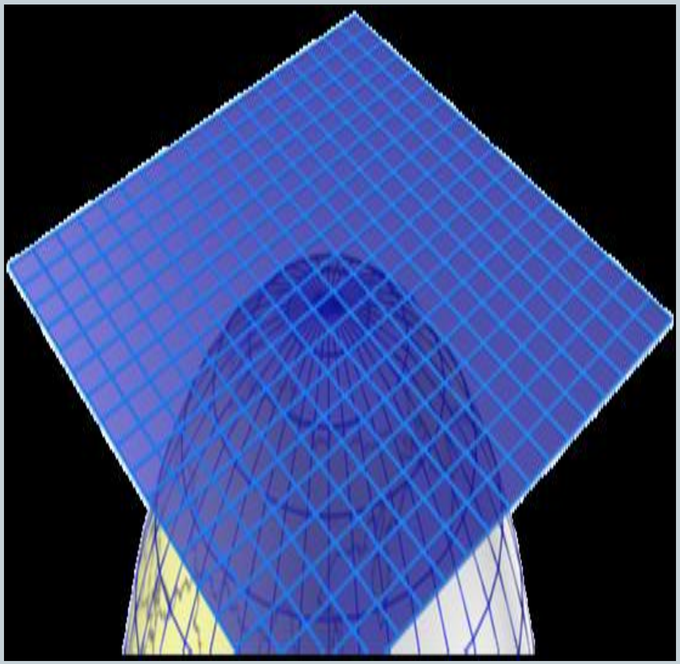


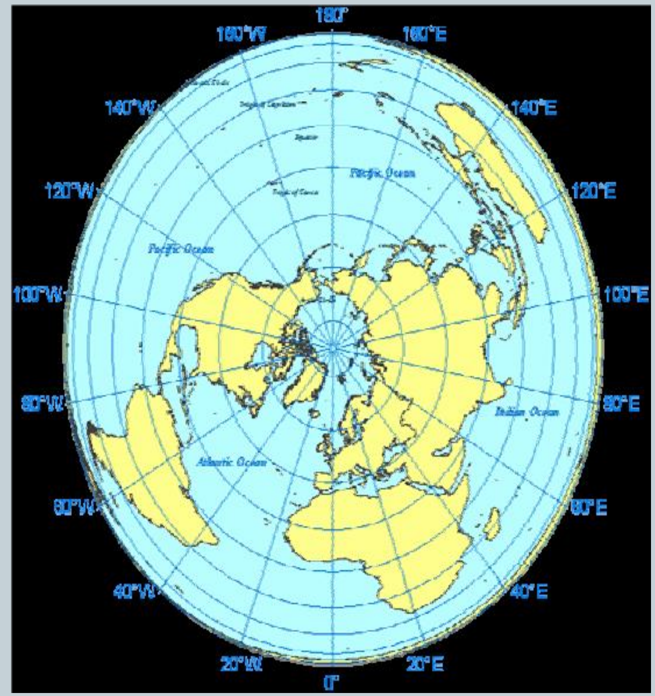


Planer, polar or azimuthal projection

- Surface of the globe is projected onto a plane tangent at only one point.
- Project map data onto a flat surface touching the globe.
- This type of projection is made upon a plane tangent to the reference surface (the globe).
- Used frequently at N or S pole
- Usually only one hemisphere shown (centered on N or S pole)
- For example: **Lambert Azimuthal Equal Area**

Cont'd




180°
160°W
160°E
140°W
140°E
120°W
120°E
100°W
100°E
80°W
80°E
60°W
60°E
40°W
40°E
20°W
20°E
0°
Pacific Ocean
Pacific Ocean
Indian Ocean
Atlantic Ocean

Based on properties preserved

based on properties preserved , map projection can be classified as follows:

I. **Conformal projection**

II. **Equivalence** (Equal Area) projection

III. **Equidistance projection**

IV. **Azimuthal or zenithal projection**

conformal projection

- preserve *shape*
- shape preserved for local (small) areas

  (angular relationships are preserved at each point)
- sacrifices preservation of area away from standard point/lines
- Used where angular relationships are important, such as for navigational or meteorological charts. Examples: Mercator, Lambert Conformal Conic.

