Lect 01_Data Representations and Visualisations 2
Lect 02_Mathematics of Cartography 17
Lect 03_Part 1 & 2_Cartographic Representation of the Abstraction of Reality 106
Lect 03_Part 3 & 4_Typography_Map Layout 173
Lect 03_Part 5_Conventional and Digital Mapping 222
Lect 03_Part 6_Map Proofing and Revision 239
Lect 04_Geographic Data Output Techniques 255
Lect 05_Production Managemet_170919 278

Data Representations and Visualisations

by

Mwanza, A R

Data

- Things known or assumed as facts which become the basis of reasoning or calculation.
- Is a set of values of subjects with respect to qualitative or quantitative variables.
- Data only becomes information when it is viewed in context or in post-analysis.
- Spatial data also known as geospatial data or geographic information is the data or information that identifies the geographic location of features on Earth.
- Spatial data is usually stored as coordinates and topology, and is data that can be mapped.
- Spatial data contains more than just location information on the Earth's surface.
- It also contains non-spatial data, attribute data, that describes a feature.
- Data is therefore a core component of Geographic Information Systems

Representations

- Data consist of symbols that represent measurements.
- Digital geographic data are encoded as alphanumeric symbols that represent locations and attributes of locations measured at or near Earth's surface.
- No geographic data set represents every possible location of the Earth .
- Geographic data are constructed by measuring carefully chosen representative samples of locations.
- Vector and raster data are the basic two distinct sampling strategies of geographic data.
- The vector data model represents geography as collections of points, lines, and polygons.
- The raster data model represent geography as cell matrices that store numeric values.
- The TIN data model represents geography as sets of contiguous, non-overlapping triangles.
- Of course the most common representation is a map scaled or not.

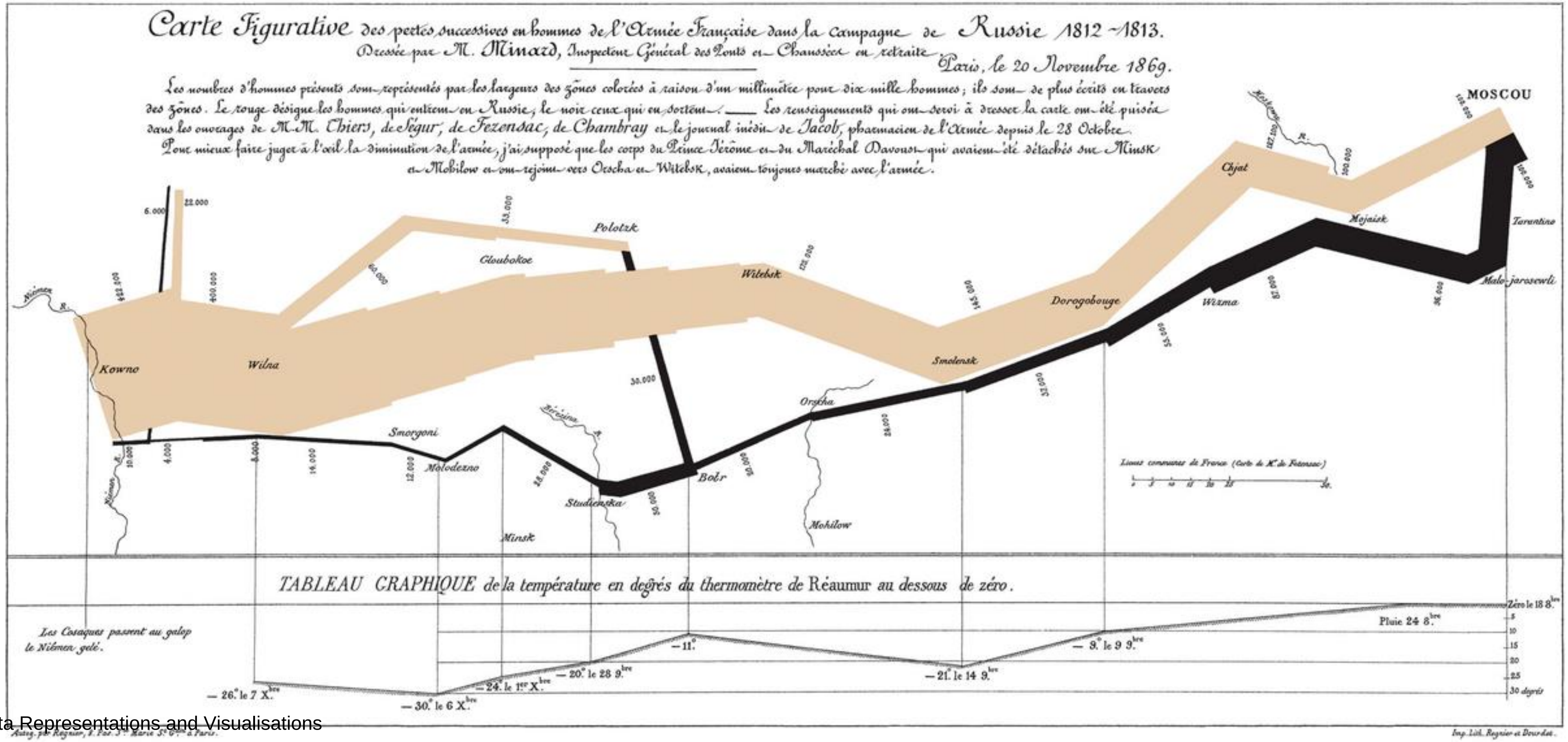
Visualisation

- Visualisation is any technique for creating images, diagrams, or animations to communicate a message.
- Visualization through visual imagery has been an effective way to communicate both abstract and concrete ideas since the dawn of humanity.
- Historically, cave paintings, Egyptian hieroglyphs, Greek geometry, and Leonardo da Vinci's revolutionary methods of technical drawing for engineering and scientific purposes are examples.
- It has been used in maps, scientific drawings, and data plots for over a thousand years.
- Examples from cartography include Ptolemy's Geographia (2nd Century AD), a map of China (1137 AD), and Minard's map (1861) of Napoleon's invasion of Russia.

Ptolemy's World Map

The Oldest Surviving Chinese World Map

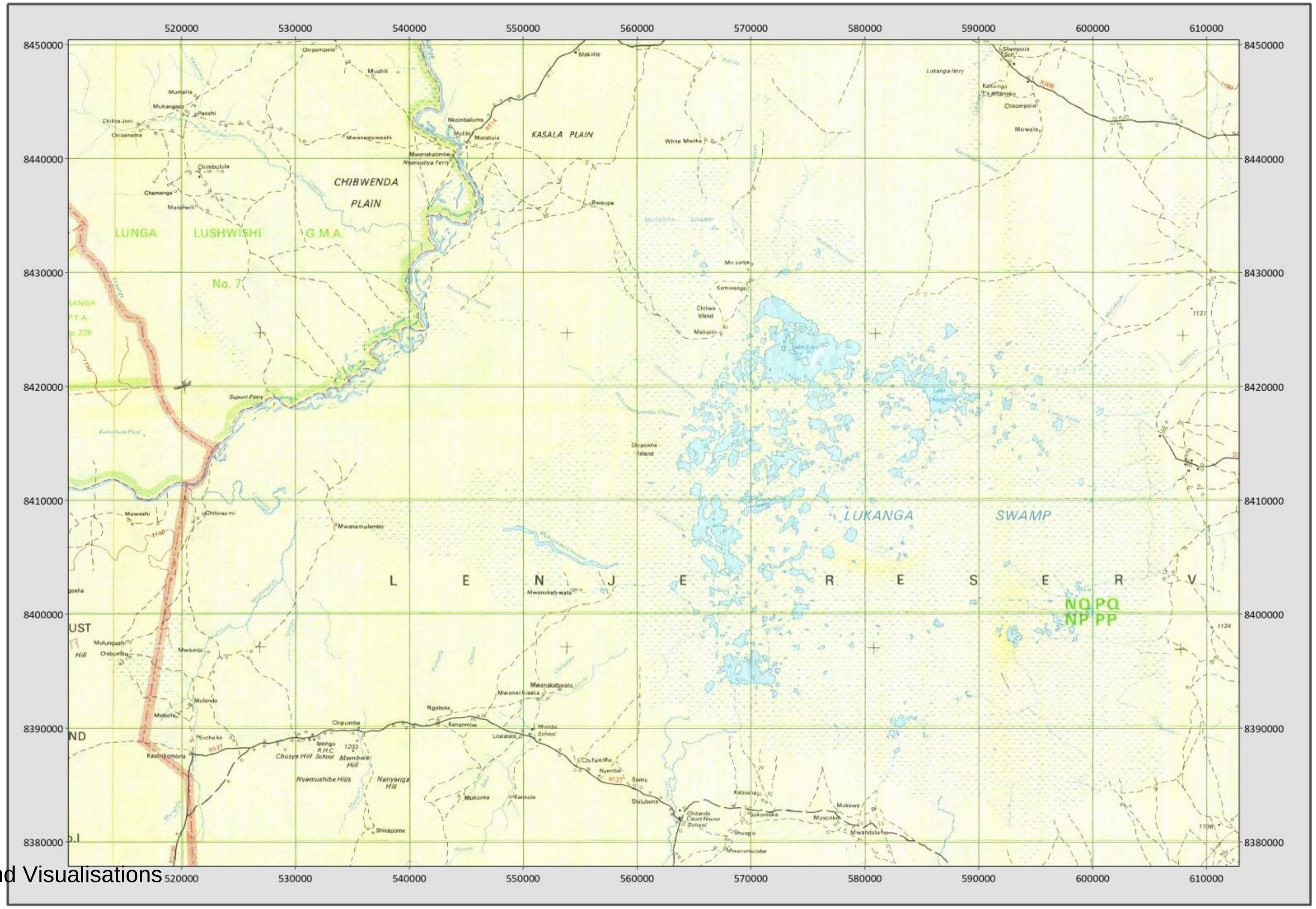
Minard’s Map of 1869



2D or 3D Data Visualization

- 2D models are basically planar, i.e., in (x, y); e.g. map on paper
- 3D models are 2D modes + height, i.e., in (x, y, z); e.g. a DTM
- 4D models are 3D models + time, i.e., in (x, y, z + time); e.g. Minard's map
- Whether to use 2D or 3D for data visualization depends on various perceptual and technical aspects such as occlusion, clutter, distortion, or scalability upon which their advantages and disadvantages relate.

2D Model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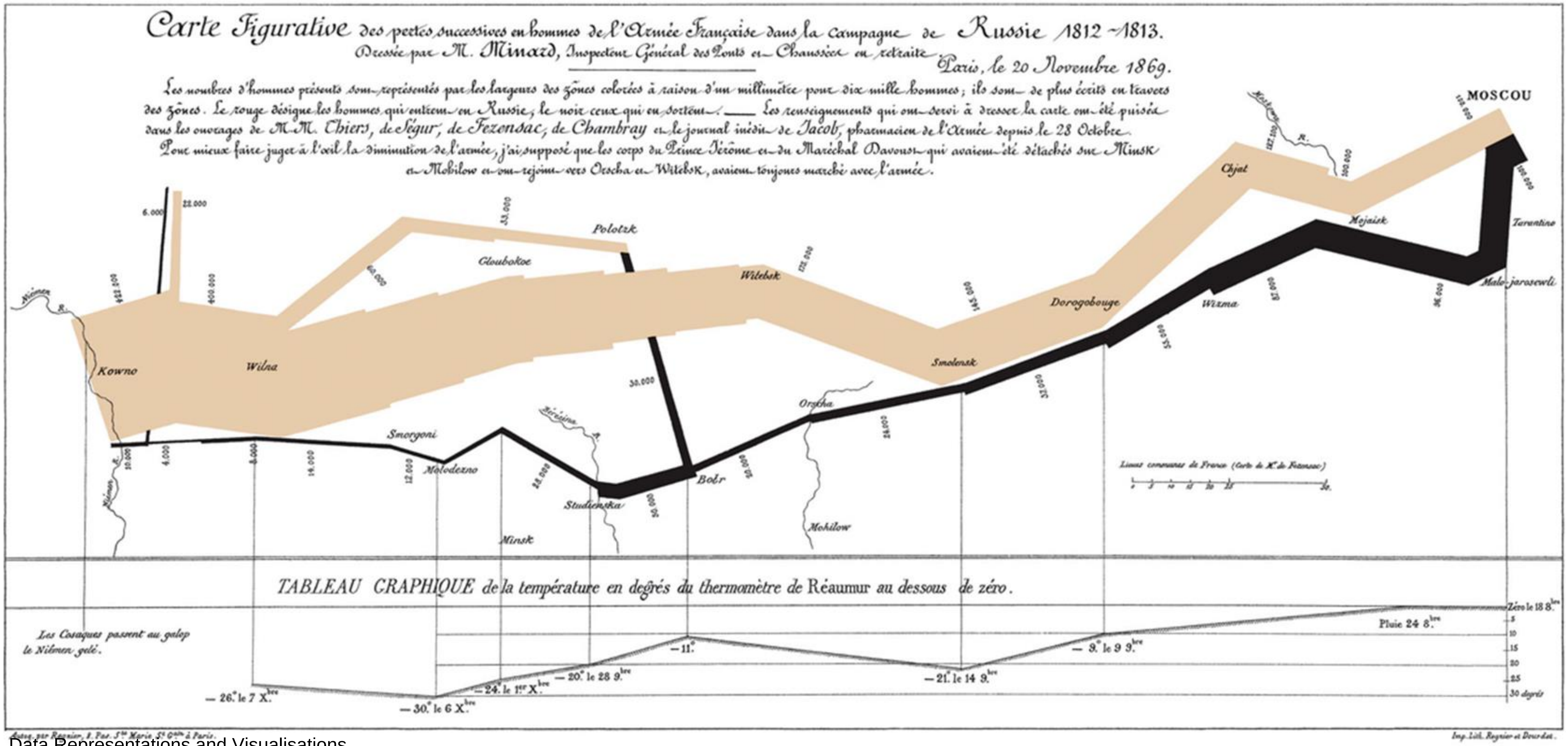
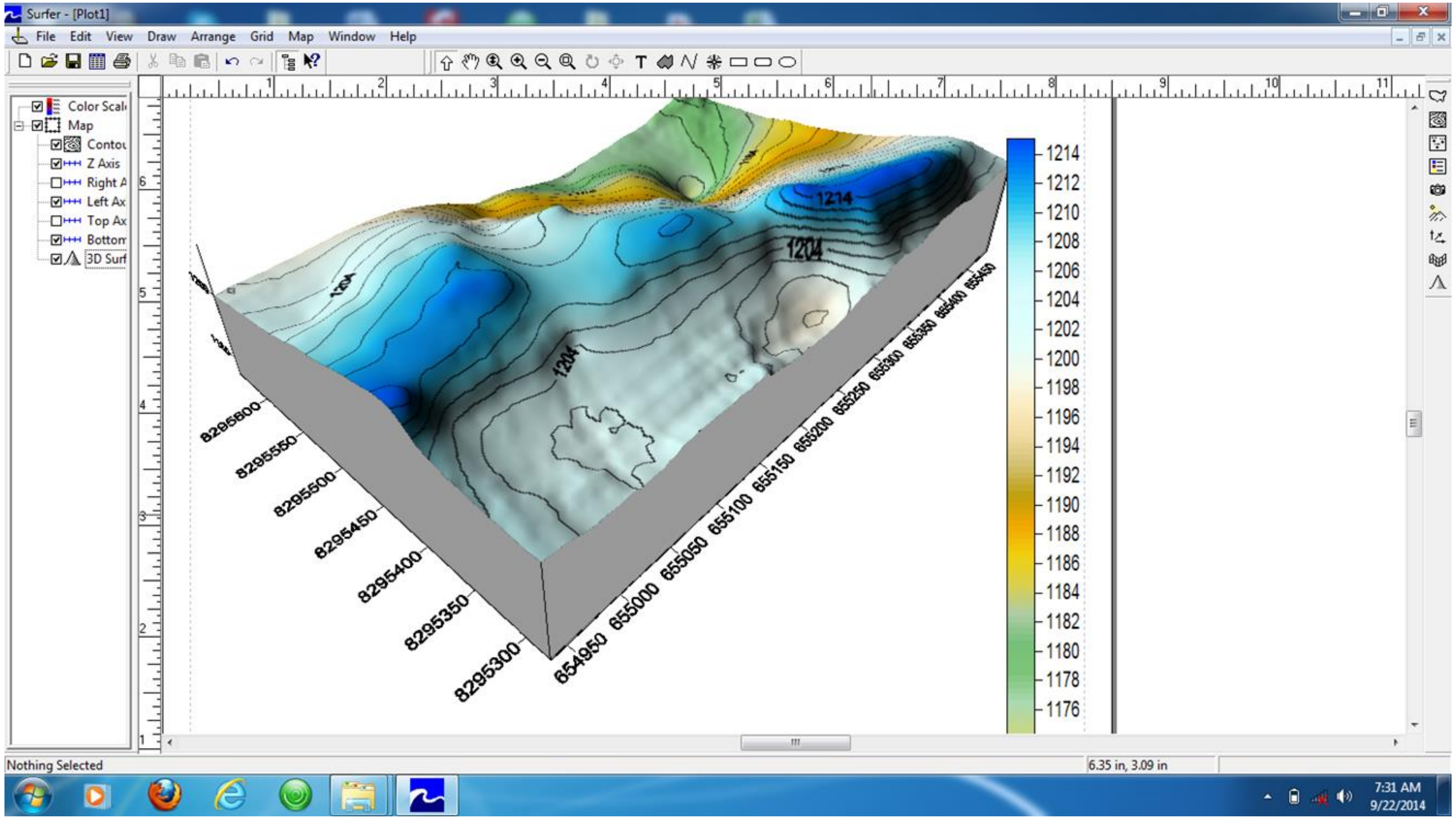
NP PP

4D model: Minard’s Map of 1869



3D Model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Data Visualisation

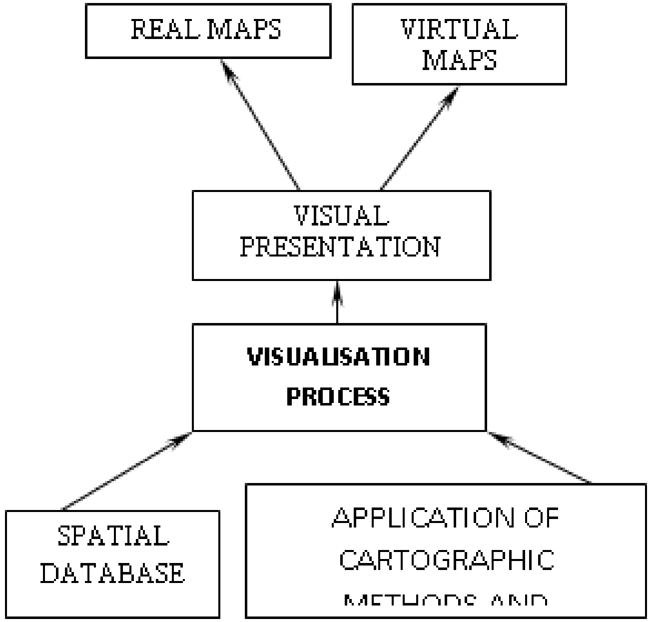
- Is some form of visual communication.
- It involves creation and study of visual representation of data.
- It uses statistical graphics, plots, information graphics and other tools where numerical data is encoded using dots, lines, or bars, to visually communicate a quantitative message.
- It helps analyze and reason about data more precisely making complex data more accessible, revealing, understandable and usable.
- Its main goal is to communicate information clearly, efficiently and effectively through graphical means (Friedman, 2008).

Cartographic Visualisation

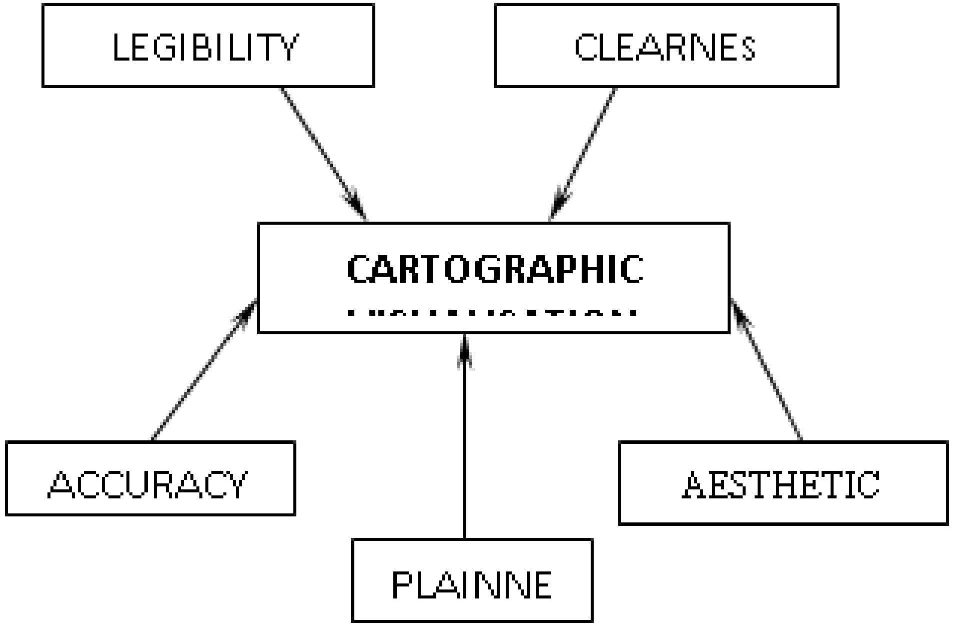
- Up until a few decades ago a map had two important functions:
  - it was a medium for storing information about space and
  - it was the image of the world or part of it that helped people to learn about the complexity of its environment.
- Spatially cartographic visualisation is considered a translation or transformation of spatial data from the database into a drawing using cartographic methods and techniques.
- Cartographic visualisation is a kind of grammar allowing optimal creation, production and usage of maps, depending on their application.

Cartographic Visualisation

Cartographic Visualisation Process

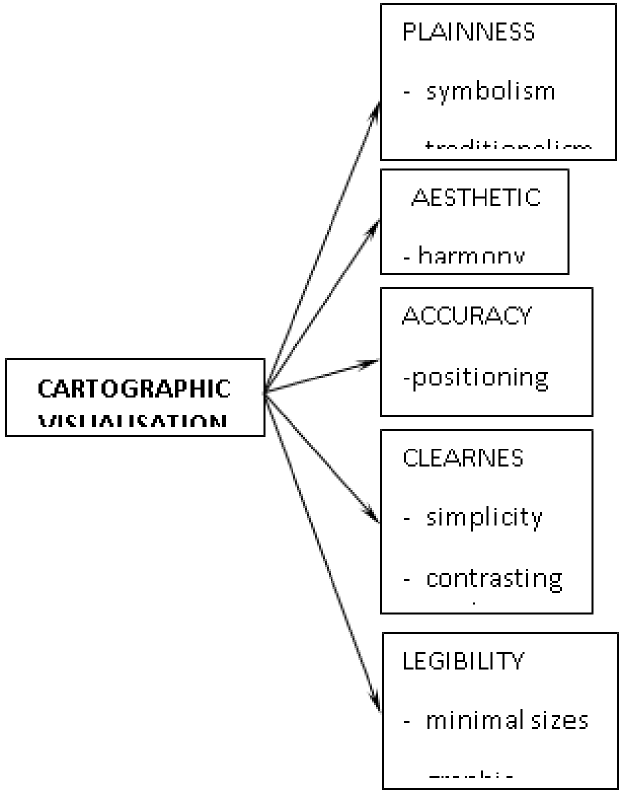


Demands on Cartographic Visualisation



Cartographic Visualisation

Cartographic Visualisation Conditions



Mathematics of Cartography

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Introduction

- **The map as an interface**
  - Maps are used to *visualize geospatial data*
  - Maps help their users to *better understand* geospatial relationships
  - From maps, information on *distances*, *directions* and *area sizes* can be retrieved, *patterns* revealed, and *relations* understood
  - Since **1980s**, developments in digital geospatial data handling have gained momentum:
  - with the computer came **on-screen maps -** 3D and Animated Maps
  - **software packages** that allowed for *queries* and *analyses* of geospatial data became known as geographical information systems (GIS)
  - GIS introduced the *integration* of *geospatial data* from different kinds of sources
  - Maps no longer only the final products they used to be - the **paper map** functioned & functions, as a *medium* for *storage* & *presentation* of geospatial data.

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Introduction

- **The map as an interface** (cont'd)
  - Geospatial analysis often begins with maps; maps support judging intermediate analysis results, as well as presenting final results.
  - maps play a major role in the process of geospatial analysis.
  - The rise of Internet brought the next revolution in mapping
  - Access to interactive maps is no longer limited to professionals.
  - Products such as Google Maps/Earth even allow people to add their own data to the maps and share it with others in a mouse click

Introduction

- **Geospatial data**
  - Why is Geographical Information *different* from *other information*?
  - Because of this *special characteristic* the *locations* of the objects or phenomena can be visualized, and these *visualizations* – called maps – are the key to their further study.
  - objects from the real world that can be localized in space (like houses, roads, fields, or mountains) can be *abstracted* from the real world as a digital landscape model (**DLM**), according to some predetermined criteria, and stored in GIS (as *points, lines, areas* or *volumes*)
  - and later, after being converted into a digital cartographic model (**DCM**), represented on maps (with *dots, dashes* and *patches*) and
  - Integrated in people's ideas about space.

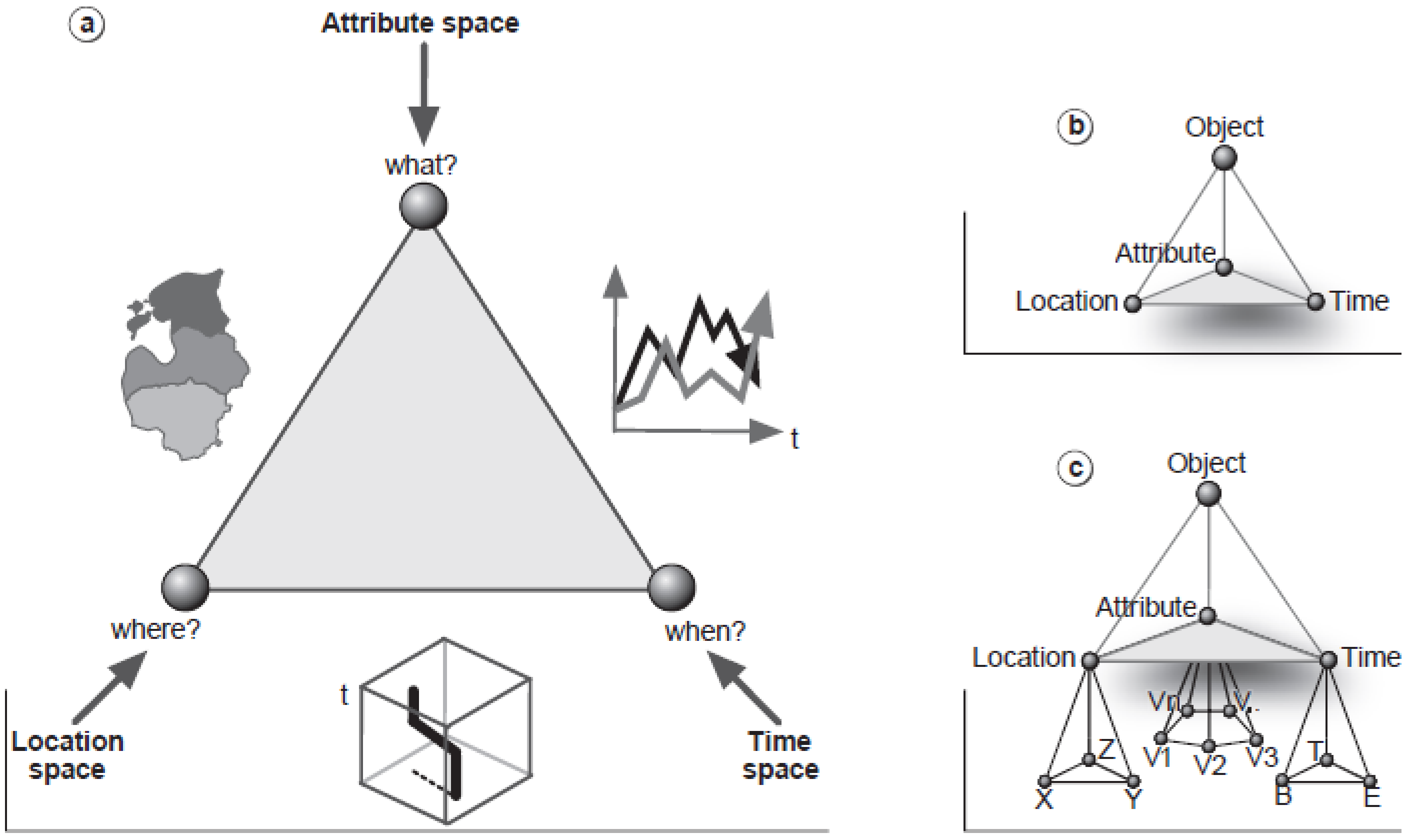


Figure 1.3 The characteristics of geospatial data: (a) its components location, attribute and time, and their related elementary questions where, what and when; (b) the object view; (c) detailed characteristics of the data components

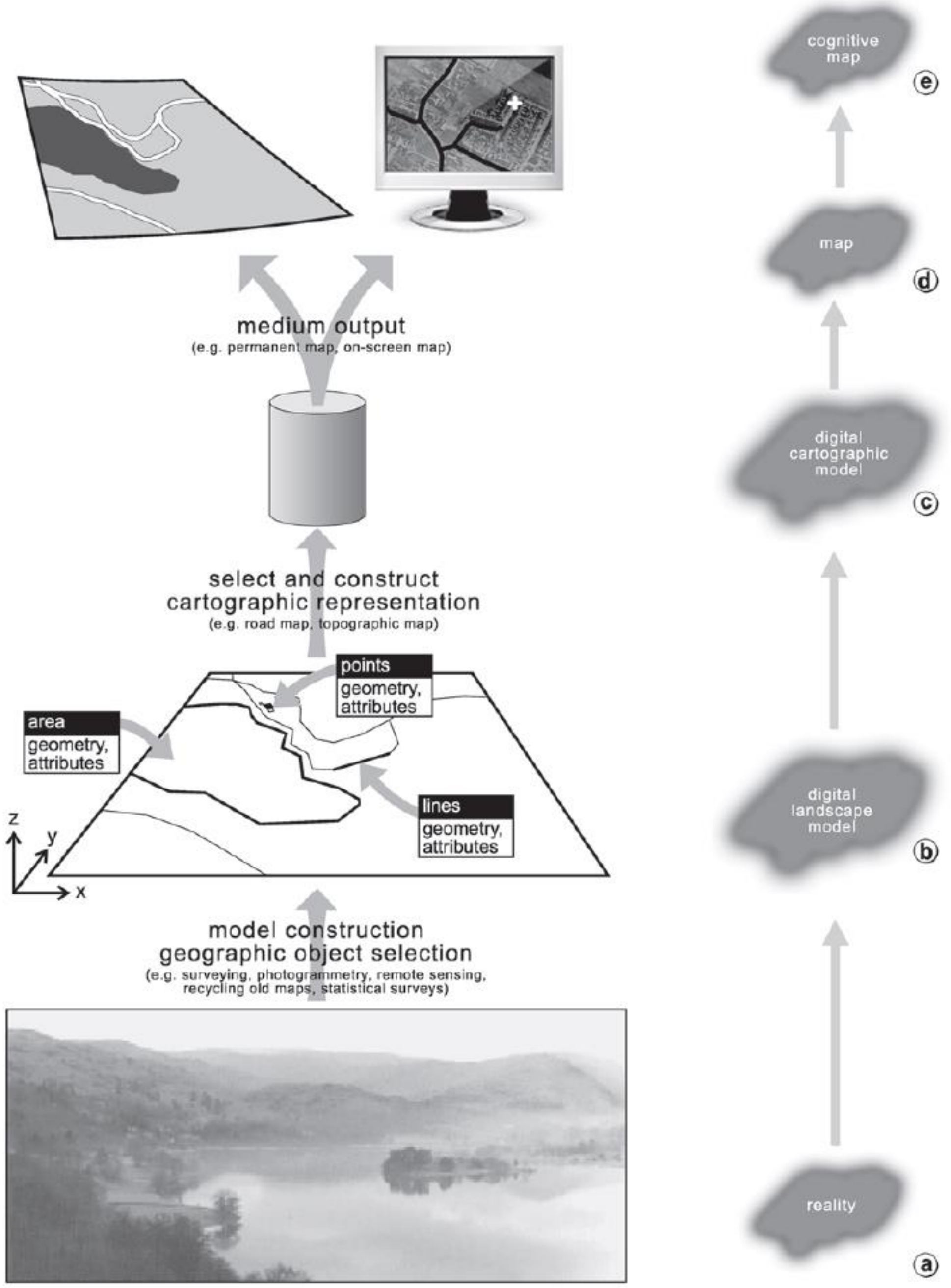


Figure 1.4 The nature of geospatial data: from reality (a), via model construction and selection to a digital landscape model (b), followed by selection and construction of a cartographic representation towards a digital cartographic model (c), presented as a map (d), which results in the user's cognitive map (e)

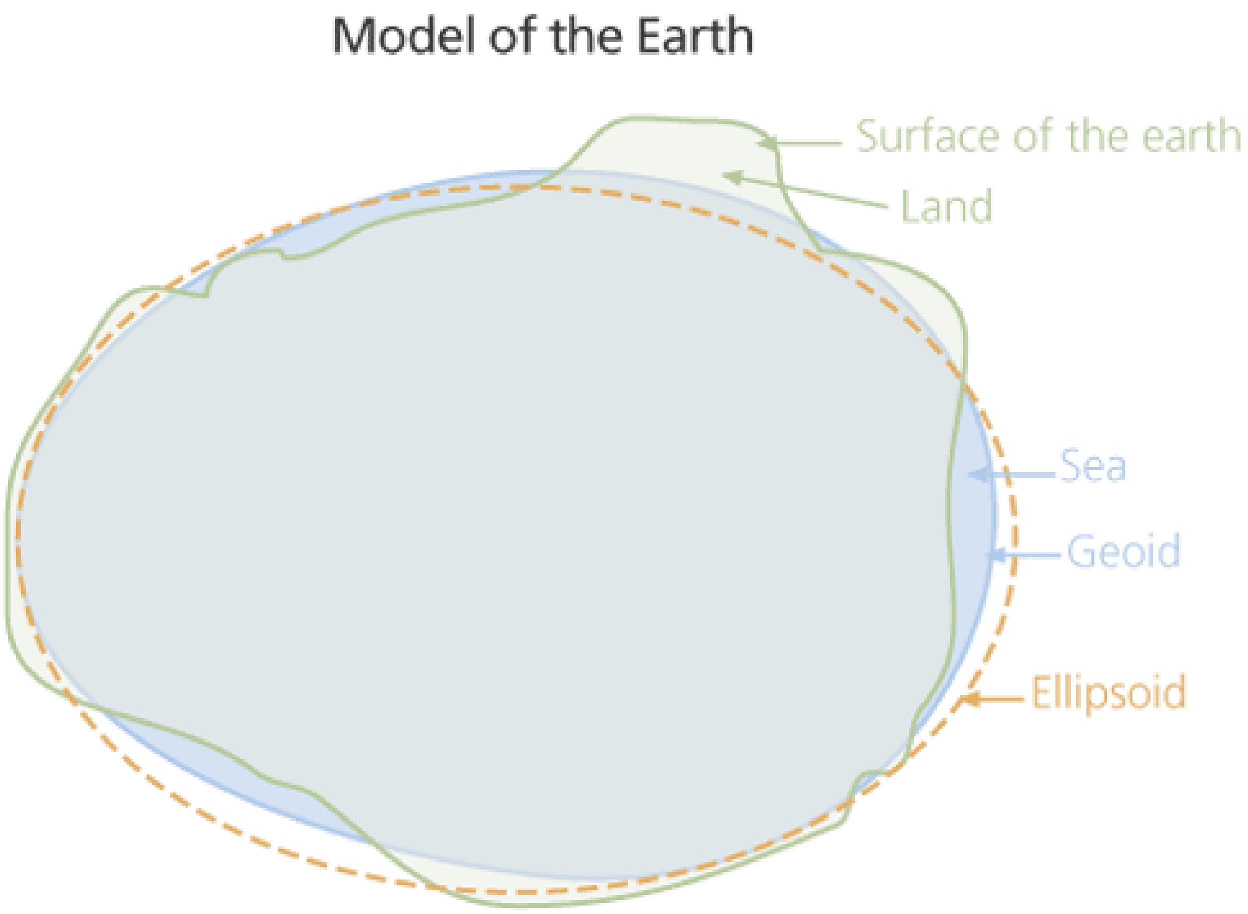
Introduction

- The surface of the earth is curved and irregular
  - To map this irregular surface a more regular surface, that closely approximates the irregular surface, has to be defined.
  - The more regular surface can then be transformed to a **plane map**.
  - Since a map is a small scale representation of the earth's surface it is necessary to apply some kind of scale reduction.
  - Meanwhile different types of coordinate systems are used to locate data on the earth's surface and on the map.

Reference Surfaces

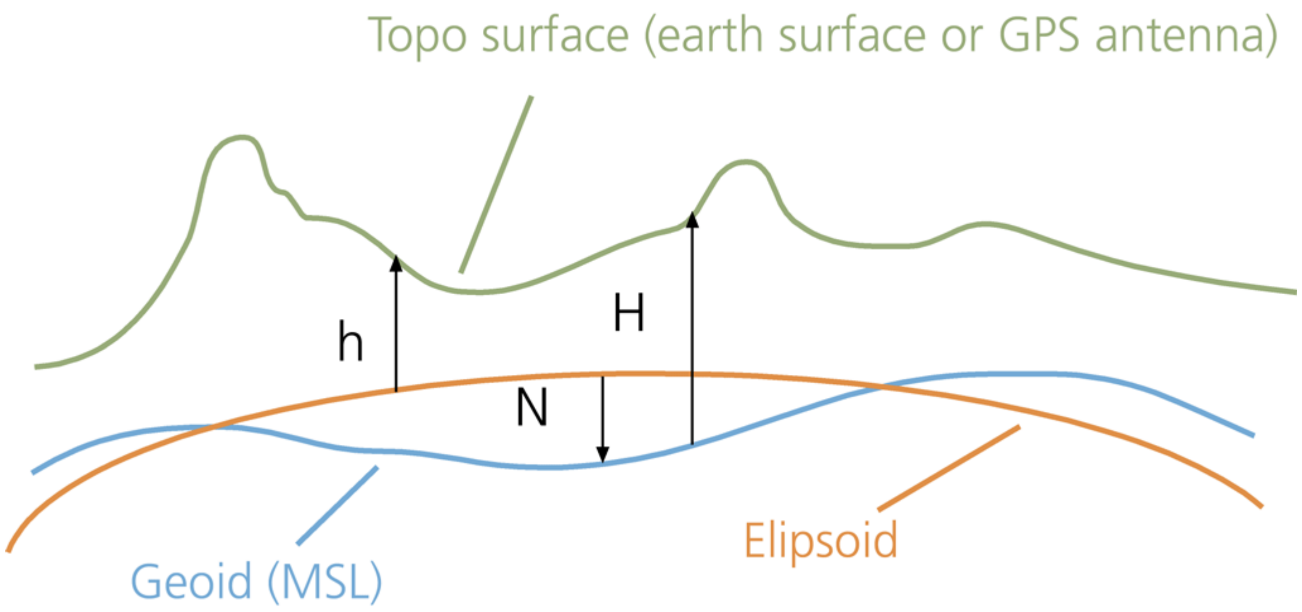
- The earth is not a uniform and smooth globe.
  - The surface of landmasses shows large vertical variations between mountains an valleys
  - Its therefore impossible to describe the earth's surface with a simple mathematical model.
- Geoid also called the Figure of the Earth
  - If we extend the oceans and seas below land masses the resulting water surface is only affected by gravity and is called the **Geoid**.
  - The Geoid represents an imagery sea level which is an equipotential surface where gravity is everywhere equal.

The Geoid and Ellipsoid



Reference Surfaces

$$h=H+N$$



h=elipsoid height
H=orthometric height
N=geoid height

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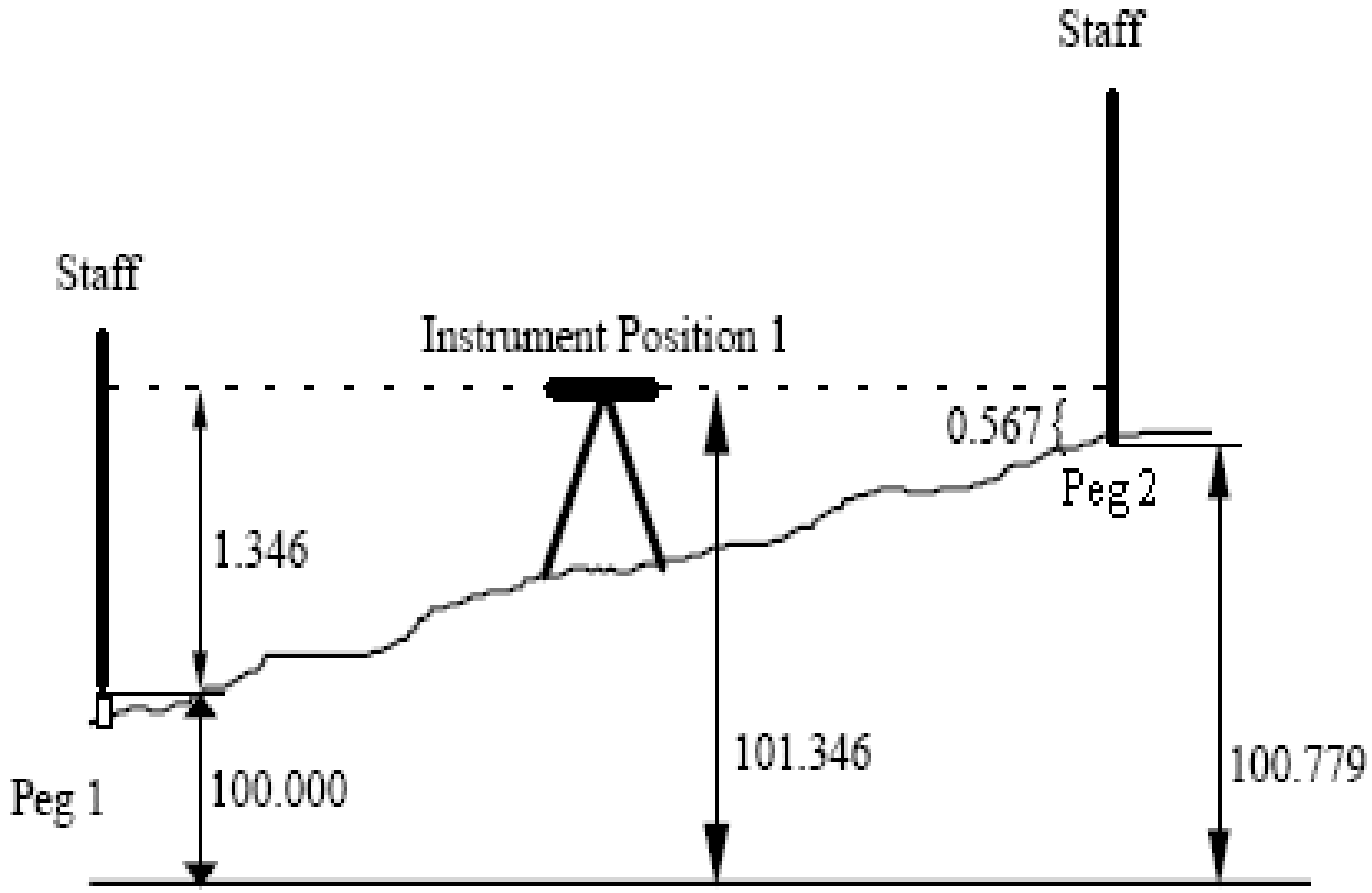
Reference Surfaces

Mean Sea Level

- In mapping the Geoid is used as a reference surface for height measurements.
- The *oceans water level* is registered at coastal places over several years and an *average* taken
- This *approximates the Geoid* and is called the **Mean Sea Level** (**MSL**)
- Heights of points on the earth's surface are transferred inland by surveying methods (spirit levelling)
- For historical, and cultural as well as political reasons nations or group of nations have established their own MSL which can differ from that of others.
    - For example, In the Netherlands heights are measured from Amstaerdam while in Belgium they are measured from Oostende
    - As a result the Netherlands heights are -2.32m lower

Spirit Levelling

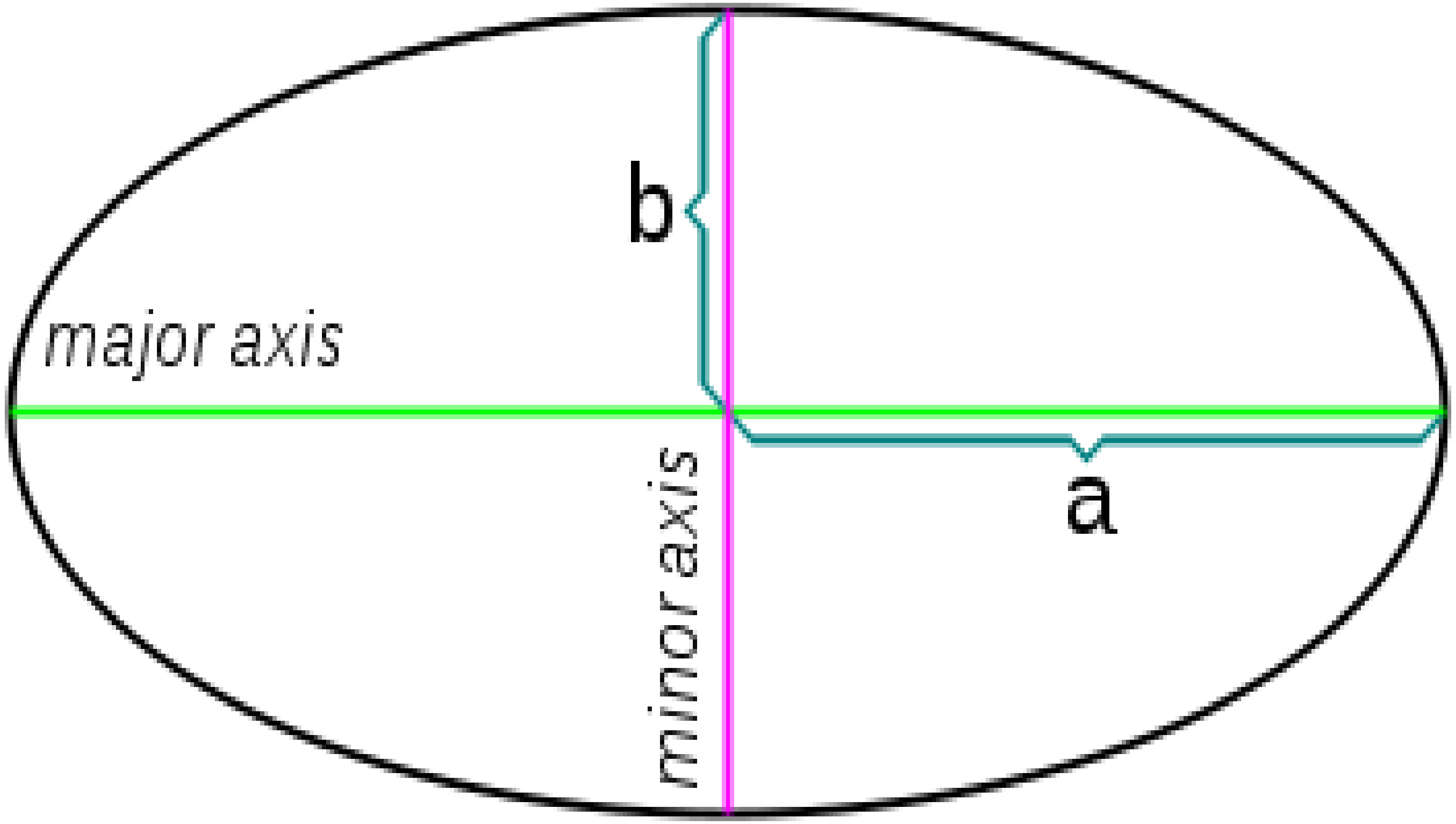


Reference Surfaces

Ellipsoid

- The Geoidal surface has **many discontinuities**
- As such it is not an analytic surface and thus not suitable as a reference surface for determination of locations
- **To carry out computations** of positions, distances, directions, etc, a mathematical frame is required
- The most convenient geometric reference surface is the **Oblate Ellipsoid**:
  - It fits the Geoid to a first order approximation
  - Its oblate because of the polar flattening
  - Its an ellipse of revolution

Ellipsoid



13

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Reference Surfaces

- Geodetic Datum
  - Topographic maps are drawn with geodetic positions that are defined with respect to an ellipsoid with a *defined shape* and *size* and a *fixed position*.
  - This is called a geodetic datum
  - To produce accurate maps, different ellipsoids have been established to fit the geoid well over an area of interest.
  - **In Zambia** we use Clarke (modified) 1880 ellipsoid where:
    - **a** = 6378.249 km
    - **b** = 6356.515 km
    - **f** = 1: 293.47
  - and our geodetic datum is the **Arc1950**
  - **GPS measurements** are done relative to the World Geodetic System 1984 (WGS84) ellipsoid.

14

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Reference Surfaces

- The Sphere
  - Using the sphere as the earth model might be sufficiently accurate for *certain small scale mapping* like the world maps in *atlases* and *wall charts*.
  - As a value of spherical radius 6371.1 km is accurate enough.

Map Projections

- The earth needs to be approximated by an **ellipsoid** or **sphere** to be mapped.
- To produce a map the curved surface of the earth has to be transformed to a flat plane by means of a **map projection**.
  - There are many ways to project the earth onto a map plane and the map maker must choose the right type of projection for a particular map.
- A **map projection** is a system which gives the relation between the position of a point on Earth and that of the same point on the map.
  - The main aim of a map projection is to transform a part of the Earth's surface from the globe onto a plane at the same time keeping distortions to a minimum.

Map Projections

- Distortions in map projections
  - It is not possible to map a curved surface onto a flat one without any distortions.
  - Every map projection is associated with distortions.
  - Imagine the earth to have a skin like an orange cut into narrow strips, the curved surface of the skin can be laid almost perfectly flat upon a plane. This kind of map projection has little deformation within the strips.
  - This leaves gaps between the strips.
  - However, it is inconvenient to show the continuous spherical surface interrupted by many gaps
  - because it is desired to map the earth continuously it is necessary to stretch each part until the intervening gaps have been filled.