Equivalent/Equal-area projection

- preserve *area:* the ratio of areas on the earth and on the map are constant.
- Shape, angle, and scale are distorted.
- all areas are correctly sized relative to one another
- sacrifices preservation of shape away from standard point/lines
- Used for maps that show distributions or other phenomena where showing area accurately is important. Examples: Lambert Azimuthal Equal-Area, the Albers Equal-Area Conic.

Equidistant projection

- preserve *distance*
- scale is correct from one to all other points on the map, or along all meridians
- however, between other points on map, scale is incorrect
- Used for radio and seismic mapping, and for navigation. Examples: Equidistant Conic,

Azimuthal/planer projection

- preserve *direction*
- azimuths (lines of true direction) from the center point of the projection to all other points are correct
- Used for aeronautical charts and other maps where directional relationships are important. Examples: Gnomonic projection,Lambert Azimuthal Equal-Area.

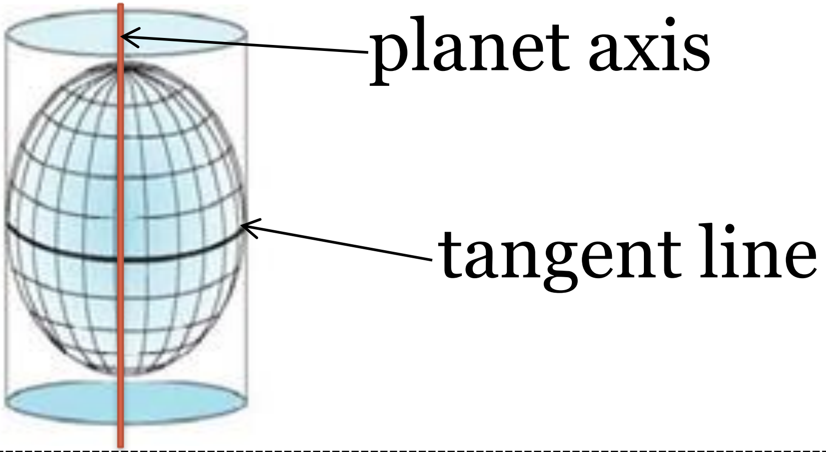
Based on orientation of axis

Types of projection based on orientation of axis:

- ✓ **The normal**
- ✓ **The transverse**
- ✓ **The oblique**

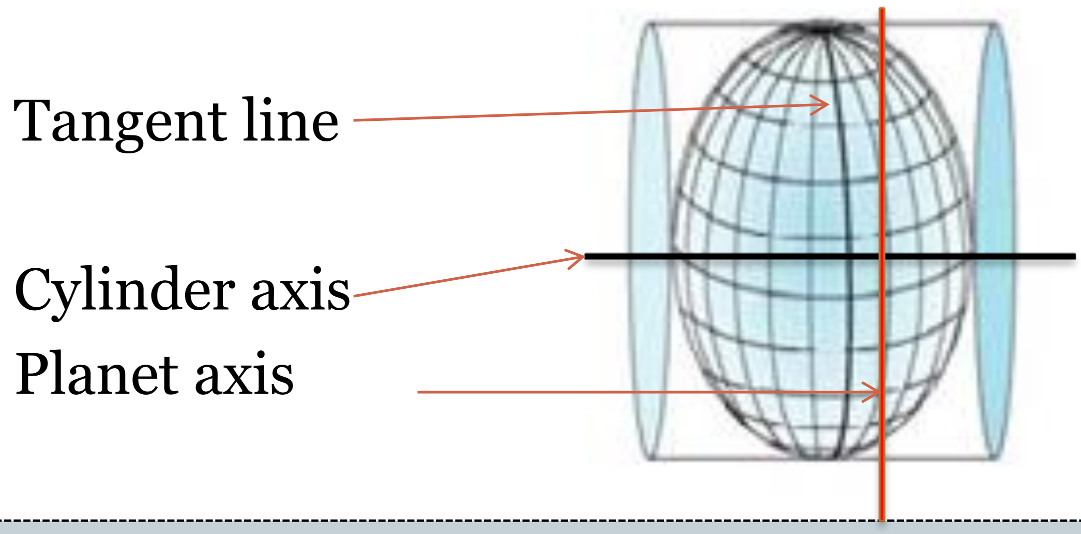
❖ **Normal projection**: occurred when the axis of the globe and the axis of projection surface is parallel.