Map Projections

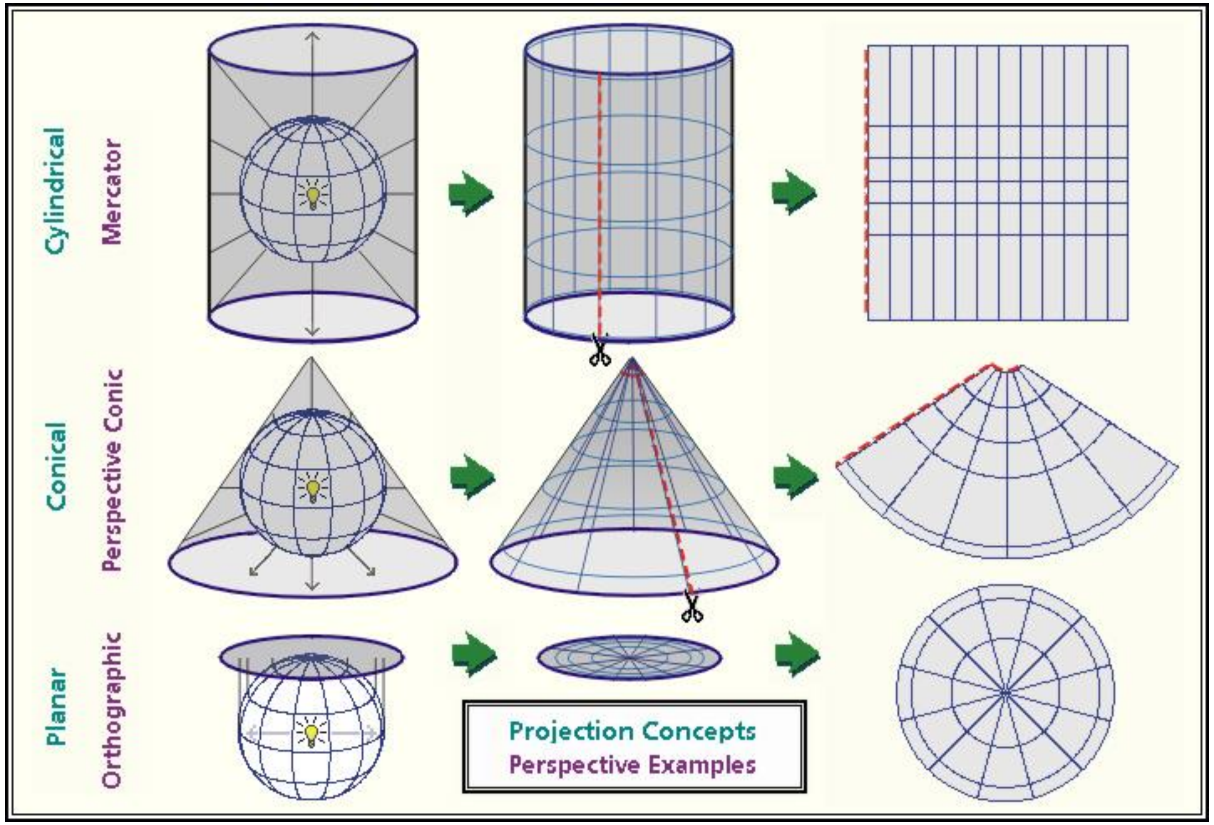
- The process of stretching alters the scale of the map and the amount by which the scale has changed increases progressively from the centre of the map towards edges.
- From the elementary definition of scale it is reasonable to make the following assumptions about distances measured on maps:
  - The scale of a map is constant:
    - *for all distances*
    - *in all parts of the map*
    - *for all directions on the map*.
  - None of these *assumptions* is correct!

Map Projections

- Distortions are present on the plane map
  - Scale varies from place to place and often in different directions at the same point on the plane map.
  - However, if we take a topographic map of 1: 50 000, for example, it is impossible to detect variations in scale with length of line, position or direction within the map sheet
    - This is because variations within such small areas (100 - 200 km^2) are so small that their effect can be ignored even though they exist.
  - This means that the elementary definition of scale is satisfactory for most kinds of map use on large and medium scale maps.
    - It becomes less reliable in the study and use of maps of scales 1: 1 mill. or smaller.

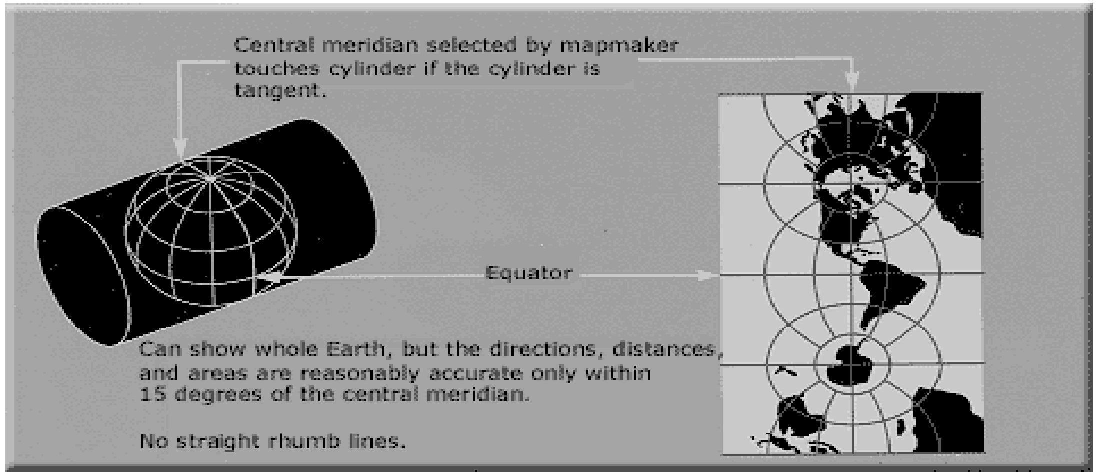
Projection Characteristics

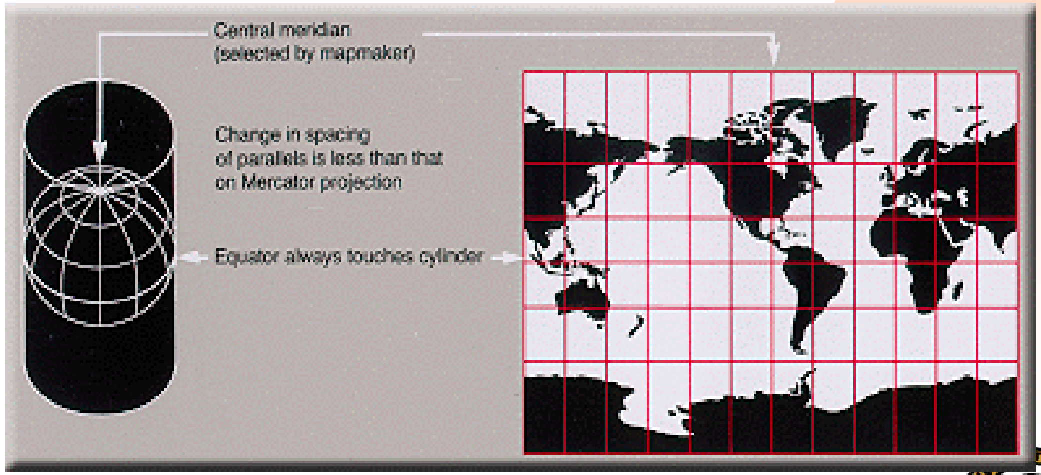
- Projections are characterised by their ***property, class*** and ***aspect.***
  - The three classes are azimuthal, cylindrical and conical



Projection Characteristics

- The orientation of the projection plane determines the **aspect** of a map project.
  - There are three orientations namely **Normal aspect**, **Oblique aspect** and **Transverse aspect**





Projection Characteristics

- The most important way to characterise a map projection is by its **property**.
- Conformal projections
  - Such projection represents angles and shapes correctly in a limited sense.
  - Shapes and angles are slightly distorted as the mapping region becomes larger.
  - Meridians and parallels intersect at *right angles*
  - This property is suitable for *topographic, sea, aeronautical* and *meteorological maps*
  - The **UTM grid** is based on a conformal projection in secant position to meet conformality and equidistance properties.

Projection Characteristics

- Equivalent projections
  - These are equal area projections which correctly represent areas on a map.
  - They are suitable for *distribution maps*
  - When used on large regions the distortion to angles and shapes is considerable
- Equidistant Projections
  - These correctly represent distances in a limited sense.
  - Distances measured on the map are only correct on one or two points in a *certain direction*
    - These are the only points in which the nominal scale is true
    - Points or lines of zero distortion also called **standard lines** or **points**

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Projection Characteristics

- Conformal projections
  - A map equidistant along meridians is one with the correct scale along meridians
  - An equidistance map is a useful compromise between conformal and equal area maps since shape and area distortions are moderate
- A projection can therefore not be both conformal and equivalent
- Selection of a projection should be made on the basis of *position, shape* and *size of the area* to be mapped and the *purpose of the map*.

Coordinate Systems

- The most fundamental principle of cartography is the establishment of a coordinate system on the Earth to which each point can be related.
- Different kinds of coordinate systems are used to position data in space.
- There are two (2) types of coordinate systems:
  - TERRESTRIAL COORDINATE SYSTEMS
    - Geographical coordinate system
    - Three-dimensional (3D) Cartesian coordinate system or geocentric
  - PLANE COORDINATE SYSTEMS
    - Plane Cartesian coordinate system
    - Raster coordinates system
    - Plane Polar coordinate system
    - Plane Grid system.

Geographical Coordinate Systems

- The best known method of referring to positions on the Earth's surface is by means of two angles,
  - Latitude and Longitude
  - which together form the system of *Geographical Coordinates*.
- The Latitude
  - Latitude is the angle measured at the centre of the Earth between the plane of the Equator and the radius drawn to a point (P) on the surface of the earth.
  - The Equator is the datum for measurement of latitude and is therefore assigned the value of 0°.
  - Northwards and southwards from the datum the latitude increases until it is 90° North at the North Geographical Pole and 90° South at the South Geographical Pole.

Geographical Coordinate Systems

The Latitude

- In calculations which are made using geographical coordinates
- N - latitudes are reckoned **+ve** and
- S - latitudes are reckoned **-ve**
- Latitude is denoted by the Greek letter **φ**.

The Length of a Degree of Latitude

- Degrees of latitude are closely the same length, but not quite because the Earth approximates an oblate spheroid
- a N-S line (a meridian) has more curvature near the Equator and less near the poles.
  - the degrees of north-south arc on the Earth vary from about 110.6 km near the Equator to about 111.7 km near the poles.
  - The difference of 1.1 km is of little significance in small scale maps, but it is important on large and medium scale maps.

Geographical Coordinate Systems

The Longitude

- Longitude is the angle, measured at the centre of the Earth, between the plane containing the point (P) and the datum plane.
- This angle is measured eastwards and westwards from the datum plane and is recorded as East or West Longitude
- In calculations,
  - E - longitude is **+ve**
  - W- longitude is **-ve**
- The angle is denoted by the Greek letter λ.
- The datum from which longitude is measured may be chosen as the plane passing through the origin of a national survey.

Geographical Coordinate Systems

The Longitude

- However, it is better to use a single, internationally recognised datum.
- During the last century many nations began to accept the longitude of the Royal Observatory at Greenwich, near London in England, as 0°. In 1884 it was agreed on at an international conference.
- This is known as the Prime Meridian or Greenwich Meridian

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Geographical Coordinate Systems

The Length of a Degree of Longitude

- The length of the Equator is very nearly the same as the length of a meridian circle. As we go towards the poles all other parallels become smaller and smaller circles until you have zero radius at the poles.
- E-W degree of longitude becomes shorter with increasing latitude and is finally reduced to NIL at the poles.
- The length of degrees of latitude is from 111.3km at the equator to 0km at the poles

30

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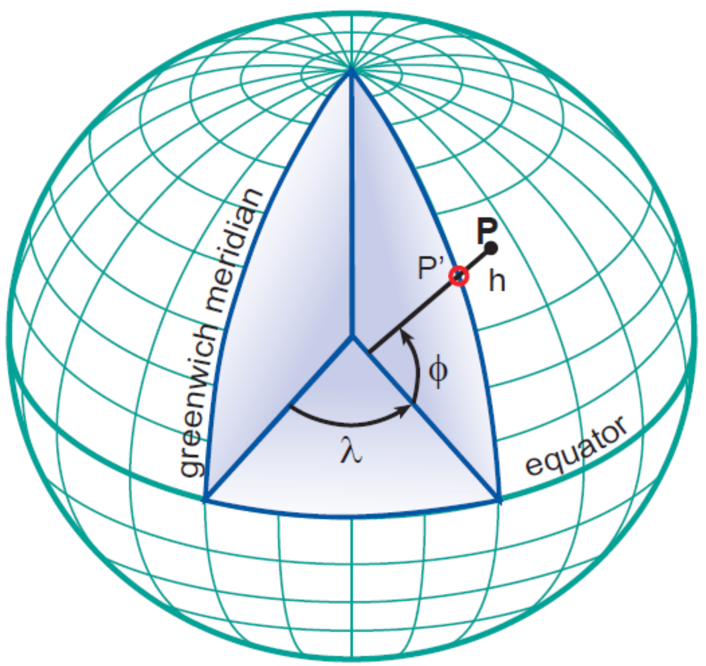
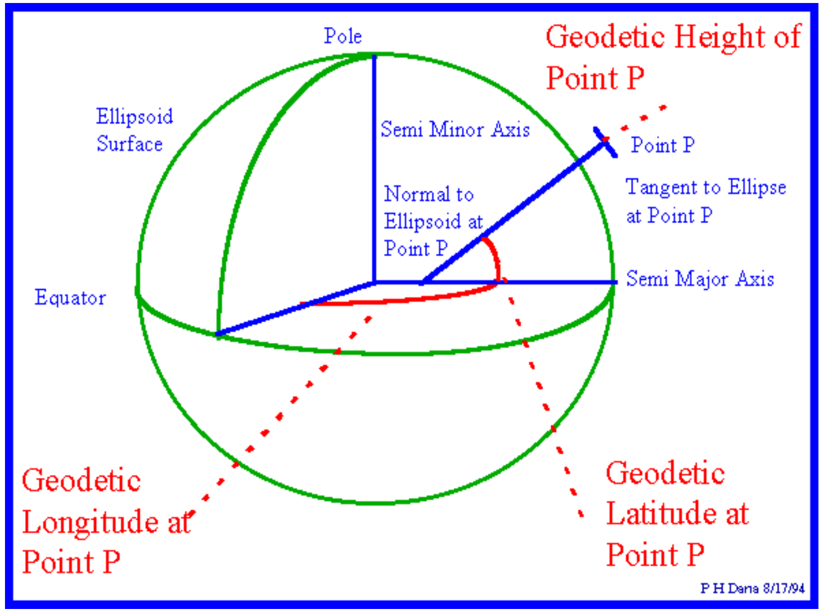
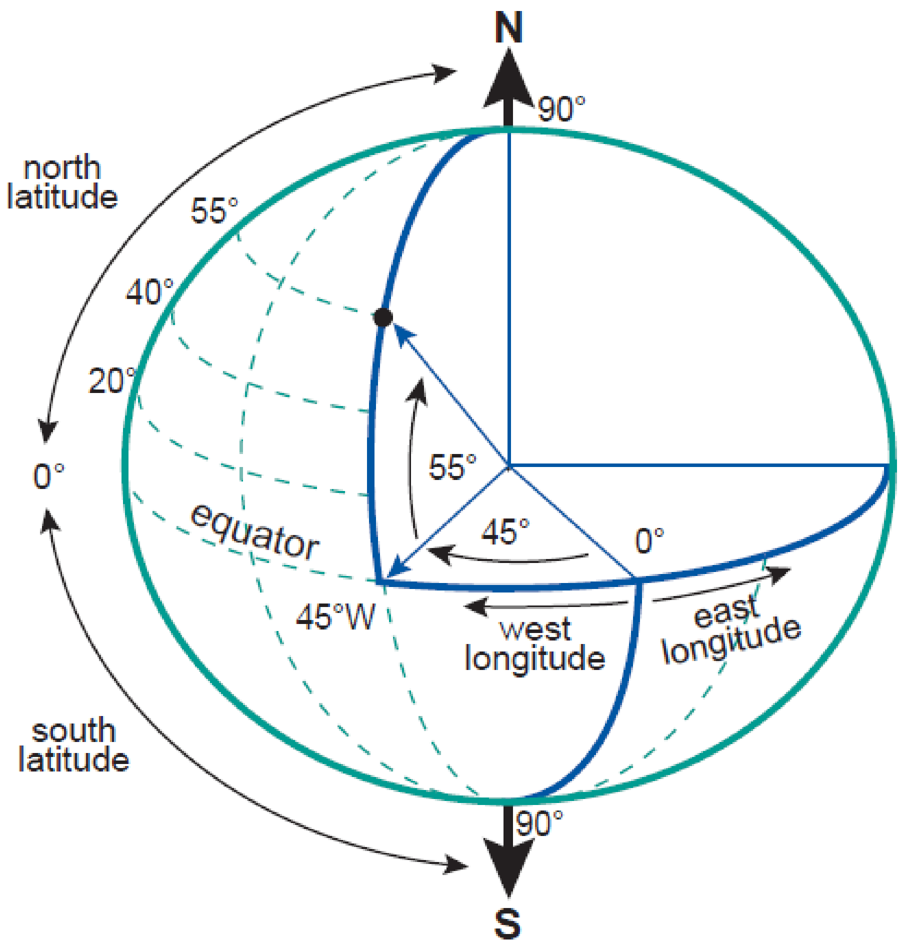
Geographical Coordinate Systems





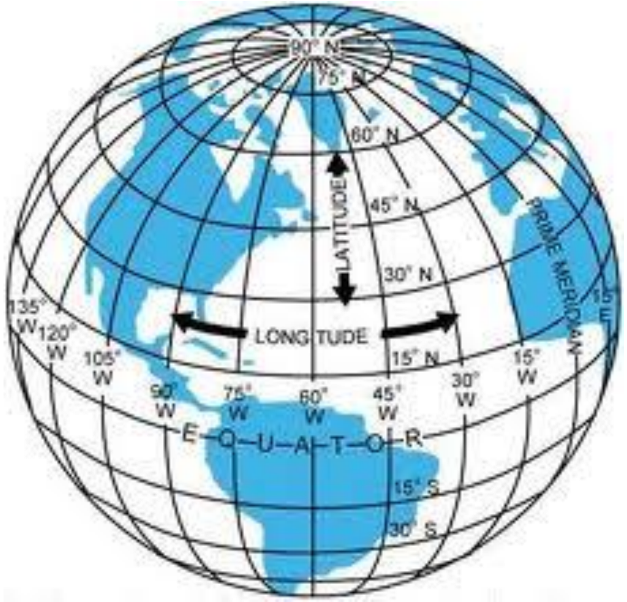


Parallels and Meridians

- The Parallel
  - The locus of all points having the same latitude traces a circle upon the spherical or spheroidal surface.
  - The plane containing this circle is parallel to the Equator and therefore its circumference is called a Parallel of Latitude or just a Parallel.
  - The radius of a parallel in latitude φ is determined as follows:
    - $r = R*\cos\varphi$.

Parallels and Meridians

- **The Meridian**
  - The locus of all points having the same longitude lies within the same plane which traces a semi-circle on the surface of a sphere or a semi-ellipse upon a spheroid.
  - Since the plane passes through the centre of the Earth, it is the arc of a great circle and is known as a Meridian.
  - All meridians intersect at the poles



33

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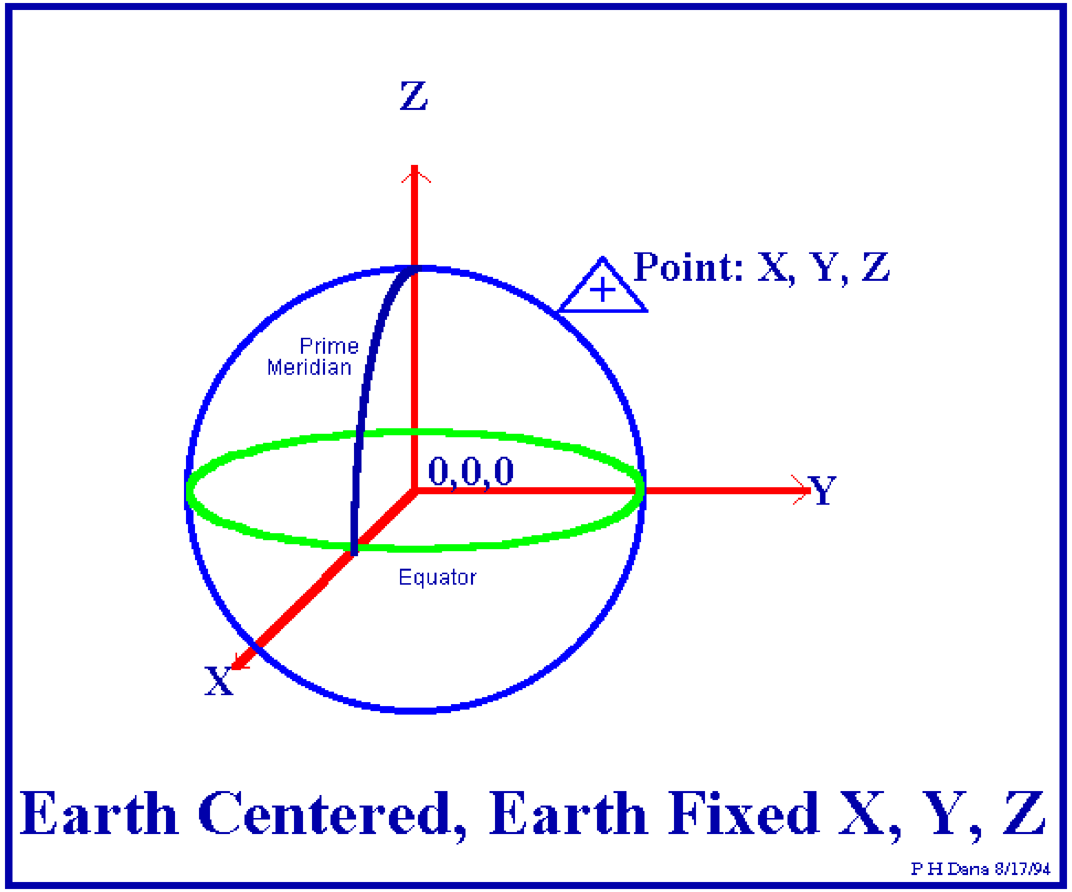
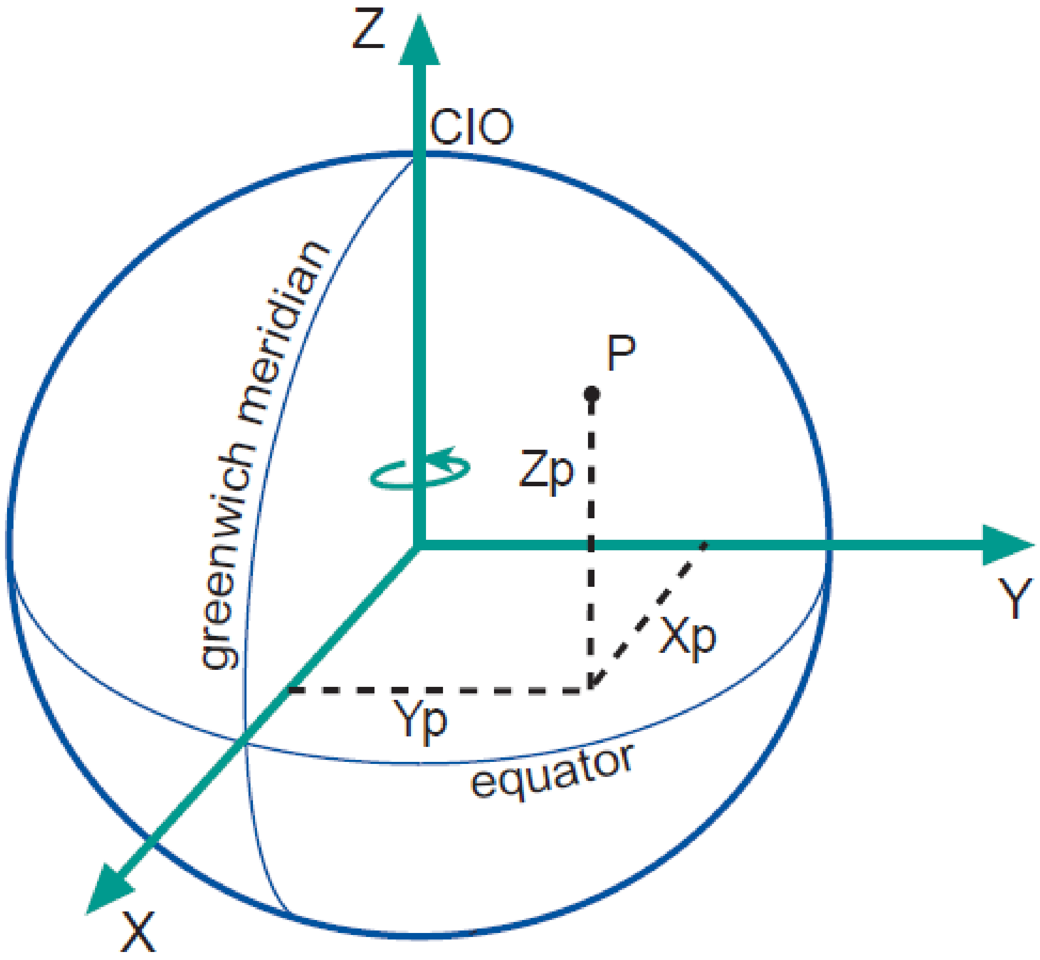
Three Dimensional (3D) Cartesian Coordinate System

- Earth Centered, Earth Fixed Cartesian coordinates used to define three dimensional positions.
- It uses X, Y, and Z Cartesian coordinates (XYZ) to define three dimensional positions with respect to the centre of mass of the reference ellipsoid.
  - The Z-axis points toward the North Pole.
  - The X-axis is defined by the intersection of the plane defined by the prime meridian and the equatorial plane.
  - The Y-axis completes a right handed orthogonal system by a plane 90 degrees east of the X-axis and its intersection with the equator

Three Dimensional (3D) Cartesian Coordinate System





PLANE COORDINATE SYSTEMS

- In order to plot the mathematical framework of a map it is desirable to use some kind of plane coordinate system.
- There are two (2) such systems in common use:
  - Plane polar coordinates
  - Plane rectangular Cartesian coordinates
  - For practical work of plotting a map, rectangular Cartesian coordinates are mostly used.

Plane Coordinate Systems

- Key words:
  - Polar coordinates
  - Plane rectangular Cartesian coordinates
  - Origin
  - Radius vector
  - Vectorial angle
  - Ordinate
  - Abscissa
  - Easting
  - Northing

Plane Polar Coordinates

- The point O is selected as the origin from which measurements are made.
- The line OA is chosen as the axis or initial line.
- The position of any point P may be referred to this origin and axis by means of the radius vector, or straight line distance OP = **r**, and **vectorial angle** AOP = θ (**Theta**).
- The position of P is recorded by the two quantities **r** and **θ.**

<u>Note:</u>

- In **mathematics** the angle θ is measured counter clockwise.
- In **surveying**, **navigation** and **cartography**, angles are measured in a clockwise direction.