- ✓ normal Mercator projection is one best example of normal projection.



Cont’d

- Transverse projection: occurred when the axis of globe and the axis of projection surface is perpendicular .
  - ✓ Universal transverse Mercator projection is one best example of transverse projection



Cont'd

- Oblique projection: occurred when the axis of globe and the axis of projection surface neither parallel nor perpendicular.

Cont'd

Universal Transverse Mercator projection (UTM)

- UTM is a cylindrical map projection established in 1936 by international Union of Geodesy and Geophysics, adopted by US Army in 1947, and the purpose was to get a transversal Mercator map of the whole Earth.
- mapping agencies, including NATO and now it is commonly used in topographic and thematic mapping for referencing satellite imagery.
- The earth is divided in 60 zones in longitude, between the latitudes 84° N and 80° S, each 6 in longitude since the distortion at the poles is too great with this projection.
- The numbering of zones starts from the 180th meridian from Greenwich and going eastwards.

Cont'd

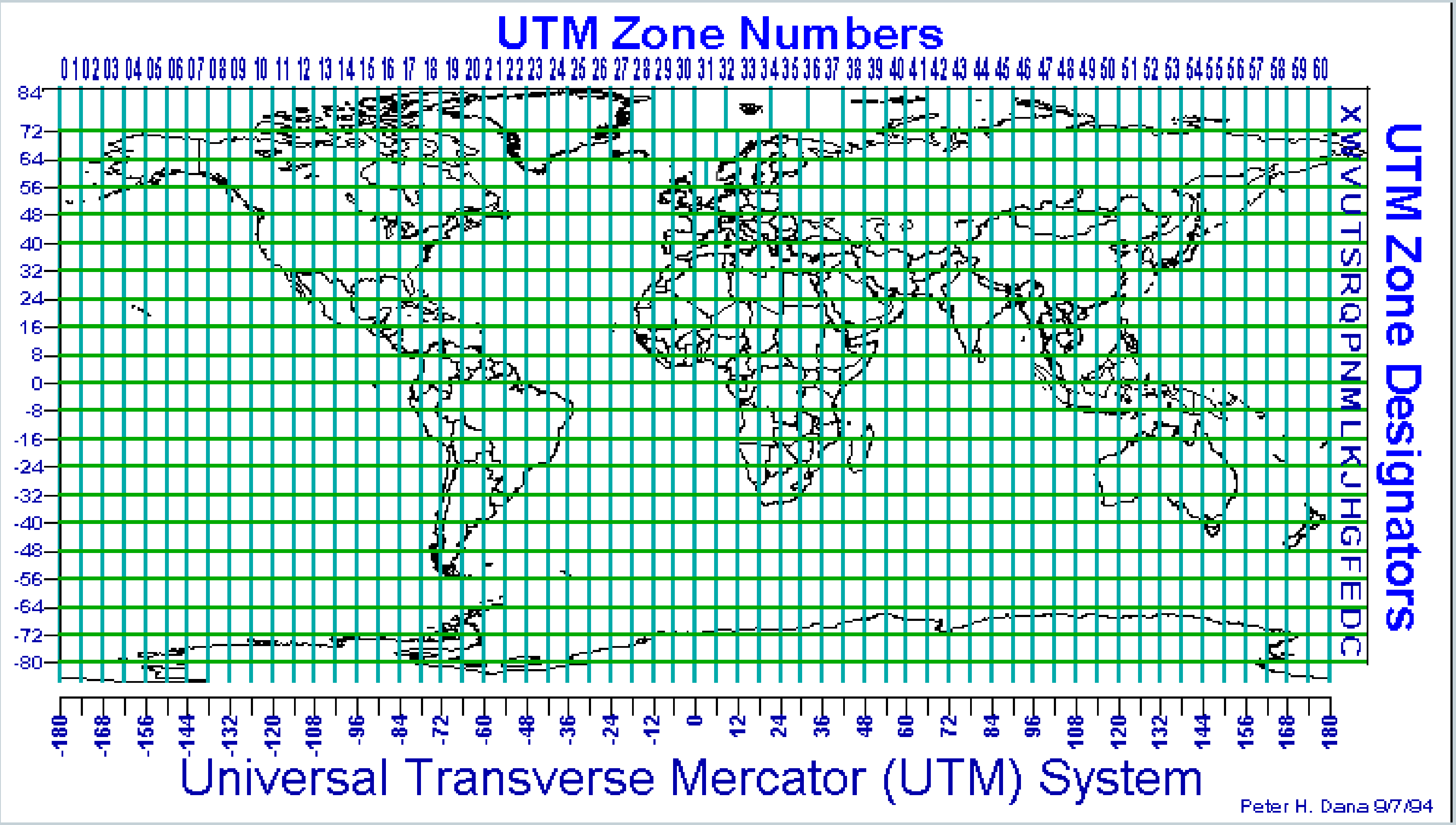
- The middle meridian in each zone is the central meridian in the projection. The international reference Ellipsoid 1924 is commonly used with the most important exception of North America where Clarke's 1866 ellipsoid is used, and in Africa Clark's 1880 ellipsoid is used Ethiopia lies in the zones 36-38.