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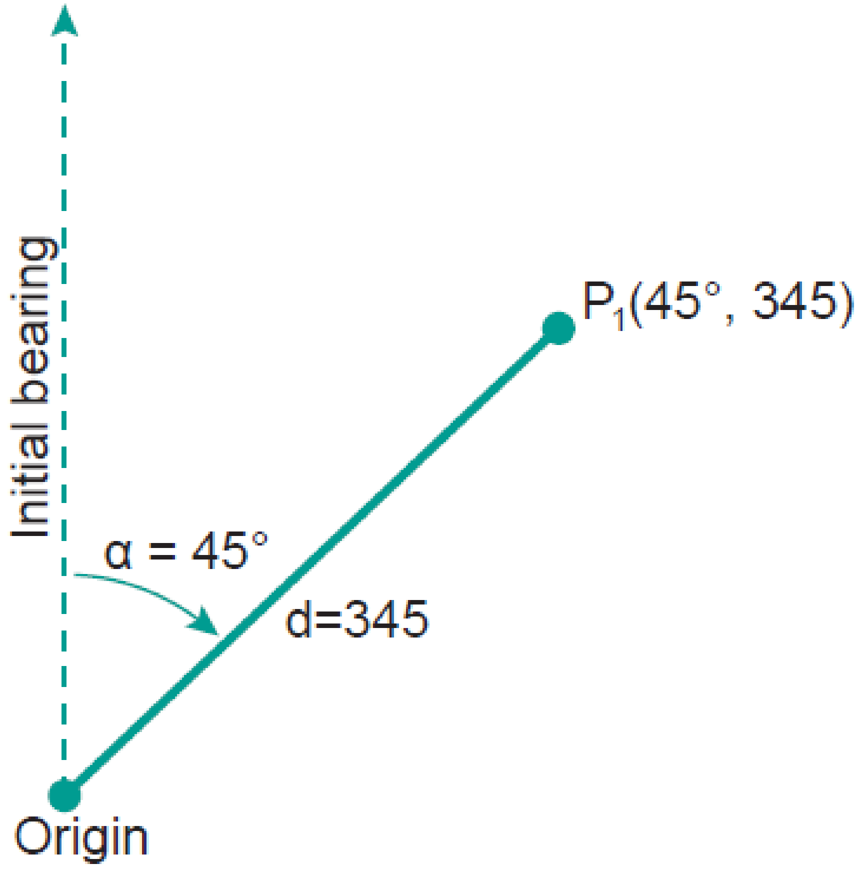
Plane Polar Coordinates (radius vector ~ d) and (theta ~ α)



Plane Rectangular Cartesian Coordinates

- These may also be called Cartesian Coordinates or just Rectangular Coordinates
- On a limitless plane surface there is no natural reference point.
- So an arbitrary system of location on a plane surface has long been used:
  - By establishing a 'point of origin' at the intersection of two conveniently located, perpendicular 'axes'.
  - The plane is then divided into a grid by an infinite number of equally spaced lines parallel to each axes.

Plane Rectangular Cartesian Coordinates

- The customary mathematical convention is to call
  - the abscissa, the x-axis and refer to linear distances as x.
  - the ordinate is called the y-axis and distances respectively as y.
  - the position of point is defined as (x, y).
  - angles are measured anti-clockwise *from the x-axis*.
- In cartography, angles are measured clockwise.
  - Therefore it is more convenient to transpose the meaning of the two axes so that the ordinate is labelled the x-axis and the abscissa becomes y.
  - Because of the confusion which may arise from using the letters x and y for both systems, it is better to use
    - the letter **E** (= Easting) for y
    - the letter **N** (= Northing) for x.
    - Point P has now coordinates (E, N).

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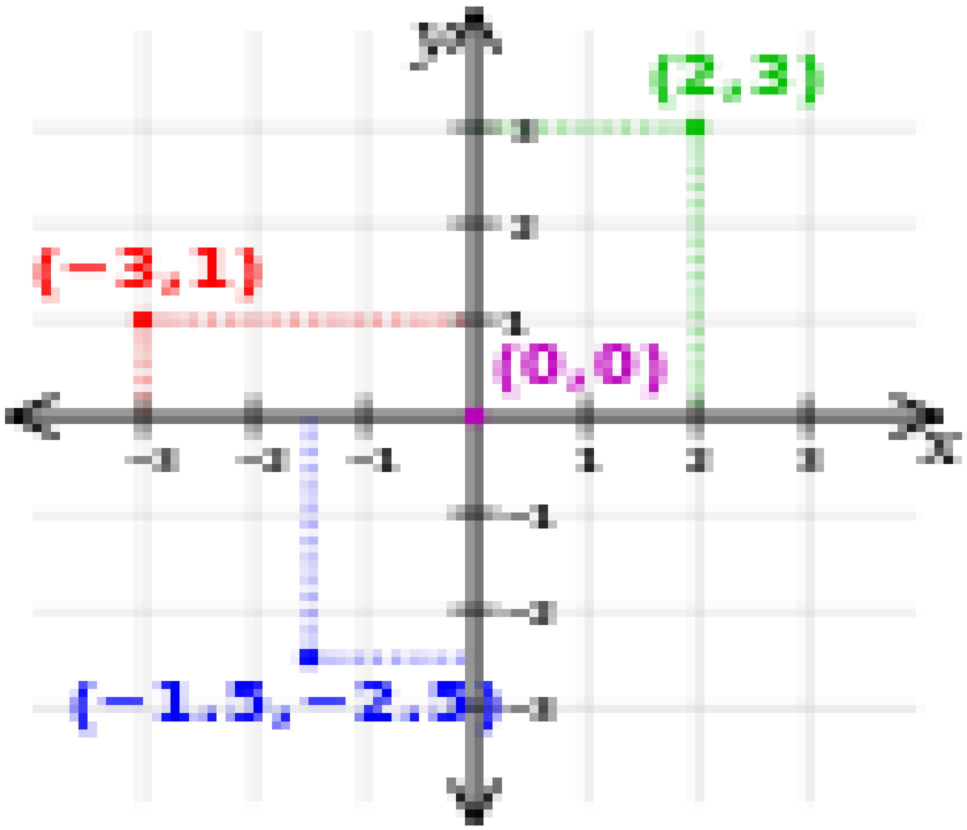
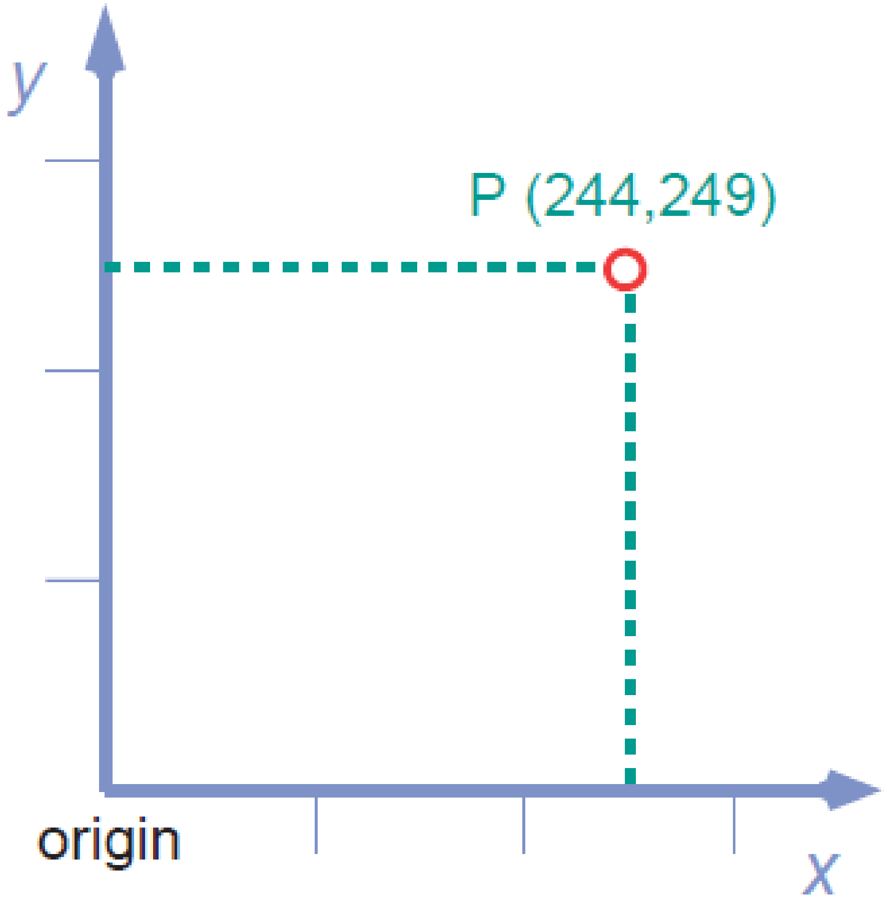
Cartesian Coordinate System (2D – X, Y)





Rectangular Grid System

- A grid is simply a plane Cartesian reference system which satisfies the following rules:
  - The origin of the grid is defined as a particular point on the earth's surface.
  - The orientation of the ordinate is normally the direction of the meridian passing through the origin.
  - Consequently the abscissa measures distances East or West of the origin.
    - Since the sign convention indicates positive coordinates to the right of the origin, the term Easting is used for these measurements.
    - The corresponding measurements along the ordinate are Northings.
  - The unit of measurement is usually the *metre*.

Rectangular Grid System

- In order to overcome the disadvantage of having any negative coordinates for points which lie South or West of the origin, it is usual to re-number the axes to ensure that all coordinates are positive.
  - For this purpose a False Origin is created for the grid.
  - This point is located beyond the south-west extremity of the country to be mapped on the grid.

Rectangular Grid System

- The **Geographical Coordinate System** is useful for *large areas* at *small scale maps* but for *small areas* at *medium and large scale maps* the **Rectangular Coordinate System** is **better**.
  - The use of rectangular grid systems has become widespread during the last century.
  - Therefore **Geographical coordinates** have to be transformed as follows:
    - Transforming the spherical surface to a plane (by a system of map projection)
    - Preparing the map on a plane and
    - Placing a rectangular plane coordinate grid over the map.
  - To locate a position we need only specify the **E** and **N** coordinates to whatever degree of precision we desire.

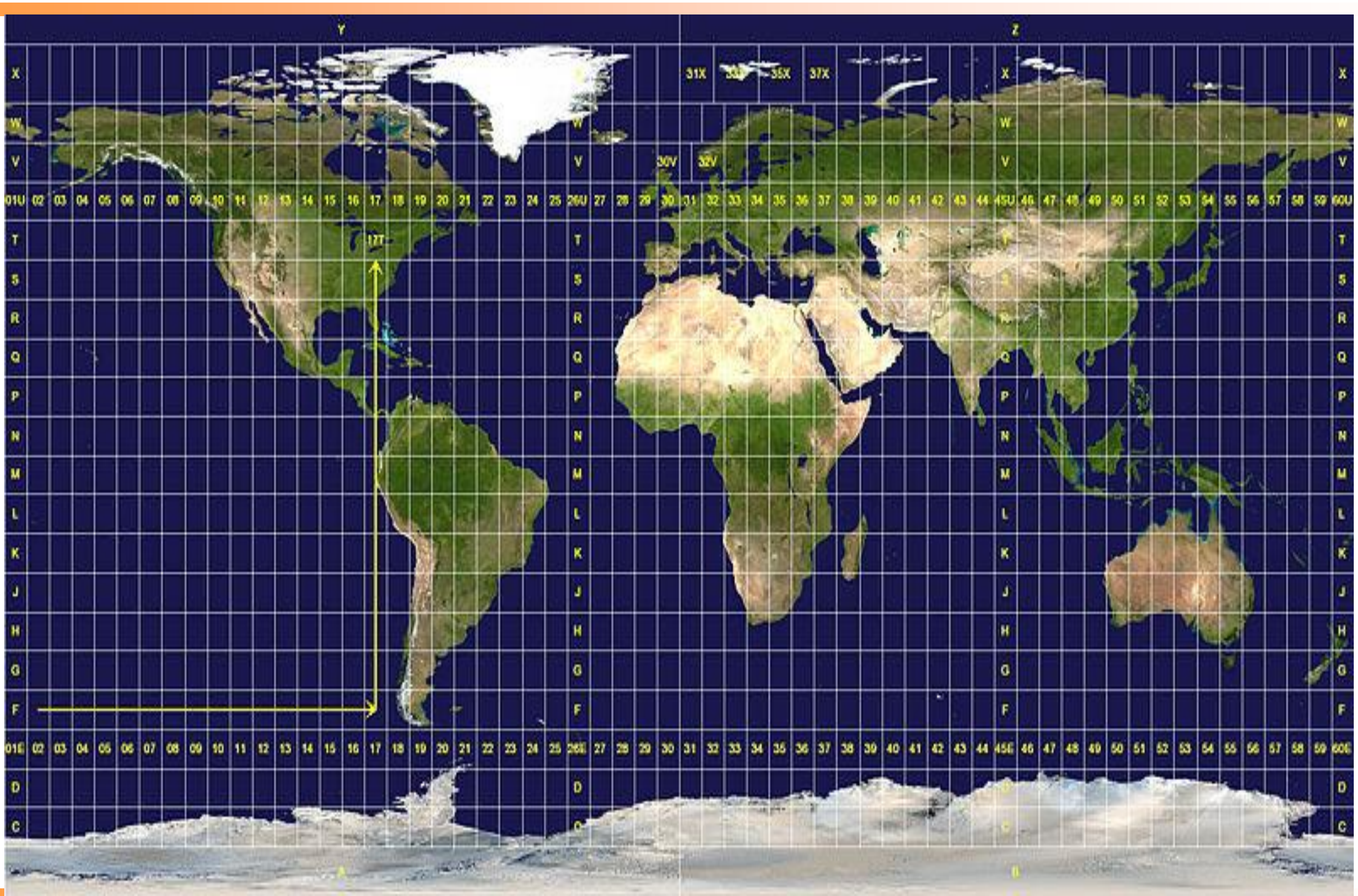
The UTM Grid System

- Individual countries may develop their own grid systems suitable for their needs, but there is one system that is commonly used in the world and also in Zambia.
- This is the Universal Transverse Mercator (UTM) grid system.
- The UTM grid system and the projection (Transverse Mercator) on which it is based have been widely adopted especially for topographic maps the world over.

The UTM Grid System

- In the UTM grid system:
  - The area of the Earth between 80°S and 84°N latitude is divided into north-south columns 6° of longitude wide called zones.
    - These are numbered from 1 to 60 eastward, beginning at the 180°W meridian.
  - Each column is divided into quadrilaterals 8° of latitude high with the exception of one row which is 12° latitude high extending from 72°N to 84°N.
    - The rows of quadrilaterals are assigned letters from C to X consecutively (I and O omitted) beginning at 80° S latitude.

The UTM Zones



48

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The UTM Grid System

- Each quadrilateral is assigned a number-letter combination.
- Within each zone the meridian in the centre is given an Easting value of 500,000 m.
- The Equator is designated as having a Northing value of 0 for the northern hemisphere coordinates and an arbitrary Northing value of 10 million metres for southern hemisphere is given.

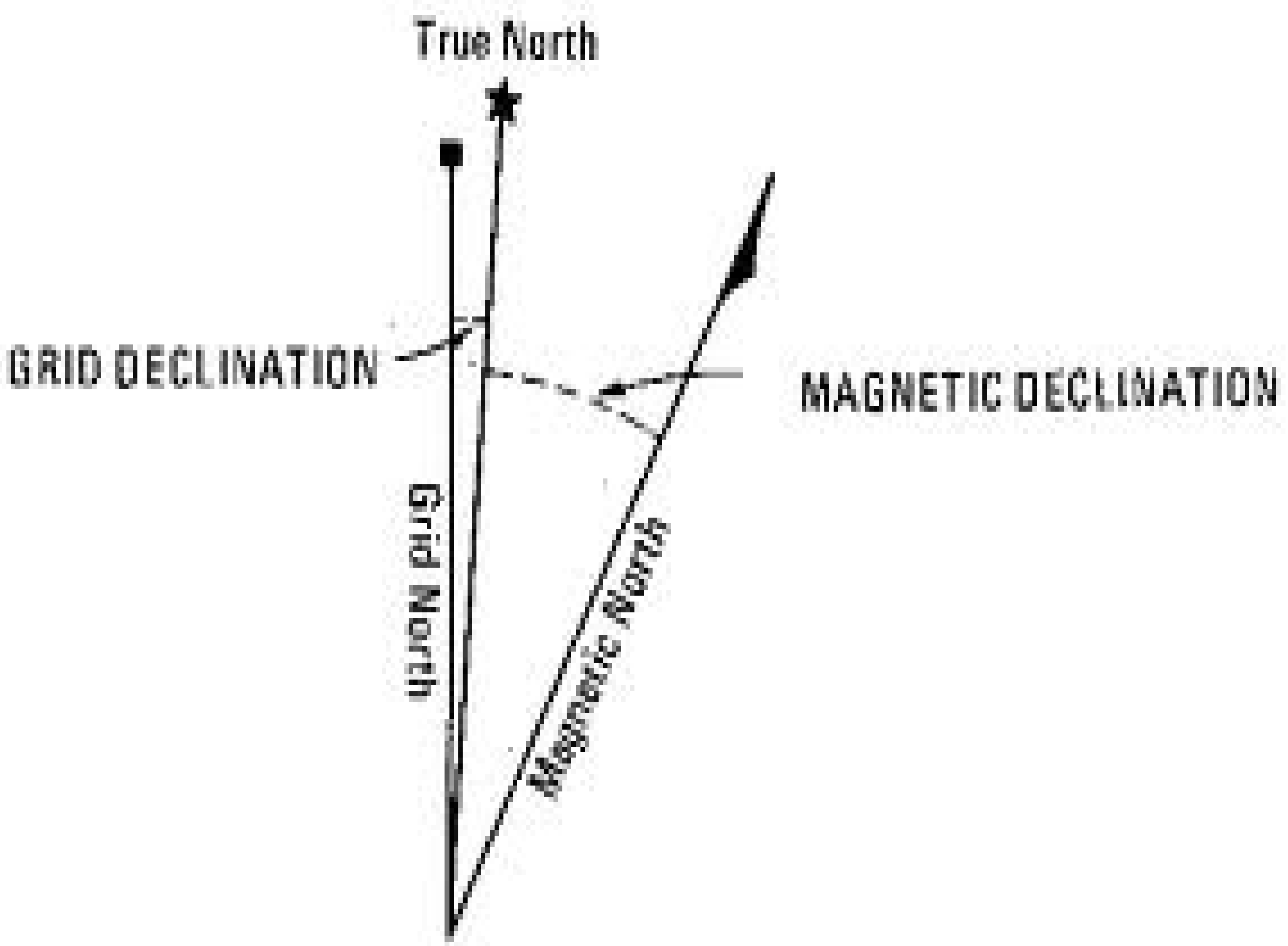
Directions

- By definition, north-south is along any meridian and east-west is along any parallel.
- The directions determined by the orientation of the graticule are called geographic or true directions
- The meridian through any point is directed to True North (TN)
- When a rectangular grid is placed over the graticule of a map, the vertical grid lines point to Grid North (GN)

Directions

- In most places the north direction of the grid will not coincide with true north.
- Therefore, primary topographic maps specify the *discrepancy* in degrees and minutes between grid north and true north at the centre of the sheet.
- This angle is called Grid Declination or Convergence
- The needle of the magnetic compass aligns itself with the total field of magnetic force and points to the Magnetic North (MN).

The Declination Diagram



52

Directions

- In most parts of the earth MN is not parallel with the meridian as there is usually a difference between TN and MN.
- This angle is called Magnetic Declination or Compass Variation.
- Declination Diagram:
  - The difference between TN, GN and MN is usually shown with a diagram on primary topographic maps.
  - Furthermore, the magnetic field changes slowly so that the variation value is likely to be correct only for the date the map was issued.
  - Often a statement of the amount of annual change is included as is the case in Zambia.

Directions

- Directions are quite commonly measured from a map and transposed by compass to a terrain and vice versa.
- The direction of a line on the Earth can be called:
  - Azimuth
  - Bearing
  - Their meaning is essentially the same, differing largely in the context in which they are used.
  - The two of importance in cartography are azimuth and bearing.

Directions

Azimuth

- This direction is reckoned by observing the angle between the Meridian of the starting point and the arc of the Great Circle.
- Since arcs of great circles are the shortest courses between points on Earth, movement along them is of major importance. Hence many maps are constructed so that directional relations are maintained as far as possible.
- The angle is given in degrees (0° to 360°), reading clockwise from true north (TN).
- The computation of azimuths in the geographical coordinate system is normally needed only in geodetic work.

Directions

- Bearing
  - A bearing is the direction from one point to another, usually expressed in relation to the compass.
  - Measuring a direction of the route AB from a topographic map by compass we measure an angle which is read clock-wise from Grid North and is called the Grid Bearing.
  - The bearing must be corrected by Total Correction, which is the angle between grid north (GN) and magnetic north (MN).
  - The total correction is added when the direction is measured from the map and transferred to the ground, and vice versa.

Measuring on Maps

- In land surveying the following ‘rules’ should be applied:
- The unit of measure for area is the:
  - hectare or square metre.
- When the area is smaller than 10 000 m^2
  - it should be expressed in m^2.
- When the area is greater than 10 000 m^2
  - it should be expressed in ha.

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Measuring on Maps

- The use of maps is not only a question of map reading and interpretation.
- There is also often a need to get numerical values of points, distances, areas, height differences, profiles and slopes

Measuring on Maps

Units of Length

- The Basic SI-Unit is the metre (m)
  - Derived units are:
    - 1 kilometre(km) = 1 000 m
    - 1 decimetre (dm) = 0.1 m
    - 1 centimetre (cm) = 0.01 m
    - 1 millimetre (mm) = 0.001 m
- The British system:
  - 1 chain = 66 English feet
  - 1 Engl. feet (ft) = 0.3048 m
  - 1 yard = 0.9144 m
  - 1 miles (US) = 1.609 344 km
  - 1 miles (nautical) = 1.852 km

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Measuring on Maps

Units of Area

- The SI-Units are:
  - 1 square metre = 1 m^2 = 1 m * 1 m
  - 1 hectare = 1 ha = 100 m * 100 m = 10 000 m^2

- The British system:
  - 1 acre = 0.40468 ha
  - 1 square mile = 640 acres

Measuring on Maps

Errors

- In any technology concerned with measurements there are the following type of errors:
  - gross errors
  - systematic errors
  - random errors
- Gross Errors:
- These are blunders made usually
  - in reading the scale incorrectly
  - in copying the results of a measurement incorrectly
  - in mishandling instruments
- The best way to avoid gross errors is to make at least <u>one extra measurement</u> than is theoretically necessary.
- The first fundamental principle is eliminate the gross errors

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Measuring on Maps

Systematic Errors

- Systematic errors are normally small errors but they are cumulative and therefore grow into large errors when they are repeated.
- Causes for systematic errors are often
  - Use of unsuitable method
  - inaccurate setting of instruments
  - e.g. measuring distances with a pair of dividers instead of a scale rule. The measured distance will not be exact because of the inaccurate setting of the dividers.
- The second fundamental principle is to Eliminate systematic errors

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Measuring on Maps

- Random Errors
  - In mapping the most significant single cause of random errors is the uncertainty of estimating distance in the engraved sub-division of the scale.
  - Small errors are more common than large ones.
  - Positive and negative errors are likely to occur.
  - If we repeat a single measurement many times, the frequency of the result has a bell shaped outline known as a Normal Distribution
  - The small errors cancel off
  - In estimating distances on maps we may expect to get a Graphical Accuracy of 0.2 mm.

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Measuring on Maps

Measuring of Coordinates

- Measuring of coordinates can have reference to the geographical coordinates (φ,λ) but normally rectangular coordinates are determined.
- In case of shrinkage the results ought to be adjusted.
- The determination of coordinates can be done:
  - manually by use of a scale and divider or set-squares
  - by use of a rectangular coordinatograph
  - by use of digitizer in combination with a desk computer

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Measuring on Maps

Measuring of Distances

- to obtain the distance between two points on a map or plan, simply mark off the distance between the points
  - with a pair of dividers or
  - with the straight edge of a piece of paper
  - transfer measurements to the bar scale and read off the distance.
- to measure curvilinear lines, e.g. roads or other irregular lines
  - step the distance with a pair of dividers
  - follow the curvilinear feature with a piece of paper
  - follow the line with a special curvilinear measuring instrument.

Measuring on Maps

- Areas can be determined on maps in many ways but three most important methods are:
  - Mathematical method
  - Use of Planimeter
  - Use of Area Measurement Overlays
- Mathematical Method
  - Areas of closed polygons can be calculated numerically from coordinates by using the Gauss Formula

$$2A = \sum_{i=1}^{i=n} x_i (y_{i+1} - y_{i-1})$$

  - In this formula the points are taken in clockwise order but should they be taken in an anticlockwise direction you will get the same answer but with a negative sign.

66

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Measuring on Maps

Planimeter Method

- An area of an irregular figure can be determined by use of a planimeter.
- The outline is followed with the tracing point and the vernier is read.
- The difference between the initial and the final readings is proportional to the area measured.
- The measuring process has to be repeated until at least three consistent readings are obtained.
- The mean of the readings is multiplied by the scale factor to produce the area.
- Usually the scale factor is available in the planimeter case or the following formula: A = R * (S/1000)□, where A = Area in hectares, R = Reading result, S = Scale denominator

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Measuring on Maps

Area Measurement Overlays

- A very simple way of making a rough check of the calculated or measured area is to use the area measurement overlays such as:
  - linear template,
  - square template or
  - dot template.

Measuring on Maps

The Use of a Dot Template

- A dot template is a transparent template where each dot represents a specific area dependent on the scale
- The overlay is handled as follows:
  - Put the overlay on the figure to be measured. If the overlay is smaller than the figure, subdivide the figure
  - Count the dots which are inside the area. Dots just on the boundary are counted as ½ points.
  - Multiply the number of the dots by the area each dot represents.
  - To get a good result the overlay should be placed randomly on the figure. The dots must be counted at least twice with a rotation of the overlay in between the two counting.
  - The procedure has to be repeated until at least two consistent results are obtained. The mean of the consistent readings is the measured area.

Measuring on Maps

Measuring of Heights, Profiles, etc.

- Measurable heights on a map can be shown as:
  - Spot heights
  - Contour lines
- The spot heights:
  - are heights of single points given numerically determined by:
  - geometric levelling with the accuracy of cm
  - trigonometric levelling " dm
  - barometric heighting or by " m
  - photogrammetric methods " dm - m

Measuring on Maps

Contour lines

- Contour lines are lines of equal height determined by:
  - plane table survey
  - tacheometric methods
  - surfaced levelling method
  - stereo interpolation or by
  - stereoplotting
- Whatever the surveying method of contour lines they are relatively inaccurate in comparison to other details

Contours and Spot Heights

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Contours and Spot Heights

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The Geometrical Framework of a Map

- The geometrical framework of a map is described by the following terms:
  - Scale
  - Graticule
  - Grid lines
  - Neat lines
  - Sheet numbering systems

Scale of a Map

- This is the ratio between distance measured on a map and corresponding distance measured on the reference surface – the ground.
  - Small Scale
    - shows large area
    - E.g. 1:10,000,000
  - Large Scale
    - shows small area
    - E.g. 1:50,000

75

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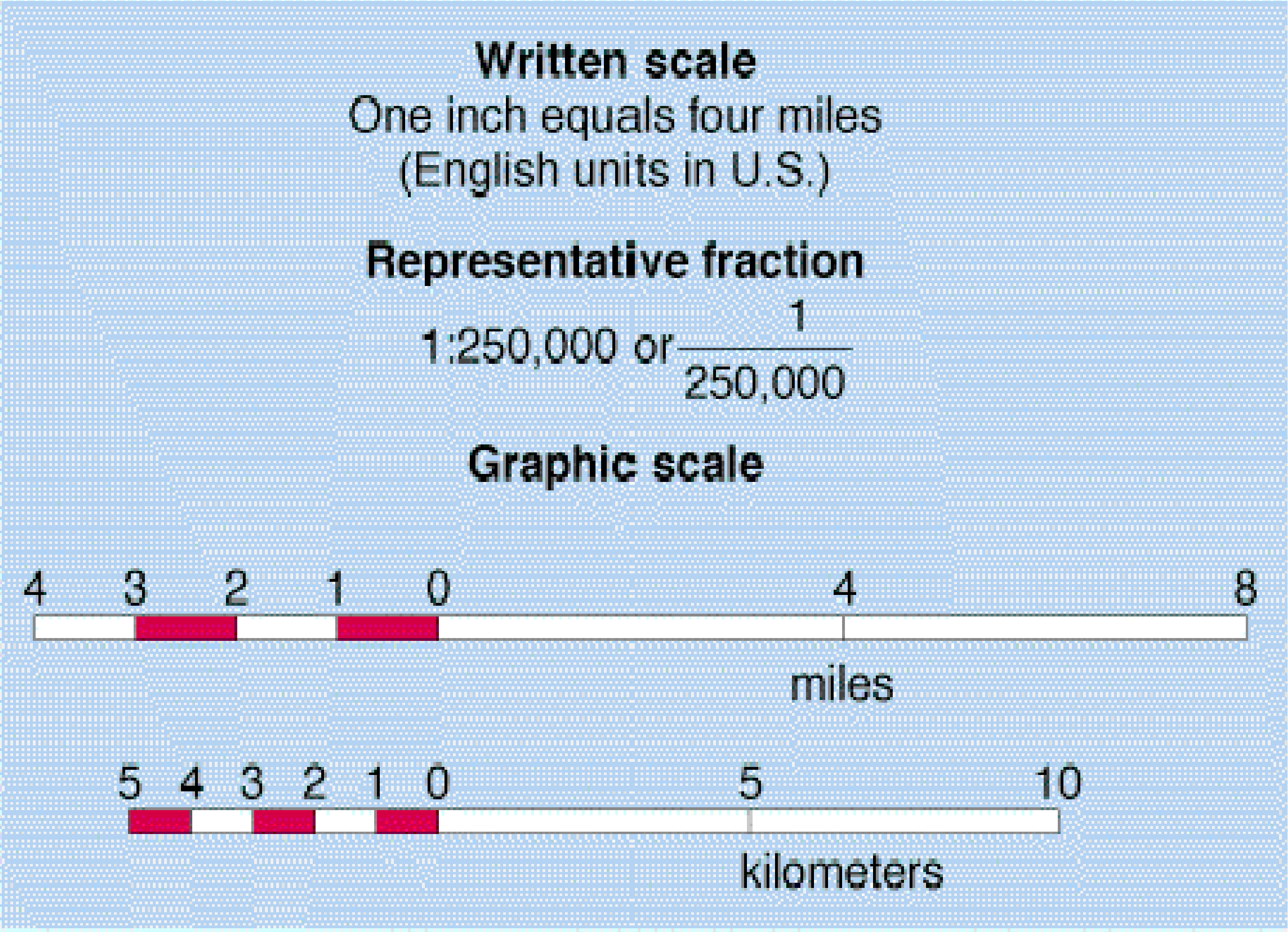
Scale types



76

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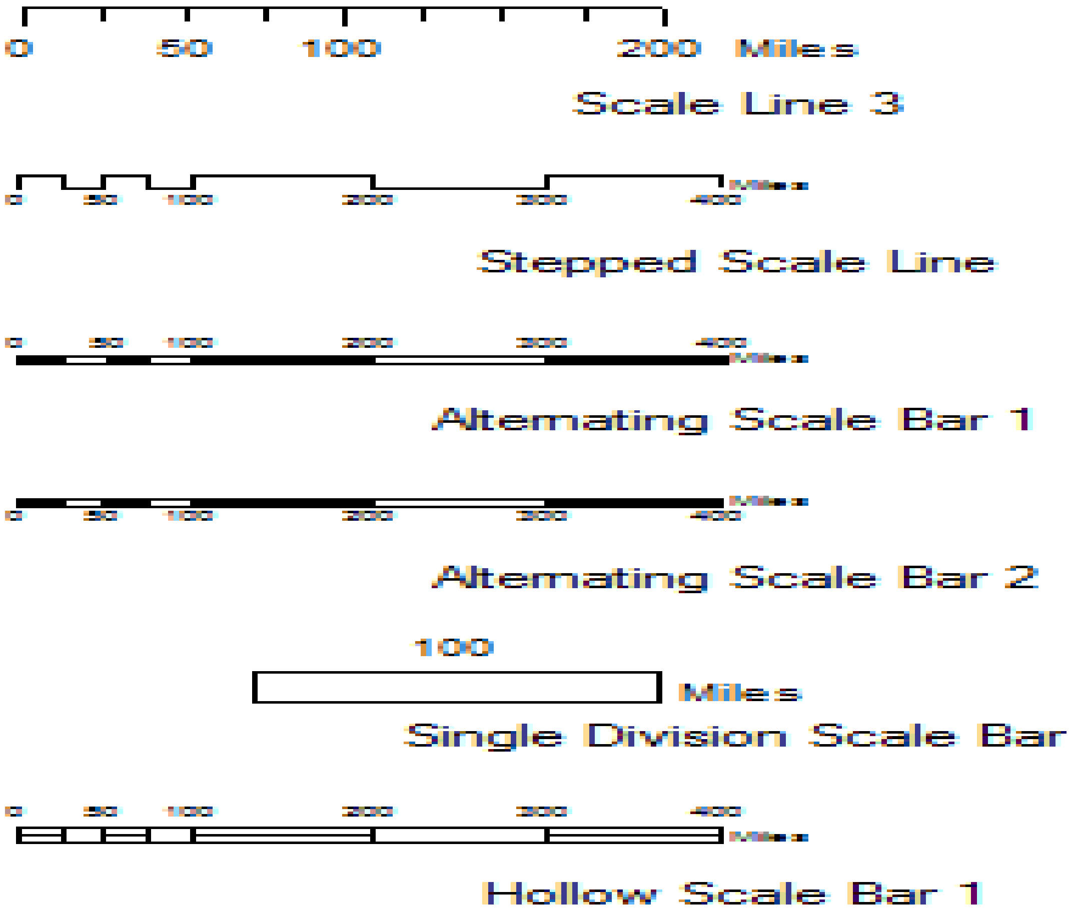
Scale Bars

- Scale bars provide:
  - a visual indication of the size of features
  - distance between features on the map
  - A scale bar is a line or bar divided into parts and labelled with its ground length, usually in multiples of map units such as tens of kilometres or hundreds of miles.
  - If the map is enlarged or reduced, the scale bar remains correct.

Scale Bars



Scale Bars

- Scale Bars make the map a useful and functional tool.
- Use a scale bar rather a verbal scale such as 1 inch = 1 mile. Maps get photocopied and enlarged or shrunk. A bar scale will always work even when the size of the paper has changed.

Scale and map content

Scale of a Map

Not to be confused with the scale bar, but related. Be aware of the scale of a map and the space on the page. A small scale map can have too much information and be difficult to "read". A large scale map may not have enough information to make it useful map.

The Graticule

- This is the network of meridians and parallels
- Each graticule is based upon a particular map projection.
- It represents the projected position of selected meridians and parallels.
- At larger scales greater than 1:10 000 the framework used on the map is almost invariably a grid.
- At scales smaller than 1:1 000 000 only the graticule is shown
- On medium scale maps grids are shown while the graticule is represented by tics along the map border

The Grid

- A grid is simply a Cartesian Reference System using distances measured on chosen projection.
- A grid on a map is a system of straight lines intersecting one another at right angles.
- It represents a method of defining position on the ground by means of distances measured upon a plane surface which is assumed to correspond to a portion of the Earth's surface.
- Arbitrary grids are possible and are often used on tourist maps.
- There must be a known relationship between graticule and grid
  - to facilitate conversion of geographical coordinates to grid coordinates (on plane).

The Neat Lines

- The neat lines of a map are those which enclose all the map details and therefore define the limits of the area mapped.
- Three kind of neat lines may be encountered
  - Grid neat lines
  - Graticule neat lines
  - Arbitrary neat lines

The Neat Lines

- **Grid neat lines**
  - On large and medium scale maps the neat lines are grid lines.
  - Consequently the format of the map is always square or rectangular.
- **Graticule neat lines**
  - On small scale maps and few medium scale maps the neat lines are formed by two parallels and two meridians of the graticule.
  - These may be straight or curved lines
  - the edge of the map closer to the pole is shorter than the side nearer the Equator.
  - Example: The Basic Zambian topographic Maps 1: 50 000

The Neat Lines

Arbitrary neat lines

- The neat lines are arbitrary straight lines which have no relationship to either grid or graticule.
- They merely serve to subdivide the area to be mapped into a series of rectangular maps of similar dimensions.
- Example: City maps in Zambia.

Sheet Numbering Systems

- The majority of maps form part of a series.
- Each map is one from hundreds or even thousands of topographic maps needed to cover the whole country.
- In order to make identification easier, each map sheet is numbered and may also have a name.
- Generally the name given to a map sheet is descriptive of the area as a whole (country) or it is the name of the most important feature (town, mountain, lake) on a particular sheet.

Sheet Numbering Systems

- Three different systems of sheet numbering may be used depending upon the nature of the neat lines used for the whole series:
  - Grid reference designation
  - Graticule reference designation and
  - Arbitrary numbering system
- The Sheet Numbering System of IMW
  - The most common, world-wide numbering system which uses graticule reference designation, is adopted for the International Map of the World (IMW) at 1: 1 Million.

Sheet Numbering Systems

- Sheet designation is made by using the following letters and numbers
  - The letter **N** or **S** indicate whether the sheet lies in the northern or southern hemisphere
  - The latitude zones of the map are indicated by letters from **A** to **V**.
    - Each map extends **4°** in latitude, therefore **A** represents the zone 0°-4°, **B** represents the zone 4°-8°, **D** is the zone 12°-16°, etc.
  - The numbers from **1** to **60** are used to denote the longitude zones
    - each of measures **6°** and corresponds to the west-east extent of a single map.
    - The numbering of the zones is eastwards from 180°W longitude so that number **1** represents the zone 180°W-174°W.
  - Sheet identification is composed of these three elements in the order above. E.g. **SD 35** and **NP 35**

Sheet Numbering Systems in Zambia

- In Zambia the numbering system of 1:50 000 and 1:250 000 topographic map series also uses the graticule reference designation.
- The 1:50 000 Topographic Maps:
  - The map area is 15′*15′
  - the sheet numbering system is based upon the geographical coordinates of the north-west corner of the map.
  - E.g. 1528A4

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Sheet Numbering Systems in Zambia

- The 1: 250 000 Topographic Maps
  - The map area is 1°*1°30′
  - The sheet numbering system is based upon the sheet numbering system of IMW, where each 6°-zone is numbered eastwards from 180°W.
  - Within each zone, e.g. SD35, there are 16 of such maps numbered 1 - 16
  - Example: SD35-15 for Lusaka

Cartographic Representation of the Abstraction of Reality (Part 1 & 2)

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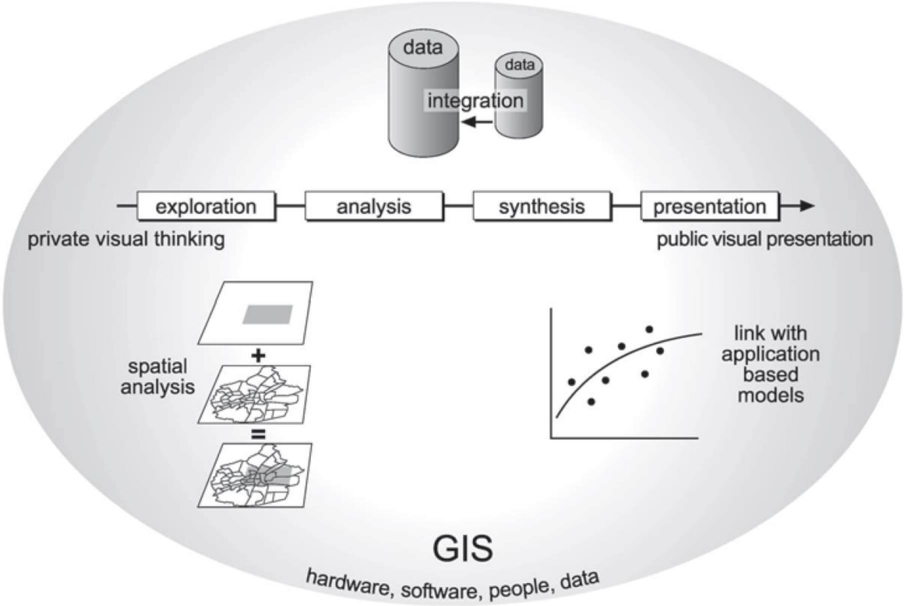
Cartography and GIS

- **Cartography** is considered as the *theory and practice of map-making and map use*.
- **GIS** is regarded as a *computer-based system* for *data input, management, manipulation and analysis, and displaying of spatial data* (*Aronoff, 1989, p.39*) *from the real world*.



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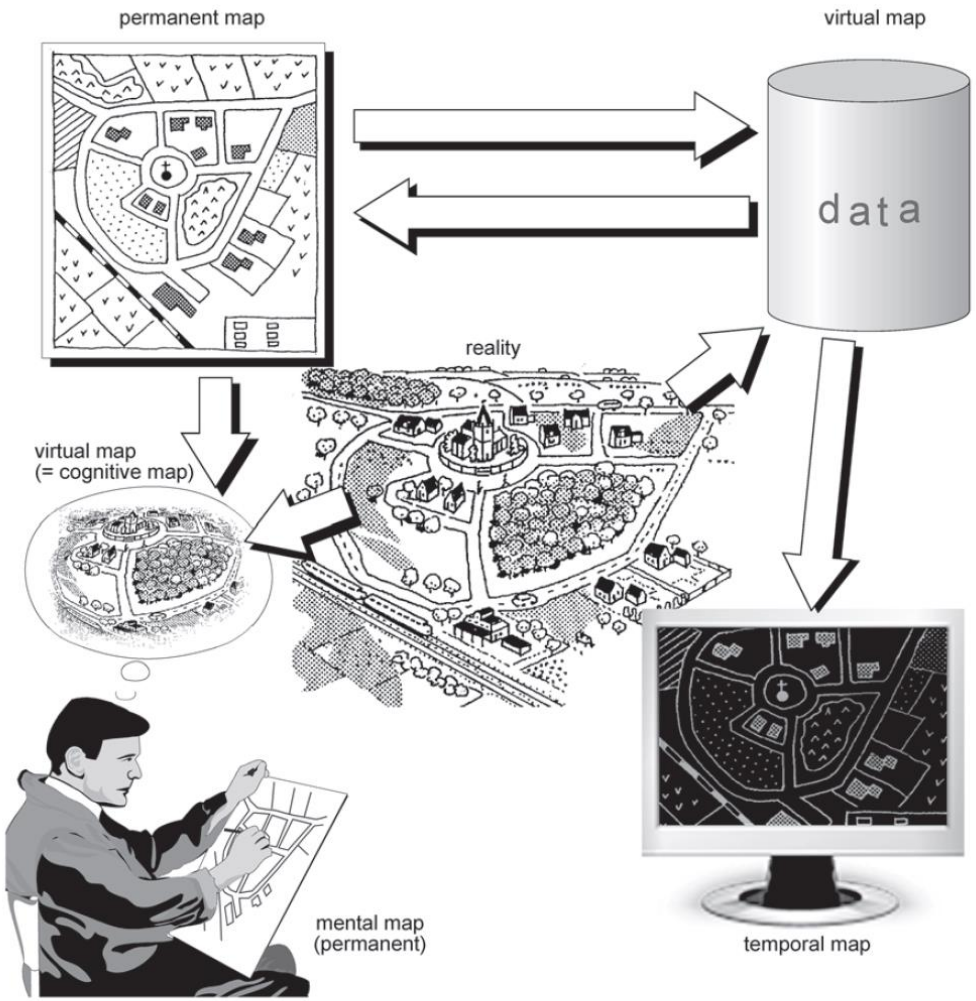
Examples of permanent, virtual, temporal and mental maps



What type of questions can a GIS answer?

- Typical GIS questions answered by maps such as those used *to identify*, to *locate* or to *find geospatial patterns*.

Key Issues between Cartography and GIS

- Key issues between Cartography and GIS:
  - Cartography is concerned with *representation*
  - GIS is concerned with *analysis* of *spatial relationships*
  - GIS is a *product* of digital cartography development:
    - Which generated *georeferenced digital spatial databases*
    - These databases became the platform for data structures that could be *linked, processed, analysed* and *displaying results* in form of maps
- Aronof (1989, p.103) further notes that *while the main function of a cartographic system is to generate computer stored maps, the function of a GIS is to create information by integrating data layers to show the original data in different ways from different perspectives*.

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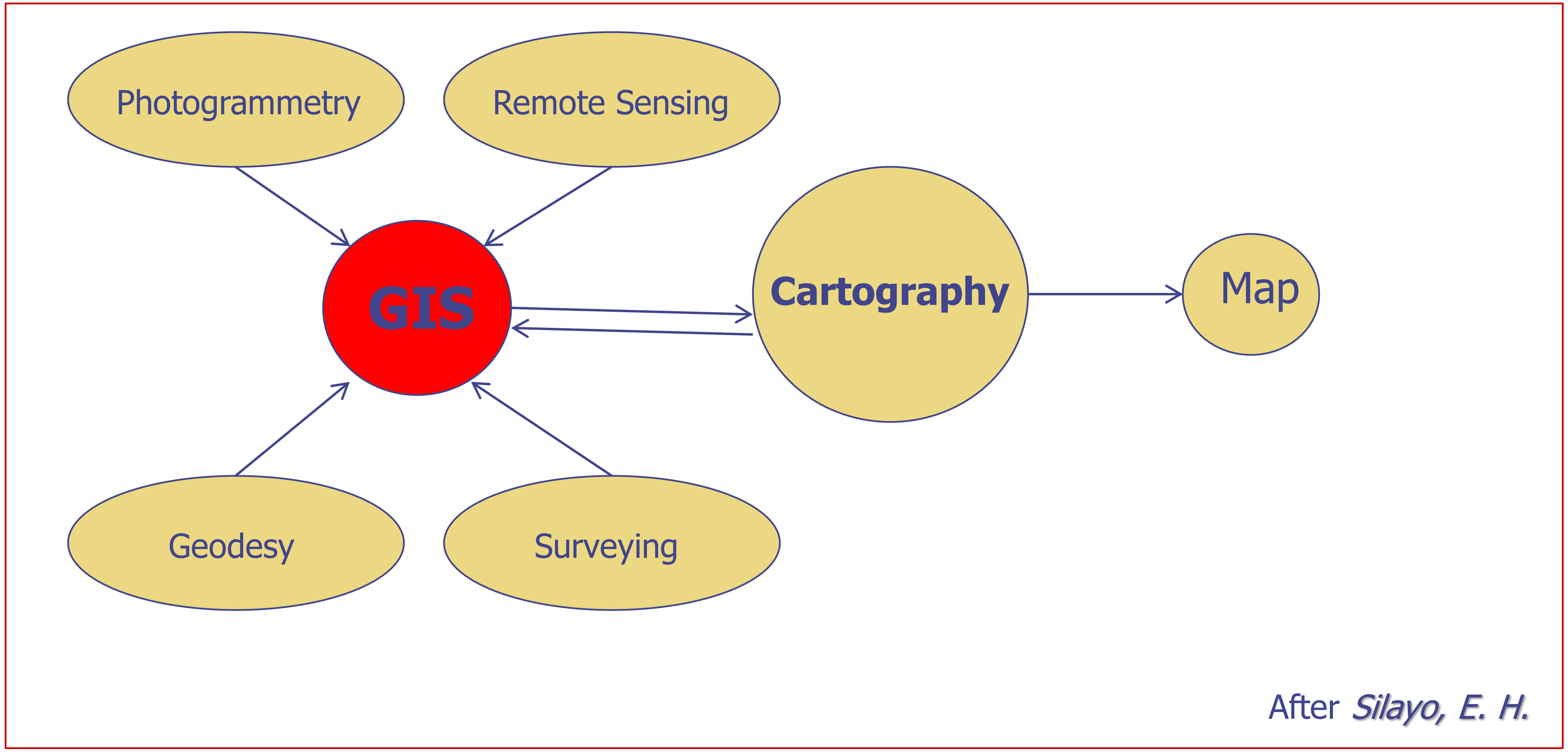
Cartography and GIS

- The *development of GIS* has made it possible for *anybody* who can operate a computer *to generate a map* from GPS data.
  - So *any GIS user* becomes *a mapmaker overnight*.
  - But **how are these maps produced?**
  - Dent (1993, p.19) stated that: *the possibilities today for maps without ethics are compounded by the proliferation of off-shelf computer programs allowing non-cartography trained persons to produce maps that may look good, but are **not** with any established professional standards or conventions*.
  - Bernhardsen (1992, p.215) observes that *GIS enables less skilled persons to produce maps but it has a drawback of permitting production of artless maps that are at best unattractive and at worst misleading*.

Cartography and GIS

- StatMap Web also observes that *Maps are a great way of displaying and analyzing statistical information but they need to be properly designed. This can be a tricky business until you know what you are doing and desktop mapping and GIS systems rarely provide much help. Most software packages will allow us to produce really bad and misleading maps.*
- Kraak and Omerling (1997, p.2) says *GIS allows users to produce their own maps even when they are unaware of cartographic grammar.*
- *Such maps may not transmit* the *intended meaning* to the *map user* at all.

GIS and the Mapping Sciences



- Information transfer *without maps* would be *cumbersome*

8

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Cartographic Shortfalls in GIS

- A *GIS user not conversant* in *cartographic principles* may select:
  - *a wrong projection*
  - *inadequate content*
  - *wrong symbols*
  - *over- or under-generalise content*
  - *inappropriate scale*
  - *unsuitable layout*
  - *unsuitable colour*

- While a GIS system may be packed up with all the information possible on earth, a *graphic output* should be *purposeful* and therefore *selective*.

Data Output and Cartography

- Cartography serves two (2) *major functions*:
  - It produces *graphics on screen* or *on paper* that *convey* the *results of analysis*
  - Other *database information* can be *generated* for *further analysis* or *use*

Maps as a Communication Tool

- People have communicated with one another since the beginning of time using *different forms of communication*.
- The *information exchange* can take place through:
  - Literacy
    - *words* (oral or written)
  - Numeracy
    - *tables*
    - *numbers* and *formulas* (in mathematics)
  - Graphicacy
    - *music* and *performing arts*
    - *pictures* and *photographs*
    - *graphic sketches* and *diagrams*
    - *cartographic presentations*

Maps as a Communication Tool

- Losses of information during cartographic processing:
  - at the first stage
    - not all the available information in *reality* is used
  - At the second stage, the *compilation of the map*
    - involves losses of information in the process of *generalisation*.
  - At the stage of map reading
    - information contained in the individual symbols is not always fully utilized because of the *insufficient cartographic training of the reader*.
  - At the interpretation stage
    - the chief aim of interpretation is the formation and expansion of ideas on mapped reality by enlisting the reader's prior *experience* and *knowledge*. But experience and knowledge *vary* from person to person. This subjective factor explains the possible variations in the *depth* and the *correctness* of *interpretation of reality* by *different users/readers*.

Maps as a Communication Tool

- Every map has a *specific communication objective*.
- In order to represent objects spatially in terms of *relationships, processes, functions, systems,* etc.
  - a *cartographic presentation* is the best
  - in most cases, the only possibility.