- **In short, the universal Transverse Mercator (UTM) system:**
  - The Projection is the Gauss-Kruger' version of the **Transverse Mercator equidistant cylindrical projection .**
  - Intended for mapping areas 84degreeN -80degrees
  - Unit of measure is meter

Cont’d

- The world is divided into 60 zones 6degreeof longitude in width
- Zone 1s starts at 180degreeW and each zone has its own coordinate system
- The easting of the origin of each zone is assigned a value of 500,000m.
- The northing for each southern hemisphere the equator is assigned a northing value of 1,000,000 m.
- The UTM might use one of the following spheroid International Clarke 1880 (Africa),
- Clarke 1866 (N. America) Everest or Bessel (Asia)

Cont'd


UTM Zone Numbers
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
84 72 64 56 48 40 32 24 16 8 0 -8 -16 -24 -32 -40 -48 -56 -64 -72 -80
X W V U T S R Q P N M L K J H G F E D C
UTM Zone Designators
-180 -168 -156 -144 -132 -120 -108 -96 -84 -72 -60 -48 -36 -24 -12 0 12 24 36 48 60 72 84 96 108 120 132 144 156 168 180
Universal Transverse Mercator (UTM) System
Peter H. Dana 9/7/94

Choice of map

- As all projections are made from geographical coordinates on the earth's surface to 2D map grids involve some sort of distortions.
- No projection has all the ideal qualities of conformity, equivalence, and equidistance all in one graticule.
- The choice of projection is governed by a desire to minimize one or more of the distortions of either angles, linear dimensions or areas.
- For this reason it is important to appreciate the process of map projection and the way in which they introduce internal changes in scale which give rise to these distortions.

Cont'd

- **Some of the factors that influence the choice for map projection include**
  - Purpose of the map and needs of the map user
  - Position of the area to be mapped on the globe
  - Shape and dimensions of the area to be mapped
  - Practical considerations

Assignment

I. Define the following terms briefly

1. Cartography
2. Mapping
3. Map
4. Map projection
5. Coordinate system

II. List and explain types of map projection

III. The Ethiopian airlines plane flies non-stop from Addis Ababa to Washington D.C. The plane took off from Bole Air Port on Monday morning at 6 am and the flight took say 14 hours.

Cont'd

a) What will be the day & local time in Washington DC when the plane arrives.

b) What will be the local time in Addis A. when the plane lands in Washington DC?

Iv. Given grid coordinates of two towns, Werabe (410000mE, 868000mN) and Kebul (393000 mE, 870000 mN), both are found in Selti Zone, SNNPR.

a) What is strait line distance between the two towns in kilometer?

b) What is the direction of Kebul due (from) Werabe?