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Maps as a Communication Tool

- Cartographic presentations *differ* from other kinds of communication for the following reasons:
  - because of the use of *mathematically derived process* of ***transformation*** called **Map Projection**
  - by the deliberate employment of a reduced form of representation through **Scaling**
  - by the *careful definition* and *delineation of concepts* called **Symbolisation**
  - through the *selection* and *simplification* of **geographical reality** according to scale and purpose called **Generalisation**

Maps as a Communication Tool

- A cartographic process makes it possible to transform a mapped part of reality into a two-dimensional (2D) spatial representation (the map) and thereby create a visual entity.
- This entity, whose contents are based on the **selection**, **generalisation** and **symbolisation** of facts, yields the desired map.
- A good map informs the map user through its scale-related spatial proportion and the selection and presentation of its contents.
- Since spatial awareness has always been one of the most important prerequisites of human life, cartographic representations can be seen to date back to the *earliest periods of man's known existence*.

The Language of Maps

- The ability to put information into and extract it from maps is termed Graphicacy.
  - the ability of a reader to extract full and accurate information is largely dependent on the skills and clarity of expression of the author, the mapmaker.
- The language of large scale maps is simple
  - Most reality could be drawn at their true plan size and shape as there is enough space among the details for drawing the features in full.

The Language of Maps

- When scale is reduced, cartography has to develop its own special language.
  - the skills of a cartographer are most needed
  - Useful information has to be shown as much as possible in an ever decreasing space and it must be clearly legible and comprehensible.
- This requires:
  - Selection
  - Generalisation
  - Symbolisation

Selection

- Selection in cartography means choosing:
  - which items of details to omit and
  - Which items to retain as scale decreases.
- The criterion used may be:
  - size or
  - importance of the feature.
- The choice of features will be affected by:
  - the purpose of the map or/and by
  - the editorial policy

Map Generalisation

- A **map** is an abstraction of reality; as such *not everything* in reality can be represented on the map
- But it should be able to assist the map reader to understand the *spatial form* and *structure* and to distinguish *important characteristics* of the phenomena represented.
- Thus, map generalisation requires:
  - Selection of features essential for *map purpose* and
  - Representation of them that is *clear* and *informative*
  - Both involve a *degree of information reduction*
  - Is dependent on scale and subjectivity

Map Generalisation

- The principal function of generalization is to distinguish between *important* and *unimportant* phenomena or events in a reference space in relation to the map space available
- Three (3) levels of the transformation of the Earth's surface can be recognised:
  - Primary (geometric; x, y surface)
  - Secondary (semi-geometric; z surface)
  - Tertiary (*generalization of data* from *reference space* to the *map space*, or XYZ → xyz).

Map Generalisation

- **Factors which Influence Cartographic Generalization:**
  - Scale
    - Scale determines the object size on the map
  - Source material
    - Source material must be ungeneralised otherwise correctly so
  - Special conditions for legibility
    - Special map reading conditions must be taken into account
  - Symbol specifications
    - It influences the degree of generalisation
  - Choice of colours
    - Pale colours require *wider lines* and *larger area symbols*
  - Technical reproduction capabilities
    - Take into account the available production and printing facilities

Semantic Generalisation

- It is concerned with the meaning and function of a map through the *identification of a hierarchical structure* in the geographical information
- **Two (2)** important hierarchs to generalisation are *classification* and *aggregation:*
  - 1. Classification
    - Hydrography
      - Rivers, lakes, etc.
    - Settlements
    - Lines of communication
    - etc.
    - Once data have been classified, *rules of selection* can be devised

Semantic Generalisation

- 2. Aggregation
  - Is concerned with *composition of phenomena*
  - Which can further be subdivided:
    - A city is composed of *administrative districts* which are themselves further subdivided
    - It may be used in a *similar manner as classification*

Geometric Generalisation

- Geometric representation of geographical information may be subject to a wide range of modifications in the course of generalisation.
  - Thus, *boundaries of residential blocks may be left out* if they are too low on the classification hierarchy
  - Most modifications are as a result of trying to meet good cartographic symbolisation relating to:
    - Clarity and ease of visual communication

Displacement

- A road symbol at a smaller scale map would cover the buildings. Therefore the building symbols are displaced outside the exaggerated line. A road symbol is displacing buildings in generalization.
- Displacement Hierarchy
  - The following hierarchy could be suitable for Zambia:
    - Railways displace
    - Waterways.
    - Roads.
    - Buildings.
    - Vegetation.
    - Triangulation and other control points *remain always at their correct exact positions*. *(Remember the primary transformation !)*

Geometric Generalisation

- Categories of geometric generalization:
  - Elimination of point, line and area geometry
    - Remove features that will create clustering of features
  - Reduction in the detail of lines, areas and surfaces
    - Rather than remove just simplify the detail of the feature
  - Enhancement of the appearance of lines, areas and surfaces
    - Smoothing and fractalisation
  - Amalgamation of lines and areas
    - Combing or merging originally distinct or entirely separate features

Geometric Generalisation

- Collapse of areas to points and lines
  - Reducing the dimensionality of an object to a geometric representation
- Enlargement or exaggeration of line and area objects
  - Exaggerate map features that have become too small to represent due to scale reduction
- Typification of line, area and surface objects
  - Communication of a representative form of an object which cannot be geometrically represented accurately
- Displacement of points, lines and areas
  - To avoid overlapping objects after exaggeration of other objects

Summary

- Map generalisation is a fundamental processes in graphic communication of spatial information.
- It is a subjective process in that the mapmaker must decide *what needs to be kept* and *omitted* from the map keeping in mind the map agenda.
- Its also important to note that generalisation is triggered by reduction in map space that arises due to reduction of map scale.

Symbol Design (Part 2)

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Symbolisation

- An unlimited variety of spatial data that is mapped is represented on maps by symbols.
  - The graphic symbol is an image chosen by the cartographer to represent data.
  - It is therefore the *most fundamental element* of the cartographic language and design.
- Symbols on a map are constructed to show clearly:
  - the precise geographic location of the feature they represent
  - the relationships existing among the symbols
  - the quality of the feature being represented.
- In addition:
  - all symbols must be identifiable without any extra effort or uncertainty, map user must identify each symbol easily

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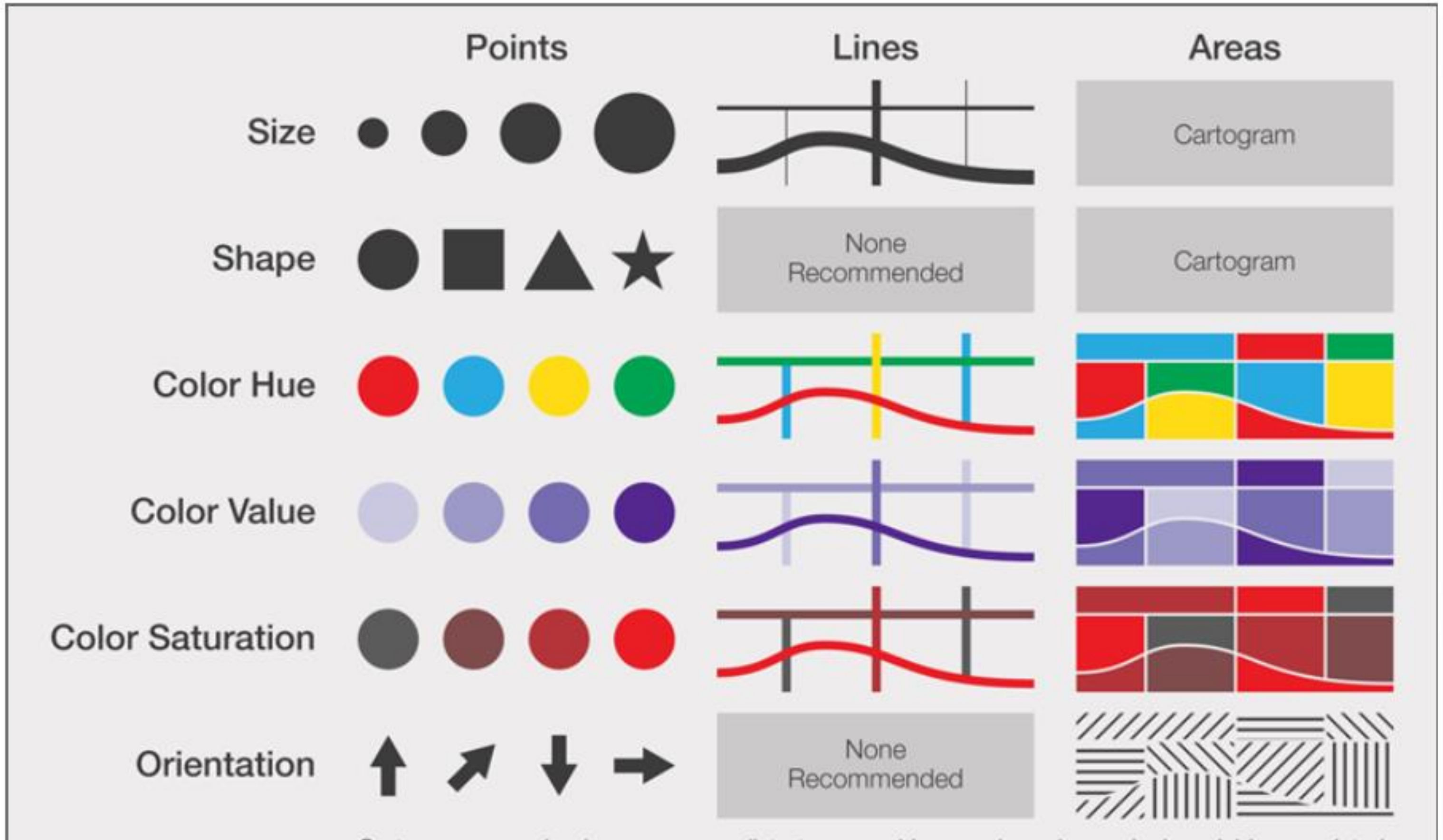
Classes of Symbols

- All symbols used in cartography can be classified in **three** (**3**) classes:
  - Point symbols
  - Line symbols
  - Area symbols
- **Point**, **line** and **area symbols** are always defined in the plane of the map by points which can be located with precision in **x** and **y**.
  - This location can be given a **code number**, **be registered** and **plotted**.
  - **Computer Assisted Cartography** is based on this principle.

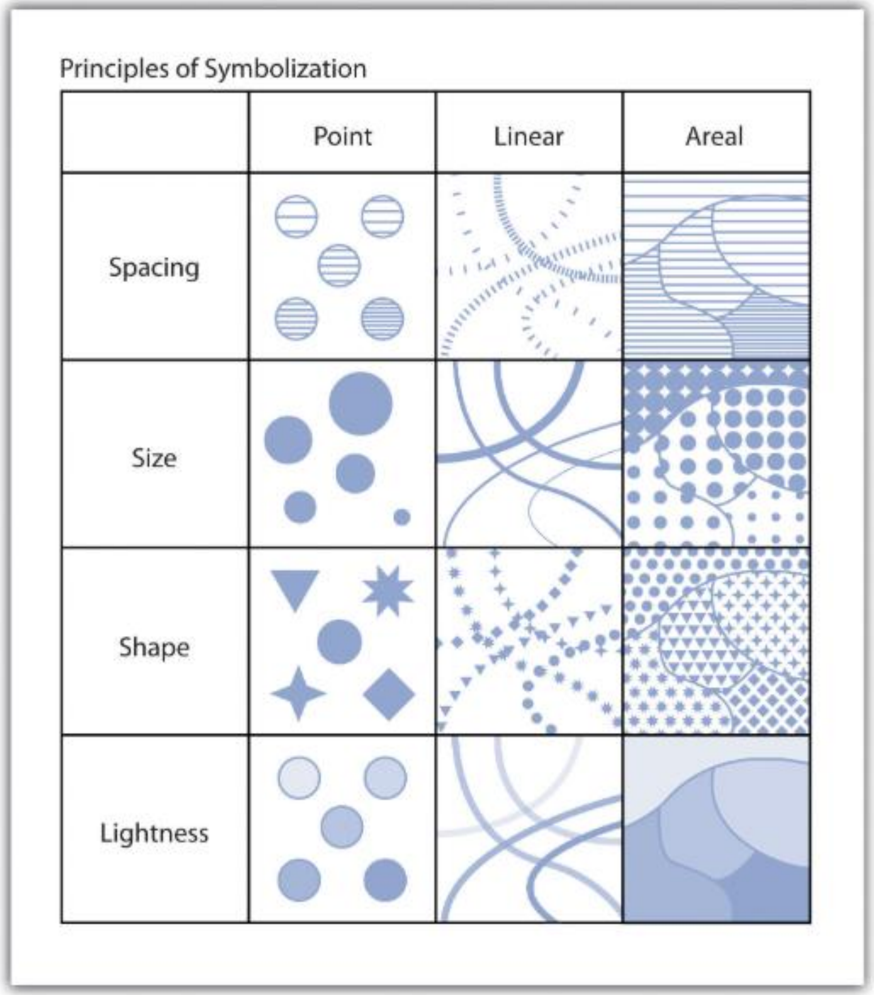
Graphic Elements in Symbolisation

- Differences in positions among data is the primary purpose of the map
  - but if this was all, a map would not be necessarily readable
  - In order to represent the different data in meaningful way, we must vary the appearance of graphic symbols.
- The different variations that can be used are:
  - size
  - texture and structure
  - value or lightness
  - grain
  - hue (colour)
  - orientation
  - shape

Graphic Elements in Symbolisation



Cartograms, or value-by-area maps, distort geographic areas based on a single variable associated that area, (e.g., the size of a county is proportional to its population density).



Size

- Symbols vary in size when they have *different dimensions*
  - such as **diameter**, **width** or **area**
  - Usually the **larger** a sign, **the more important the feature** is thought to be.
- Variations in size are almost unlimited.
  - only limitation is the aptitude of the eye to perceive certain minimum thresholds of linear or area size differences.
- **The size** of the symbol will depend on **two (2) factors**:
  - The minimum size **at which it can** be **perceptible**
  - The size required to **demonstrate** its **level of importance**

Size

- Limits of Visual Perception
  - A map should be readable without difficulty, in normal light, by a user having normal vision.
  - To ensure the legibility, a map designer must take the following criteria into consideration:
    - Threshold of perception
    - Threshold of separation
    - Threshold of differentiation

Size

Threshold of Perception

- This is the minimum size of a graphic element which can be seen with a naked eye under normal circumstances.
- In the practical work the following standards are normally used:
  - Point
  - Line
  - Full square
  - Empty square

Threshold of Separation

- This is the minimum distance between two (2) graphic elements which can be observed with the naked eye under normal circumstances.
- In practice this is 0.2 mm for parallel lines.

Size

- **Threshold of Differentiation**
  - This is the minimum difference between two (2) graphic elements or between two (2) symbols of nearly the same size which can be observed with the naked eye under normal circumstances.
- In order to follow this rule, one should avoid:
  - shapes which are too similar
  - the use of tint screens which are too similar
  - sizes too similar for symbols of the same shape.
  - It is important to respect this limitation of differentiation in cartography, and especially in the thematic mapping.

Size

- The threshold of perception and separation are very important in generalization, particularly in topographic mapping.
- Example of size demonstrating importance:
  - Main road 0.60 mm
  - Secondary road 0.30 mm
  - Other roads 0.15 mm
- Differences in line widths must be perceptible differences which can be detected by the map user

Texture and Structure

- Some simple graphic elements can be distributed inside a point, line or area symbol.
- Texture (Spacing)
  - refers to spacing of a series of dots or lines that are components of a symbol.
  - Texture can be coarse or fine, and when it becomes *very fine* it may be difficult to distinguish *from* value.
- Structure
  - refers to the regular spatial arrangement of simple graphic elements inside a symbol.

Value or Lightness

- Value or lightness is the variation in intensity of light perceived by eye as shades of grey, *varying* from white to black.
- Through a size variation of the graphic element and consequently a space between them, a variation in value is obtained.
  - Value is thus the relation between the surface covered by graphic elements and the white space between them expressed in percentages:
    - a white surface corresponds to 0%
    - a surface is 50% when there is an equilibrium between white and black (or other colour)
    - A surface is 100% when the elements cover the entire surface.
      - It is said to be **saturated**.

Grain

- The grain is a size variation of the graphic elements, points and lines, spread over a surface.
  - The relation of the graphic element (dot or line) to white background (= value) remains constant.
  - It is expressed in dot or line/cm (international) or dot or line/inch (UK)
- Flickering Effect
  - Whenever the graphic elements are in equilibrium with the white background (value = 50%), a vibration or flickering effect is produced.
  - Especially when the graphic elements are big enough to be perceived separately, the flickering effect appears.
  - The eye then flickers between the white and the black elements of similar importance. This gives a disagreeable appearance and should be avoided.

Hue or Colour

- On printed maps, variations in hue between red, yellow, green, blue etc., which the eye can perceive when looking at symbols are not produced by using particular simple graphic elements, but by changing the printing ink used on the map.
- What is colour? The sensation of colour can first be defined as a physical phenomenon.
- The colours used on a map are components of the light of the sun.
  - Coloured light is composed of light particles, *photons*, each one moving with a different wavelength.
  - Solar light appears to be white, when it is made up of all its components together.

Hue or Colour

- The components of solar light can be separated from one another in a well-defined sequence:
  - violet-blue 410 nm
  - blue 450 nm
  - green 510 nm
  - yellow 560 nm
  - red-orange 600 nm
  - red 650 nm

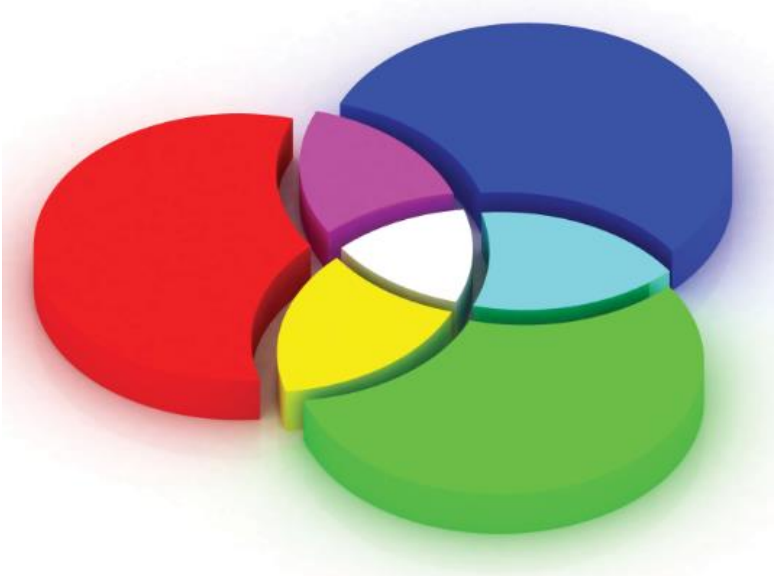
  - The wavelengths from 410nm - 670nm (nanometres) corresponds to a visible zone of the solar spectrum or electromagnetic spectrum.

Hue or Colour

- Primary colours
  - Some hues are called as primaries.
  - All other colours may be created by a suitable mixture of them.
  - A primary colour is not a pure spectral hue, but like all non-spectral hues, it is a combination of wavelengths in which one portion is dominant.
- Additive Primaries
  - Blue
  - Green
  - Red

Hue or Colour

- If three circles of blue, green and red light are projected on a white screen, the superposition of:
  - red and green = yellow
  - green and blue = cyan
  - blue and red = magenta
  - red, green and blue = white



- This is called an additive synthesis.
  - A colour-TV functions by additive synthesis.

Hue or Colour

- Subtractive Primaries
  - Colours on a paper result from pigments being applied to the surface, which, when *illuminated by white light* absorb or subtract some of the *wavelengths*.
- The subtractive primaries are:
  - cyan (greenish-blue)
  - magenta (purplish red)
  - yellow
- Most colours can be created by a subtractive mixture of these pigments.
  - This process is called subtractive synthesis.

Hue or Colour

- Printing systems of coloured images such as maps are based on subtractive synthesis.
- The so called "4-colour" printing system, uses subtractive primaries plus black (also called process colours)
  - this is the most common printing system for multicolour images.

Hue or Colour

Colour terminology

- Colours can be differentiated in terms of their **hue**, **value** (or **lightness**) and **saturation**.

Hues	Y	yellow
	O	orange
	R	red
	P	purple
	V	violet
	B	blue
	G	green
Lightness	W	white
	L	light colour
	D	dark colour
	S	black
Saturation		pure colour
	GY	neutral grey

Hue or Colour

- Colour, Value and Saturation
  - All colours can be subjected to variations in their value (lightness) i.e., they will appear lighter or darker, depending on the percentage of the screen which has been used.
  - Pure colours (without any white) are said to be *saturated*.
- It is not possible to distinguish more than:
  - three degrees of saturation of yellow,
  - four or five degrees of green, or orange-red
  - six degrees for red and
  - up to eight degrees for blue and violet.

Hue or Colour

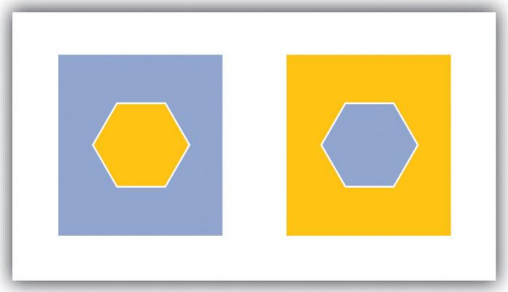
- Perception of the Brightness of Colours
  - The colour of an object or map element will be perceived by the eye according to the amount and the composition of light shining on it.
  - If the object or map is observed in incomplete light, the original colour of the object will be modified.
  - For instance, yellow and red map elements will appear grey in an orange electric light.

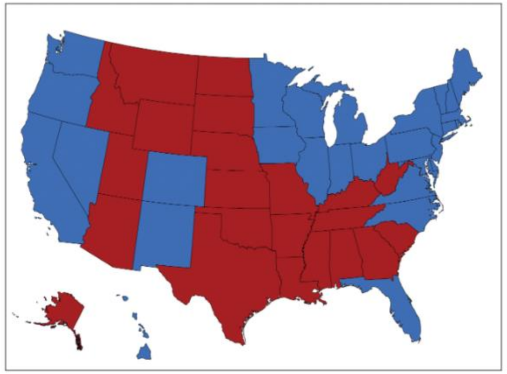
- When selecting colours in a map designing process, artificial light conditions should be taken into consideration.
  - The intensity of light will also influence the perception of colours.
    - colours with a long wavelength (yellow to red) appear *brighter* under intensive light and *softer* under subdued light (at dusk).
    - The effect is opposite for colours with a short wavelength (blue to violet).

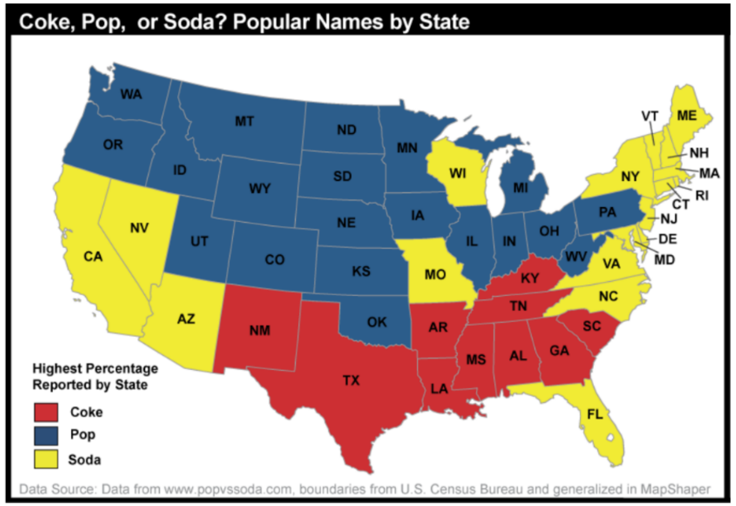
Hue or Colour

- Psychological Aspects of Colour
  - The feeling and sensations which a map reader experiences when looking at colours have always been consciously or not, *a guide for map makers*.
- Connotative colours
  - are those which remind the reader of the colours found in nature (green for forest and vegetation in general, blue for water, etc.).
- Warm colours
  - (red, yellow) are used in order to represent those elements of the map which have to appear more important or higher.
- Cool *colours*
  - (blue, violet) represent less important or weaker elements.

Hue or Colour







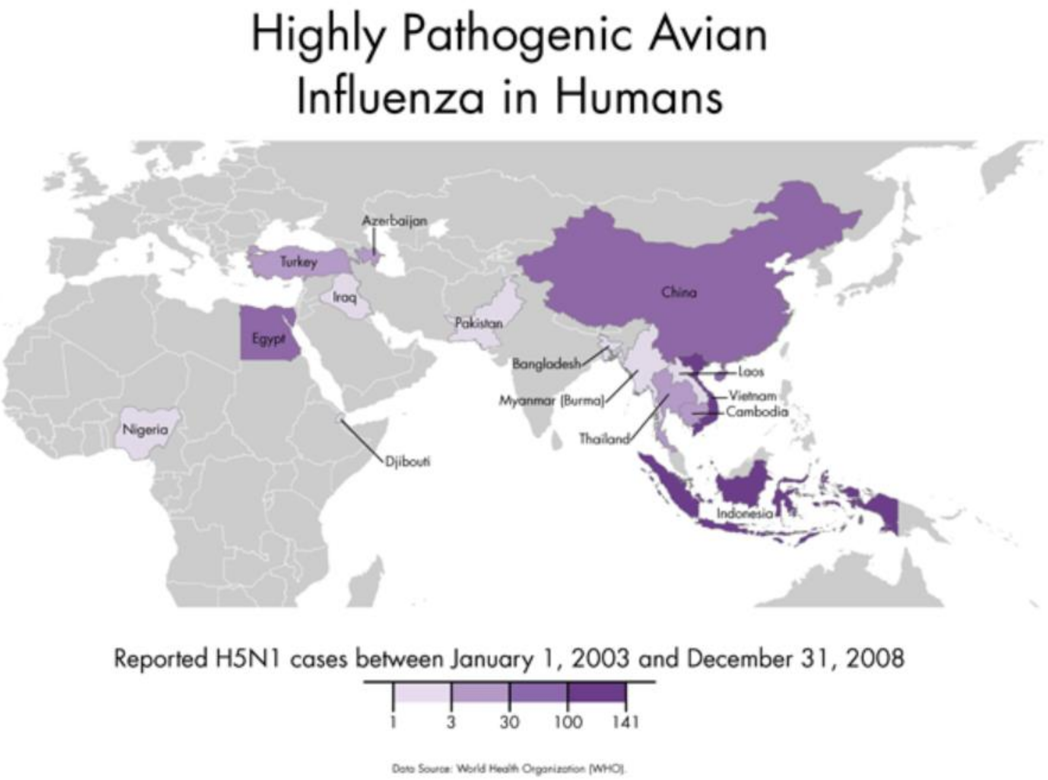


Figure 3.10: Reported H5N1 Cases (Avian Flu) Per Country from January 1, 2003 to December 31, 2008.

Credit: Created by Paulo Rapolo.

Hue or Colour

- **Colour Appearance Systems**
  - Each of the three (3) characteristics of colour varies continuously, and all colours can therefore be arranged as a three-dimensional (3D) colour appearance system.
  - A number of colour-appearance systems have been developed, e.g. CIE, Munsell, and Kirschbaum systems.
- **CIE-system (Commission International de l'Eclairage)**
  - is based on instrumentation and the mathematical analysis of the physical characteristics of light.
- **Munsell system**
  - is based on the human perceptual reaction to light and its colours.

Hue or Colour

- The Kirschbaum system
  - is an oblique double cone.
  - Its central axis (W-S) is the grey scale with black at the bottom and white on the top.
  - Every horizontal layer contains all of the colours of equal lightness.
  - The hues Y-O-R-V-B-G-GY are arranged in the form of an oblique diameter, called a colour circle.
  - Within this model colours may vary continuously, but may also be split up into steps so that each colour sample differs from its neighbours by a noticeable amount.

Orientation

- It is possible to express differences between symbols by their orientation.
- This variable can only be used on the graphic elements or on linear symbols
  - which restricts its possibilities.
- Orientation can be used so that each orientation represents a different group of information (human type, vegetation species, etc).
- Orientation is the only visual variable which can provide effective representation of all dynamic phenomena: directions, movements, attractions, migrations.

Shape

- Variations of shape or form, not to be confused with the shapes of areas, consist of changing the outline of the symbol.
- These variations only apply to point symbols or, in certain circumstances, to line symbols, and never to the outline of an area symbol, as this outline represents a geographic location and thus cannot be changed.
- In order to express shape differences within area symbols:
  - the only possibility is to introduce graphic elements or point or line symbols at regular intervals across these areas.
  - Their shape remains the same throughout a particular surface area but may vary from area to area, each shape representing a particular category of data
  - this type of symbol patterns are very common in topographic maps

Shape

- The forms used in cartography are called pictorial or representative when they suggest, in a general way, the real shape of the features represented.
- Geometric shapes such as squares, circles and triangles are commonly used in thematic mapping, especially representing statistical data.

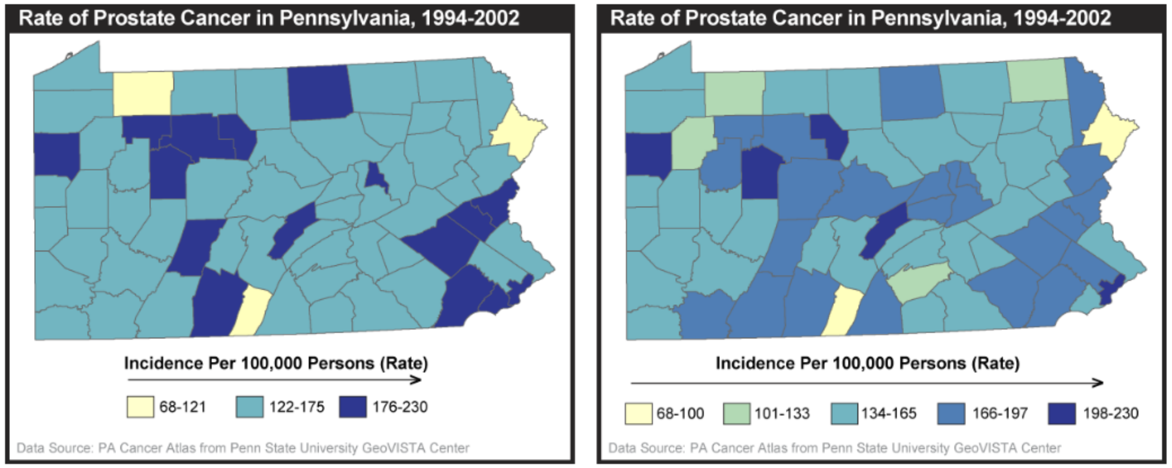


Figure 3.6: Incidence rate of prostate cancer per 100,000 persons per county in Pennsylvania, visualized using three classes (left) and five classes (right).

Credit: Jennifer M. Smith, © The Pennsylvania State University; Redesigned after PA Cancer Atlas from Penn State University GeoVISTA Center.

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Symbol Perception

- Four (4) types of visual perception properties:
  - Associative Perception
  - Selective Perception
  - Ordered Perception
  - Quantitative Perception

- Visual variables may have one or more of these perceptual properties

Symbol Perception

- Do all symbols look of similar importance?
  - If yes then the symbol has an Associative Perception
- Can distinct groups of symbols easily be separated?
  - If yes then the symbol has a Selective Perception
- Can any specific order be recognised?
  - If yes then the symbol has an Ordered Perception
- Can the order be specified by amounts?
  - If yes then the symbol has a Quantitative Perception

Associative Perception

- A visual variable is called associative if spontaneously all symbols represented by that variable are seen as of equal importance
- Such a group of symbols has a homogeneous appearance such that no one symbol stands out above the others
  - Form, orientation, colour and texture* are associative
  - Value, size and grain are NOT associative

Selective Perception

- A visual variable has a selective perception if spontaneously all symbols differentiated by that variable can be arranged in distinct groups
  - Value, size, orientation, texture and grain are <u>selective</u>
  - Form is <u>NOT selective</u>

Ordered Perception

- A visual variable has an ordered perception if spontaneously all symbols differentiated by that variable can be placed in an unambiguous order
  - E.g. Low – high, least – most important
  - Value, size and texture are ordered
  - Orientation, colour, form and grain are NOT ordered

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Quantitative Perception

- A visual variable has a quantitative perception if spontaneously all symbols differentiated by that variable may be separated from another by a distinct amount
  - E.g. B is 2 times A and C is 3 times A
  - Only size has a quantitative property
  - All other variables are NOT quantitative

Types of Information and their Perception Property

- A particular type of information is represented by visual variables with a particular perception property.

- Nominal Information = Associative/Selective
- Ordinal Information = Ordered
- Interval Information = Ordered
- Ratio Information = Quantitative

Types of Information

- Qualitative Information is measured on a nominal measurement scale
  - This measurement scale gives information on the different nature/identity of things
  - E.g. Arable land, pasture, built up area, forest

- Ordered Information is measured on the ordinal measurement scale
  - This measurement scale gives information with a clear element of order though not quantitatively determined
  - E.g. Hamlet, village, town, city, conurbation

Types of Information

- **Quantitative Information** gives information about specific amounts
- It is measured on either interval or ratio measurement scales
- The Interval measurement scale ranks data and the interval between the data is quantitatively determined
  - However the zero point is arbitrary e.g. Temperature
- The Ratio measurement scale ranks data on a quantitative scale using an *absolute zero point*
  - E.g. Number of employees, production figures

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Systematic Approach to Symbol Design

- Analyse the information
  - Has it got a clear spatial component
  - Its dimensional property (point, line, area)
  - Its organisational structure
  - Its measurement level (nominal, ordinal, interval, ratio)
- Select visual variables with corresponding perceptual property
- Compose the most appropriate symbols
- Combine the symbols into the map

Typography and Name Placement
(Part 3)

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Introduction

- Throughout the ages, mankind:
  - searched for ways to communicate
  - Then communication was only possible by voice
  - To meet the need to communicate without actually seeing or hearing each other
    - people started to use objects such as *stones, shells* or *branches of trees* put together in a specific way
    - when people involved knew its meaning communication was established.
    - The first primitive symbol was born.

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Introduction

- The Egyptian hieroglyphics, the Chinese and Japanese characters of today are perfect examples of symbols representing a specific meaning or object.
- The combination of them can lead to another meaning.
- Pictorial symbols which are commonly used to symbolise *railway stations, hospitals* are in fact based upon the same principle.
- Another way to communicate with each other was by drawing symbols which were representing human sounds
  - (phonetic type) The Latin alphabet is in fact based upon such symbols and developed from the Roman ages up until now, resulting in literally thousands of different type variations.

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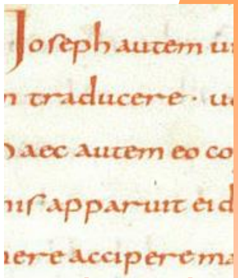
Latin Type

History of the Latin Type

- modern Latin alphabet consists of CAPITAL, Lower case and Italic lettering
- CAPITAL script
  - The alphabet as developed by the Romans
  - were composed of CAPITAL lettering only, characterised by a strong horizontal vertical contrast, caused by the Chisel to cut the type into stone.
- UNCIAL script
  - (1000 AD) was characterised by the addition of *ascenders* and *descenders* to the Roman capital script to improve legibility.
  - E.g. ROMAN UNCIAL

Latin Type

- **Carolingian script**
  - (1200 AD) consisted of lower case characters only.
- **Italic script**
  - Developed approximately 1500AD in response to the need for a *more elegant* letter type.
- **Gothic script**
  - About 1200AD developed a combination of a more elegant version of the Roman capital script where the Carolingian style and the Uncial script applied to both the capital and the lower case lettering
  - Thus from 1500 AD the Latin alphabet was composed of CAPITAL, Lower case and Italic *characters*.



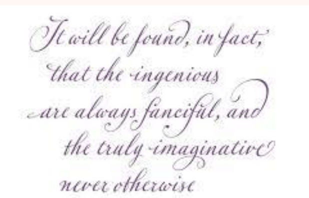
Gospel St.Matthew

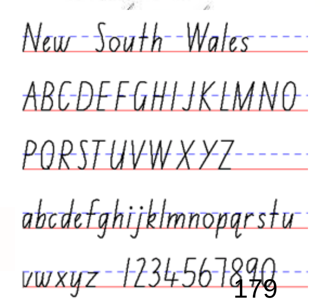
Type Styles

- There are thousands of type variations.
  - Rigid but also fancy lettering is applied in *magazines, paper screen displays* etc.
  - only a limited number of the thousands of type variations are suitable for cartographic purposes.
  - To enable the mapmaker to make an appropriate choice of a letter type it is useful to have some knowledge of the basic forms that are applied in type.

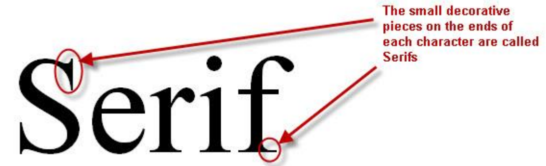
Typographic Designs

- finds its "roots" in the middle ages
  - **writing** was a profession of **religious clerks**
  - was done by a hand-cut drawing **pens** and **ink.**
    - pens had a **flat top** causing the characters to have strong horizontal vertical stroke contrast.
    - This basic letter style is called "**Old style**".
  - Later on, **more elegant letter styles** developed
    - because the drawing pens got a **sharp point.**
    - characters had a more fluent change of the contrast between horizontal and vertical direction.
    - This style of lettering is called "**New style**".



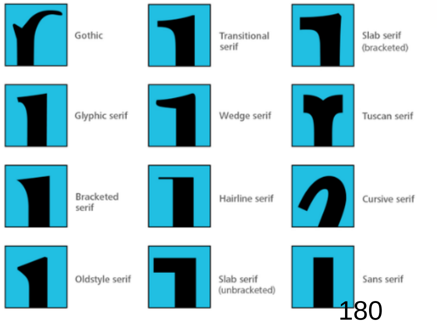


Typographic Designs



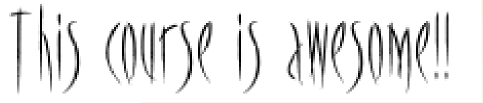
San Serif

- Serif
  - A result of copying the former technique of chiselling characters into stone.
- Invention of printing
  - About **1450AD** the printing technique was invented in Europe by a Dutchman (Laurens Jsz. Coster).
  - The first printing letter style were copies of the handwritten letter styles.
- Sans serif
  - At the end of the **18-century** a new, rigid letter style developed **without serifs** and **no contrast** between horizontal and vertical strokes.
- **ABCDEFGHIJKLM**



Typographic Designs

- Scripts
  - Besides the basic letter styles
    - old style, new style and sans serif a fourth group can be distinguished
    - the script of phantasm letter style characterised by 'fancy' forms.



    - Based on these four basic forms:
      - typographers have developed over the years thousands and thousands of letter types
      - Most of them have been forgotten or are just seldom applied,
      - For cartography only a limited number of letter types are suitable.

Typographic Terminology

- Typography is the art to design and apply type.
  - Typographers are specialised in the design of new type.
  - Software developed for the p.c. to *handle text* has increasing nowadays
  - The graphic capabilities of system software has also widened
  - GIS packages offer an overwhelming range of type faces that can be applied in text, illustrations and maps.
  - Many desktop publications, magazines, reports and maps are samples of bad typography *disturbing the communication process*.

Typographic Terminology

- Type face or font
  - This is a design of a character set that shares a similar appearance using one of the four (4) basic forms of typography.
  - The characteristics include letters, numbers, punctuations, and symbols. On computers 'type face' is also referred to as 'font'.
- Font
  - In many application fields of typography like DPT, the term 'font' is often confused with type face and family.
  - Traditionally the term, 'font' represents a complete set of characters or symbols which share the same style and size.
- Typestyle or type family
  - Typestyle is the visual variation of a basic typeface used to create order.
  - Typestyles are important, especially for mapmakers, as they can be applied to create *emphasis, order, ranking* etc. in text.

Typographic Terminology

- Type variations
  - The four (4) basic variation of typestyle found in most computer software are:
    - plain upright (also called; Normal, Roman or Medium)
    - bold upright, italic and bold italic
    - other variations are extra light
    - extra bold etc.
  - Some typeface offer only one type style, while other typefaces offer >30 variations
    - For mapmakers the more variations, the better!!
    - Well known lettertypes that offer these variations are:
      - Gillsans
      - Universe
      - Helvelica
      - Times
      - Souvenir

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Typographic Terminology

- **Weight**
  - The variations between typestyles like **light, medium** and **bold** are also referred to as **weight**
    - Related to the measurement of the stroke width
- **Condensed Vs Expanded**
  - Another *typestyle variation* based upon the **width of the individual character**
    - the character width can be **normal** but also be **condensed** or **expanded**.
    - Text presented in a **condensed** way is made for a feature which should *fit a restricted space*.
    - **Expanded** text is meant for a features of a *larger extent*.
    - **Weight upright** and **italic variations** can also be applied in combination with these two type styles.

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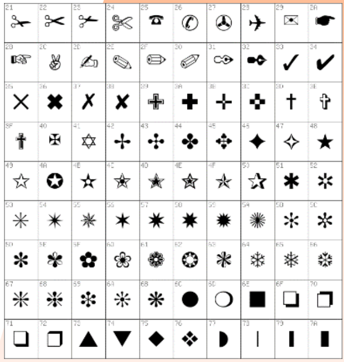
Typographic Terminology

- Characters
  - Each typeface consists of a character set.
  - A characterset contains only symbols:
    - Carto typeface only contains cartographic symbols
    - ZapfDingbats contains all kinds of symbols that can be used for general use in reports etc.
  - With special software like Altsys Fontographer the user can create own characters or symbols which can be applied to DTP software like any font.



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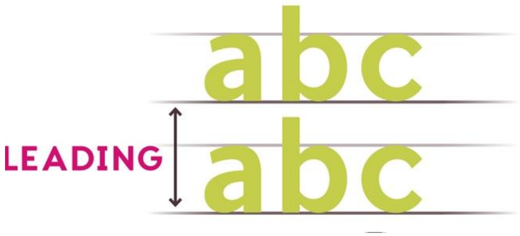
Typographic Terminology

- Letter (body) size
  - Normally determined by measuring from the highest ascender to the lowest descender plus an additional white space on descender line.
  - The white space to the descender line is to create space between sentences for legibility purposes.
  - Most DTP and Word Processing software is using this method of height indication.
- Capital size
  - Another, less applied method to measuring lettertypes based upon the actual height of the capital letters within a character set. This method is often applied in CAD software.

Typographic Terminology

- "X" height
  - Reference is made to the height of the lower case lettering without ascenders and descenders the so called 'body'.
  - A rare reference for height measurement. However, it is used in cartography to describe distances from point/line features to their names.
- Leading
  - Leading, pronounced as 'leading' is the space between the text line.
  - Originally, this was the space between the lines of types to space them apart
  - In computer terminology this is the space from the baseline to baseline within a block or text.



Typographic Terminology

17

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Typographic Terminology

- **Baseline**
  - The imaginary horizontal line on which all characters per line rest.
- **Points and mm's**
- In typography, letter size and leading is expressed in points.
  - The point is a measuring unit that refers to a system developed by the French typographer Didot in the 19th century.
  - Didot points
    - One Didot point is approximately 0.37mm.
  - Pica points
    - In the USA another point system was applied based upon 1 (pica) point = 0.35mm
  - The white space to the descender is different for each lettertype.
  - e.g. a 10pt. Univers character is different in the actual size of the character from a 10pt Souvenir character.

Typographic Terminology

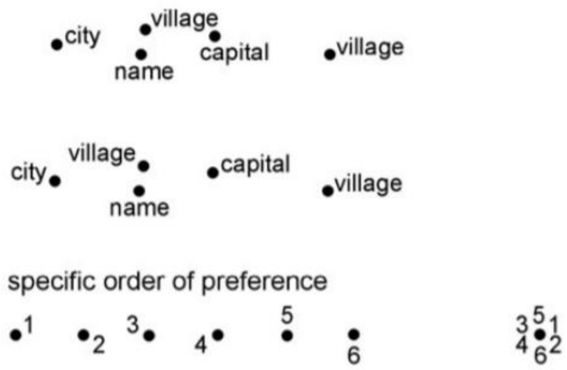
- Letterproof
  - refer first to a letter proof or a print proof from your printer with samples of letter sizes before you make a final lettertype size selection to apply in your map.
  - if a programme has a mm option for size determination, be careful as it usually refers to CAPITAL size though not always
- Typographic computer terminology
  - type managers, type caching
  - downloadable, postscript, bitmaps, vector-, screen-, and printer fonts

Name Placement

- Name placement criteria
  - There should not be any doubt as to which feature a name refers
  - the name should be positioned within the open graphic space surrounding the feature.
  - The position of the name should show a direct relation to the position of the feature
    - Normally, for line and area symbols this does not create a problem but small point symbols do so.
- Positioning of text
  - Three (3) basic methods of text positioning can be applied:
    - based upon a fixed position system
    - Based upon the available open graphic space
    - Based upon a combination of both methods

Name Placement

- Fixed position method
  - to the right and slightly above and below the point feature
  - to the left and slightly above and below the point feature
  - centrally above and below the point feature
    - This method has the advantage that text positioning can be easily programmed and automated
    - However, although there are 6 position variations, text is often positioned at locations where it interrupts line or other point features in a disturbing manner.



Order of Name Placement

- In general follow the principle of placing names in order of letter sizes and freedom of positioning as follows:
  - Spot heights, benchmarks, trig points, etc.
  - Names of other point symbols (from small to big)
  - Names of natural area symbols (from big to small)
  - Names of administrative areas (from small to big)
  - Contour numbers and non-topographic text
    - placement of non-topographic text may sometimes differ in order of placement especially in thematic maps.
    - In thematic maps text with a categorised function like soil numbers may be placed central in the soil unit areas, thereby disturbing the position of other natural features.
    - For this type of maps, the thematic area text should have a higher priority than the names of other topographic area names.

Order of Name Placement

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Map Layout
(Part 4)

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Map Layout

- The term Map Layout refers to the *spatial arrangement of the various map elements* that together make up what is called a map.
- What are the Goals of Map Layout ?
  - We can identify five (5) clear goals which need to be taken into account to create a good map layout:

Clarity

- The information on a map should be presented in a clear and unambiguous manner. Anything that does not enhance the map message should be eliminated.

Order

- Order refers to the logical arrangement of the various map elements such as the legend and title

Map Layout

Visual balance

- Every element of the map has weight. These weights must be distributed properly about the optical centre point slightly above the actual centre, (or the map will appear to be top heavy, weighted to one side or unstable.

Contrast

- Contrast refers to the difference between light and dark, thick and thin, heavy and light. More choices means a higher contrast.
- Little contrast in a map (e.g. using one pen size) will decrease its legibility.

Unity

- Unity refers to the relation between the lettering, the map purpose, the scale, the symbolisation and the reproduction.
- For instance the text has to be legible over any background colour and shading.
- Furthermore unity means the map appears to be a unit, not a series of unrelated bits and pieces.

Map layout process

- The process of making a layout for a specific map involves quite some creativity from the side of cartographer.
- It is not a linear process, e.g. very often the initial layout decisions are changed when a hard copy of the map becomes available.
- The decisions related to the arrangement of the map elements often involves aesthetic choices.
- This is especially the case for one-off maps.
- Map series like topographic maps mostly have a fixed map layout.
- Not all cartographers can deal with these Aesthetic choices.
- An independent good eye assesses the visual impact of the map since no fixed recipes are available.

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Preconditions for Map Layout

- The process of map layout can only start after it is clear:
  - What the purpose of the map is
  - who is the map user
  - what is the topic of the map
  - what the scale and the format is
  - How the map will be reproduced

Map Layout Elements

- The main map layout elements are:
- **Map face**
  - This is the surface of the screen or paper which is actually occupied with the mapped information itself.
  - The map face is bordered by the neatline.
- **Neatline**
  - This line limits the mapped information. The word neat is well chosen because all points, line and area symbols of the map face run up to this line and any slight misfit caused, e.g. by printing, will be camouflaged by this line.
- **Outer border**
  - This frame, rectangular or squared, is positioned around the neatline.
  - The space between the neatline and outer boarder line can vary from 0.5 to 2cm.
  - This kind of frame is optional on most maps, however, it is regularly used in topographic map series.
- **Boarder information**
  - This is information like ticks and figures, concerning geographical and rectangular coordinates.
  - It is positioned between the neatline and the outer boarder.

Map Layout Elements

North indicator

- Map users are accustomed to visualise areas orientated to the north.
- Not all maps are necessarily orientated to the north, sometimes due to the shape of the mapped area.
- To make sure the orientation is obtained, a north arrow has to be shown on the map.

Marginal information

- This is all information to evaluate, interpret and use the map.
- It is in most cases positioned next to or around the neatline or outer boarder.
- For topographic maps a comprehensive list of marginal items has been defined by international agreements.

Marginal Information

Title

- Every map should have a title. it is an important part of the design.
- In fact the title is the most generalised description of the total content of the map and should therefore be at an eye-catching position.
- Main Title
  - The main title covers the area being mapped,
- Sub Title
  - the subtitle explains the theme of the map
  - The text used for the title is the largest on the map.

Marginal Information

Legend

- All maps need a legend or legends.
- It is in the legend that the symbols used in the map are described.
- Legends can, depending on the type and complexity of the map, vary enormously in size.
- It is quite a tradition to place the legend (s) to the left, right or lower margin in the case of frame maps.
- In the case of island maps, the irregular area influences the position of the legend (s).
- The amount of items in the legend must be counted and the necessary amount of space provided in the most appropriate position
- In no way should the legend(s) be positioned horizontally along the top of the map face.

Marginal Information

Scale

- Since the mapped area is a representation at a reduced scale of (a part of) the earth surface, a graphical and a numerical scale indication has to be shown.
- In general maps showing quantitative information e.g. population, rainfall, temperature, etc. You need only a statement of scale to let the map user have some idea of the size of the area being mapped.
- Maps which show qualitative information such as roads, touristic features, geological, geomorphologic, soil, land use, urban maps etc should have a scale line added so that the map user can determine distances directly.
- The length of a scale bar should not exceed 15cm.
- Keep it in proportion to the space available and do not over emphasise it to the rest of the marginal information.

Marginal Information

Location diagram

- The location map should depict an area large enough to the map-reader to recognise a part of the world and see where the mapped area is within that part of the world.
- Location maps are reduced skeleton maps of a province or country showing the position of the mapped area.

Sheet history

- This note describes which data are used for compilation and therefore gives the map user an indication about the reliability of the map.
- The sheet history should include the source data and its date, the map publisher, the date of publishing, projection information etc.

Main Types of Map Layout

- Map layout can be divided into three (3) distinctive types.
  - Frame map
  - Island map
  - Bleeding edge map

- **Frame map**
  - This type of layout has an outer border line around the map face.
  - This outer border line functions to separate clearly the map face from the marginal information.
  - Topographic maps are good examples of frame maps.
  - This type of map is quite traditional and very suitable for map series.

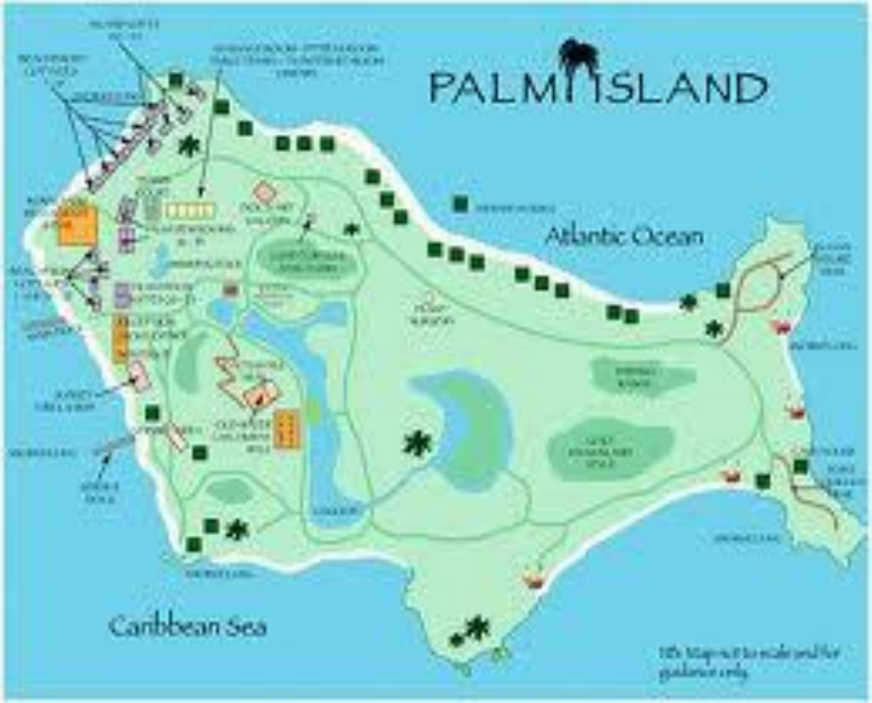
Frame Map

Main Types of Map Layout

- **Island maps**
  - This is less traditional than the frame map.
  - The neatline or boundary of the mapped area functions as the frame.
  - An island map has therefore an irregularly shaped appearance.
  - This type of map is less traditional and allows the cartographer more freedom in designing a suitable layout.

- **Bleeding edge map**
  - This type of map has the information running up to the trimmed extremes of the map.

Island Map


PALM ISLAND
Atlantic Ocean
Caribbean Sea


Easter Island
(Rapa Nui)

Bleeding Edge Map

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Map Sheet Orientation

- **Landscape orientated map**
  - In this type of map the orientation of the total map (including marginal information) is such that the height is shorter than the width of the map.
- **Portrait orientated map**
  - In this type of map the orientation of the total map (including marginal information) is such that the height is larger than the width of the map.

What determines a map layout?

- Apart from the presence of the map elements mentioned before, the appearance of the final map is influenced by the content and scale of the map.
- Furthermore conditions like available equipment and marketing considerations can influence the map layout.
- Individual aesthetic choices of a cartographer will give the map its full appearance.
  - **Map purpose/content**
  - For which group of map users is the map designed?
  - How much information has to be given per unit or area of the terrain that will indirectly determine the amount of marginal information?

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What determines a map layout?

- **Map scale/accuracy**
  - The map purpose and the density of the map content influences the kind of scale to be chosen.
  - The degree of accuracy is proportional to the scale of the map.
- **Reference system**
  - This information is essential for the reliability of the compiled data on the map.
  - This information is usually placed just outside the neatline (it occupies at least 1 cm around the neatline).

Map Production Constraints

- **Production**
  - The technical capability and facilities available for cartography, reproduction and printing have to be assessed.
    - E.g. There may be no offset printing machine available in the organisation which means that colour printing thousands of maps is not possible.
- **Map user**
  - The requirements of the map user e.g. size of the printed map, density and the amount of information, number of languages used, etc. have to be known.
- **Marketing**
  - A good marketing survey will indicate the number of copies desired and proper price per copy.
  - The results of this marketing survey also indicate the map production method and the use of colour desired.

Aesthetics

- **Fashion**
  - Although not a general rule, trends are noticeable in different periods of time.
  - e.g. ornaments around the mapped area in the Middle Ages or coloured backgrounds around the mapped area nowadays.
- **Taste**
  - Although this is highly personal and depending upon taste, well designed and balanced maps appeal more to the map user than bad designs and poor layout.
  - Marketing plays an important role in this.

- In principle, **map layout** can be divided into **two (2)** groups:
  - **Layout for individual maps**
    - a unique layout is made specially for one particular map.
  - **Layout of series maps**
    - for this type of map a master design is made suitable for the whole series and is known as the 'pilot sheet layout'.
    - This is done to give the whole map series a uniform appearance.
    - Examples are topographic maps, geological maps, etc.

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Visual Balance

- The information covered so far has given you a guide for a so-called 'good map layout'.
- Main type of balances:
  - In **Graphic Design** three (3) ways to balance information can be distinguished:
    - Symmetric balance
    - Informal balance
    - Formal grid based

  - **Symmetric balance**
    - In this kind of balance, the marginal information is positioned in such a way that it is in perfect symmetry with the graphics (map face).
    - The title of the map is positioned above the map face along the central axis
    - The other marginal information is evenly distributed above and below the map face aligned to the sides.

Visual Balance

- **Informal balance**
  - In this case, the shape of the map face determines the position of the marginal information.
  - The creativity of the **cartographer** plays an important role where the marginal information will be positioned.
  - However, it is important that 'optical balance' is achieved.
  - Optical balance means wherever positioned, none of the map elements is emphasised.

- **Formal grid based balance**
  - Although not visible on the final printed version, a grid is used during layout to position all information in a systematic way to obtain a pleasant and well balanced map.

Inset Maps

- An inset map is a small secondary map face which is included in the field of a larger map face.
  - It should not be confused with the main map by providing a clear distinction between the two.
- **Types of inset maps**
  - **Extension inset**
    - If the region being represented extends beyond the size of the main map, an extension inset is provided to show the area falling outside the main map.
    - Its scale must be same as that of the main map
    - Otherwise, the scale must be a multiple of that of the main map
    - Such insets must be placed in the same general direction of the region they represent where possible
    - A location diagram showing relative positions of the areas must be included
    - Its map units must be the same as those of the main map

Inset Maps

- **Detail Inset**
  - If the area being mapped has a variable density of features some crowded parts of the map are enlarged to improve legibility.
  - A detail inset should be positioned near the region they represent.
  - Its scale should be easily comparable with that of the main map.

- **Thematic inset**
  - If a specific theme on the map needs special explanation, an inset representing that special theme is created.
  - E.g. In a land use map there may be need to show a rainfall map as an inset to aid in understanding certain land uses better.

Map Folding Systems

- Some maps such as street maps and tourist maps are designed to be folded for easier handling.
- The fact the a map is folded influences the layout of the map
- Very often, the map has a cover page which is also visible after folding.
- It also has a back page which should also be visible after folding.
- The material on which such maps are printed must have a certain folding resistance to withstand the folding and unfolding when in use.
- Paper sizes normally used are the A-series.

Conventional and Digital Maps
(Part 5)

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The Map

- Professional cartographers think of maps as vehicles for transmission of knowledge.
- A map is a graphic representation of the milieu.
  - Milieu being used broadly to include all aspects of the cultural and physical environment.
  - This definition includes mental abstractions that are not physically present on the geographic landscape.
- We assume a map being tangible although there exists also mental maps

Mapmaking

- Mapmaking or mapping refers:
  - to the production of a tangible map
  - which is the aggregate of individual and largely technical processes of:
    - data collection
    - cartographic design
    - construction (drafting, scribing, display)
    - reproduction and
    - all that is associated with the actual production of maps.
- Mapping is the process of:
  - Designing
  - compiling and
  - producing maps.

Cartography

- **Cartography** is broader than mapmaking;
  - it encompasses the study of map communication
  - philosophical and theoretical basis of mapmaking.
- The International Cartographic Association (ICA) defines cartography as:
  - The art, science and technology of making maps together with their study as scientific documents and works of art.
  - Including all types of maps, plans, charts, sections, three-dimensional models and globes representing the Earth or any celestial body at any scale.

Types of Maps

- Broadly there are two (2) types of maps:
  - General purpose maps
    - Reference maps or topographic maps
      - They display both natural and man-made objects from the geographic environment
      - With emphasis on location
      - The purpose being to show a variety of features of the space
  - Thematic maps
    - Special purpose, single topic or statistical maps
    - ICA defines it as a map designed to demonstrate particular features or concepts
      - Purpose is to illustrate structural characteristics of some particular geographical distribution
      - Physical and cultural phenomena or abstract ideas about them are mapped

Conventional Maps

- A conventional map is a map produced using conventional methods of mapmaking
  - Photo control to give ground coordinates to photos
  - Taking of aerial photos and checking them for verticality
  - Photogrammetric compilation
    - Photo orientation
    - Stereoplotting using stereoplotters
    - Manuscript creation
  - Cartographic processing
    - Scribing
    - Fair drawing
    - Reproduction
    - Final map compilation
  - Map printing

Conventional Maps

- The fundamental issues of conventional maps:
  - setting the map's agenda
  - select traits of the objects to be mapped - map editing
    - Traits
    - Physical roads or land masses,
    - Abstract toponyms or political boundaries
  - Represent the terrain of the mapped object on flat media
    - This concerns of map projections
  - Eliminate characteristics of the mapped object that are not relevant to the map's purpose
    - This concerns generalisation
  - Reduce the complexity of the characteristics that will be mapped
    - This also concerns generalization
  - Orchestrate the elements of the map to best convey its message to its audience.
    - This is the concern of map design

Conventional maps

- **Disadvantages** of conventional maps:
  - Cumbersome to use in some cases
  - cover only a designated area
  - Lack certain details that are normally omitted
  - there is no way to update a paper map except to obtain a new version

Digital Maps

- **Digital mapping** (also **digital cartography**)
  - is the process by which a collection of data is compiled and formatted into a virtual image.
    - The primary function is to produce maps that give accurate representations of a particular area
    - detailing major features and other points of interest
    - The technology also allows easy measurements and calculations on maps
  - Early digital maps had the same basic functionality as paper maps:
    - they provided a “virtual view” of the earth
    - They now provided, in addition, **dynamic maps** based on capabilities of the system to allow more interactive use

Data Sources

- **Existing maps and documents**
  - **Digitising**
    - Manual digitising
      - Manual operation
      - Stream mode
        - Distance stream
        - Time stream
      - Spaghetti and meatballs
      - Errors
        - Inaccuracies in source data
        - Operator limitations
        - Equipment limitations
        - Correct detected errors there and then
        - Visual feedback and checkplots

Data Sources

- Errors in linear and polygonal feature digitising
  - Dangling chain (undershoot and overshoot)
  - Unlabelled polygon
  - Conflicting labels for a polygon
  - Chain (line segment) with same left and right labels
  - Sliver polygons
- Semi-automatic line following digitising
  - Early models involved a flat surface where the document lie
  - User intervention is required at junctions
- Scanning systems
  - Small document scanners
  - Full document scanners
  - Use of registration marks

Data Sources

- **Primary data acquisition**
  - **Ground based surveys**
    - Total stations and levels
    - GNSS equipment
    - Hand held computers
  - **Photogrammetry**
    - Photography from various sources
      - Aerial vehicles
      - Spacecraft
      - Artificial satellites

Data Sources

- **Remote Sensing**
  - Optical systems
    - Landsat
    - Spot
    - IRS-1C
    - Commercial systems
  - Mircowave systems
    - ERS 1 & 2
    - JERS-1
    - ENVISAT-1
    - RADARSAT

Data Sources

- Image processing of remotely sensed data
  - Geometric restoration and correction
  - Image enhancement
    - Contrast manipulation
    - Combining wavebands
    - spatial filtering
  - Classification

Mapping Milestones in Zambia

- 1841 - Dr. Livingstone started his journeys
- 1855 - The oldest known map of Zambia
- 1890 - BSA Company Rule was established
  - Some small scale maps were produced
- 1902 - Survey Department was formed
  - the first Chief Surveyor Mr. L. A. Wallace was appointed
- 1905 - The first tourist map was published
  - This was map of Victoria Falls
- 1907 - 1: 2.5 million general map of Zambia with contours was published
- 1925 - The first aerial photography was taken over the Zambezi Valley

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Mapping Milestones in Zambia

- 1928 - The first provisional series of 1: 250 000 maps
- 1938 - Three sheets of the 2nd “New Series”
  - For 1: 250 000 topographic maps
- 1949 - Modern mapping based on aerial photography
  - for 1: 50 000 topographic maps
- 1958 - The compilation of the Federal Atlas initiated
  - 1964 - 24 sheets were published
- 1966 - The compilation of Zambian Atlas was initiated
  - 1976 - 23 sheets were published
- 1977 - The Geological Atlas of Zambia was published
  - 4 sheets of the atlas
- 1985 - The first surveyors graduated at UNZA

National Maps of Zambia

- The main national maps are:
  - 1:50 000 topographic maps ~ 900 sheets
  - 1:100 000 " ~ 70 "
  - 1:250 000 " 71 "
  - 1:750 000 " 4 "
  - 1:1.5 Million general map 1 sheet

Map Proofing and Revision

(Part 6)

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Map Proofing

- Before a map is finally printed and published consider the following factors:
  - Accuracy
  - Completeness
  - Design
  - Legibility of the map - names on one colour separation not to obscure important detail from another
- Because of the above reasons, make a colour proof before printing
- *Do this to avoid repeat corrections - time wasting!*

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Preamble

- *Human influence and activities upon the surface of the Earth have grown tremendously over the years and are now spreading even to areas where they have never before been seen and/or felt.*
- *For this reason and massive expansion in existing areas, there are calls for good management, monitoring and planning of the exploited resources.*
- *There is also greater demand for preservation of some of these resources that are now being wantonly exploited.*

Preamble

- But management and preservation of all resources can better be done with a good inventory of what the situation was and what it now is.
- From such information, various analyses about the situation could be carried out so as to seek necessary remedies to the particular situation.
- In this regard, basic topographic maps have for ages carried this responsibility but are slowly failing to carry on this duty in areas where they are rapidly becoming out-of-date with the passage of time.
- In Zambia, this is particularly a problem because it is exacerbated by the severe lack of the necessary resources (aerial photography mainly) to carry out map revision.

4

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Preamble

- *The advent of Geographic Information Systems (GIS), for **management** and **analysing** various aspects of human activities on Earth, has also brought about a new dimension to the form of **geo-data** that need to be provided.*
- *Thus, the need for up-to-date geo-data has become a two-pronged approach. That is, to keep maps up-to-date and to provide up-to-date GIS capable data.*
- *Therefore, data needs to be collected for multiple use, a situation which calls for a change in the archival systems currently in use as well.*

What is Map Revision?

- Production of a revised version of a map
- Retains same series and sheet number
- Version number changes
- Factual data and operational value changes
- Amount and nature of changes vary
- Very important task usually forgotten in preference for new mapping

Factors affecting map revision

- The ideal situation is to keep all maps up-to-date both *administratively* and *in detail* and this is a responsibility of the mapping agency which is usually an arm of government as Sebert (1997) of Canada observed that, "*When a government publishes a series of topographic maps there is an implied commitment to keep these maps reasonably up to date*".
- Factors affecting map revision:
  - Rate of change
  - Desired change on map or not
  - Is revision economical?
  - Can revision be done?

Types of revision

- **Full Revision**
  - All factual data revised
  - All principal items of detail revised
  - New edition published
  - Major changes in map design and specifications
- **Partial Revision**
  - Either part of the map or selected items on map
  - Explanatory notes required on what has changed e.g. only roads may have been updated

Revision Policies

- Cyclic Revision – short and long term

<u>Short term</u>

- Short periods of time involved e.g. aeronautical charts may need updating every 28 days
- Revision is a major commitment in this case

<u>Long term</u>

- Medium and small scale maps mainly
- Needs new aerial photography or imagery
- 5 to 20 years cycle
- Inelastic revision policy
- Puts greater demand on meagre resources

Revision Policies

- **Selective Revision**
  - Certain areas are given priority e.g. urban areas
  - May also be based on fixed time interval
  - May be driven by demand
  - Flexible revision policy
- **Continuous Revision**
  - May be due to limited manpower
  - May be due to digital revision systems in use
  - Spreads resources evenly over a period of time
  - Selective policy based
- **Chart Revision**
  - Additional data on changes issued separately

Data likely to change

- **Control network**
  - Not likely to change for a long time
- **Planimetric features** (buildings, lines of communication, land use, water systems, etc)
  - Change faster than anything else on the map
- **Relief**
  - Not likely to change except in areas of exploitation or construction e.g. quarries, mines, etc.
- **Names and symbols**
  - Change along qualitative and quantitative data
- Changes are more on large scale maps

Accuracy of revised maps

- Same as original map (0.3mm – 0.7mm at map scale in planimetry)
- Vertical scale depends on contour interval e.g. for 2° slope the error must not exceed one third of the contour interval; for slopes greater than 6° the error must not exceed the contour interval itself
- Need for producing a completely new map arises when there is over 40% change or the accuracy of the map is lost

Methods of Revision

- Medium scale maps
  - Field control – GPS and other methods
  - Photogrammetric control – aerial triangulation
  - Common features on old maps and new aerial photos act as a check for map accuracy
- Orthophoto method
  - Use new aerial photos and existing DTM to produce orthophoto
  - Compare orthophoto with old map
  - Extract new features and delete missing features
  - In digital mapping, digitize new features

Methods of Revision

- Stereo compilation method
  - Like for new mapping
  - Identification of new data done by comparison
  - Check map accuracy carefully
  - Obscured details filled in by field surveys
  - If captured digitally enter directly into database
- Up-to-date large scale map method
  - Reduce to scale of unrevised map
  - Compare the two
  - Update with regard to generalization rules
- Small scale aerial photos and satellite imagery
  - Very useful for updating medium and small scale

Methods of Revision

- Large scale maps
  - May need current and periodic revision

Current Revision

- Cadastral maps and documents
- Land classification documents
- Engineering surveys

Periodic Revision

- Updating only planimetric and vertical content
- Modernising the map – content and transformation

Updating Service Copy

- Master copy on which changes are noted
  - Dashed red lines for measured changes
  - Solid red lines for transferred changes
  - Any other suitable notation
- Best way to keep track of reported changes
- Best way to determine threshold of change

Geographic Data Output Techniques

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Introduction

- Until **1980** computer graphics was a small field
  - Hardware was expensive
  - Graphics-based applications not easy to use
  - Only a few of them available
- The PC with bitmap graphics brought about the breakthrough
- Desktop – a metaphor for organising the screen space, *windows*
- Direct manipulation of objects by ‘point and click’ became state-of-the-art
- Today computer graphics is largely interactive with the advantage that:
  - Objects can be moved or tumbled with respect to a stationery observer or vice versa e.g. flight simulator - Motion dynamics
  - The change of shape, colour or other properties of objects are being viewed e.g. change of shape of an aircraft wing in flight

Introduction

- Definition – methods and techniques for converting data to and from graphics displays via computer *(data processing vocabulary – computer graphics 1982)*
- Computer graphics belongs to applied science in fields such as:
  - Computer graphics
  - Image processing
    - Image enhancement
    - Pattern detection and recognition
    - Scene analysis and computer vision
- Computer graphics concerns pictorial synthesis of scenes or reconstruction of models of objects from their pictures.

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Introduction

- Uses of computer graphics:
  - Design engineering e.g. CAD, CAM, CAE
  - Architectural design e.g. facilities management
  - Mapping e.g. GIS, cartography, geophysics
  - Science and medicine e.g. imaging and analysis
  - Graphic art e.g. electronic publishing
  - Visual communications e.g. presentations

- Classification of applications
  - 2D
    - Line drawing
    - Grey scale image
    - Colour image
  - 3D
    - Line drawing (wireframe)
    - Line drawing with various effects
    - Shaded, colour image with various effects

Introduction

- Type of interaction
  - Offline/online plotting
  - Interactive plotting
  - Predefining or calculating the object and flying around it
  - Interactive designing

- Role of the picture
  - The picture is an end in itself e.g. a map
  - The picture is a means to an end e.g. an architectural design

- Relationships between objects and their pictures
  - Only one picture at a time e.g. plotting
  - Time-varying sequence of related pictures e.g. motion or update dynamics
  - Structured collection of objects e.g. a CAD hierarchy of assembly and sub-assembly drawings

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Hardware for Computer Graphics

- Output Technology
  - Hardcopy device produce output that can be touched e.g. a plot of a map
  - Softcopy device permits only a temporary display which disappears when the device is switched off or cleared e.g. graphic screen

Hardware for Computer Graphics

- Hardcopy devices
  - Vector devices
    - Pen plotters
    - Flatbed and drum plotters
      - Can only draw lines
      - Can't fill areas properly
      - Flatbed positions pen better than drum plotters but can't plot on long paper
  - Raster devices
    - Dot matrix printers
      - Low resolution 120 – 240 dpi
      - Low quality print

Drum Plotter

Flatbed Plotter

Dot Matrix Printer

Hardware for Computer Graphics

- **Electrostatic plotters**
  - Places –ve charge on image parts on paper then flows a +vely charged toner over the paper. Toner adheres to –ve charged parts of paper
  - Each dot on an electrostatic plot is either black or white; grey levels are created by dithering
  - Color electrostatic makes paper pass over according to the number of colours
  - Electrostatic plotters are faster than pen plotters and may also double as high quality printers
  - However, pen plotters create high contrast images *than* electrostatic plotters
- **Laser printers**
  - Scan a laser beam across a +vely charged drum coated with selenium and parts hit by the beam lose their +ve charge
  - A –vely charged toner adheres +vely charged parts of the drum which is then transferred onto paper to form a print
  - In color printing this process is repeated for each colour

Laser printer

Hardware for Computer Graphics

- Inkjet printers
  - Spray cyan, magenta and yellow on paper
  - Inkjets are mounted on a head in a printer-like mechanism
  - Slight irregularities may occur if paper moves faster or slower than required
  - Inkjet may accept video as well as digital input making them attractive for creating hardcopies from raster display screens
  - Inkjets printers require more maintenance than other printers
- Thermal transfer printers
  - Another raster hardcopy device reminiscent of electrostatic plotters
  - Heating nibs transfer pigments from coloured wax paper to plain paper
  - Wax paper and plain paper are drawn together over a strip of nibs which are selectively heated to cause the transfer of the pigments
  - Common use of this technology is in colour printing where rolls of alternating cyan, magenta, yellow and black are used
  - Nibs heat and cool very rapidly such that a single colour print is created in less than a minute
  - May accept video and digital bitmap input to create hard copies

Inkjet Printer

Hardware for Computer Graphics

- **Thermal sublimation dye transfer printers**
  - Similar to thermal transfer printer except the heating and dye transfer process permits 256 intensities each of cyan, magenta, yellow an black to be transferred
  - Creates high quality full colour images with spatial resolution of 200dpi
  - Process slower than wax transfer
- **Film recorders**
  - Camera records colour image directly from CRT
    - Image resolution limited due to colour monitor shadow mask
  - Alternatively a B & W CRT is photographed through colour filters
    - Produces very high quality raster and vector images
  - Input to film recorders could be raster video signal, bitmap or vector style instructions

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Hardware for Computer Graphics

- Display technologies
  - Interactive computer graphics demand display devices whose images can be changed quickly
  - CRT is by far the most common display device
  - Monochromatic CRT
    - Same as for home B & W TV
    - Because phosphor's light output decays exponentially with time the entire picture must be refreshed many times per second so that the viewer sees what appears to be a constant un-flickering picture.
    - Refresh rate is at least 60 frames per second and is independent of picture complexity whereas vector systems do
    - Critical fusion frequency (CFF) is the refresh rate above which a picture stops flickering and fuses into a steady image
    - Monochromatic CRT resolution is just as for hardcopy devices measured with a shrinking raster
    - Resolution is not a constant. It decreases with increasing electrons in a beam because of what is called *bloom*

Hardware for Computer Graphics

- Modulation transfer function relates the input signal to the output signal in defining resolution
- Bandwidth of a monitor has to do with the speed with which the electron gun can be turned on and off

Colour TV and colour raster displays

- use some form of shadow mask CRT which is a thin metal plate perforated with many small holes and mounted close to the viewing surface and is so aligned such that each of the three electron beams can hit only one type of phosphor dot
- In the flat panel colour CRT the electron beams move parallel to the viewing surface and are then turned 90° to strike the surface
- The need for shadow masks and triads imposes a limit on the resolution of the colour CRTs not present with monochrome CRTs

Direct Viewing Storage Tube (DVST)

- Is similar to standard CRT except it does not need to be refreshed as the image is stored as a distribution of charges on the inside of the screen
- Can therefore display complex images without need for high scan rate and bandwidth required by a conventional CRT
- Any change on the image requires redrawing the image to establish new charge distribution which could be unacceptably slow

Hardware for Computer Graphics

- Liquid Crystal Display (LCD)
  - Made up of six layers
    - A vertical polariser plate in front
    - Next is a layer with thin grid wires electrodeposited on the surface adjoining the crystals
    - And then a thin (0.0125mm)liquid crystal layer
    - Then a layer with horizontal grid wires on the surface next to the crystals
    - Then a horizontal polariser and
    - Finally a reflector
  - The liquid crystal material is made up of long crystalline molecules
  - Active matrix panels are LCD panels that have a transistor at each grid point which are used to cause the crystals to change their state quickly and to control the extent of change
    - Allows LCDs to be used in TVs with continuous tone images
    - Crystals could be dyed to provide colour
    - Transistors also serve as memory for the cell and can hold a cell in a particular state untill it is changed
    - Thus the cell remains on all the time and hence brighter than it would be if it were to be refreshed

Hardware for Computer Graphics

- Advantages of LCDs are:
  - Low cost
  - Low weight
  - Small size
  - Low power consumption
- Only disadvantage was that they were passive

The Plasma Panel

- Is an array of tiny neon bulbs
- Each bulb can be put on or off and remain like that until explicitly changed
- This memory property means that they do not need to be refreshed
- Advantages
  - Being flat
  - Transparent
  - Rugged and
  - Not needing a bitmap refresh buffer
- Used mostly in the military because of smallness and ruggedness

Hardware for Computer Graphics

Electro-luminescent (EL) Displays

- Consist of small grid-like structure as used in LCD and plasma displays
- Advantages
  - Display is bright
  - Can be switched on and off quickly
  - Transistors at each pixel can store the image
- Disadvantage
  - Power consumption is higher than that of LCDs

Comparison of display technologies

	CRT	Electroluminescent	Liquid crystal	Plasma panel
Power consumption	Fair	Fair-good	Excellent	Fair
Screen size	Excellent	Good	Fair	Excellent
Depth	Poor	Excellent	Excellent	Good
Weight	Poor	Excellent	Excellent	Excellent
Ruggedness	Fair–good	Good-excellent	Excellent	Excellent
Brightness	Excellent	Excellent	Fair-good	Excellent
Addressability	Good–excellent	Good	Fair-good	Good
Contrast	Good–excellent	Good	Fair	Good
Intensity levels per dot	Excellent	Fair	Fair	Fair
Viewing angle	Excellent	Good	Poor	Good-excellent
Colour capability	Excellent	Good	Good	Fair
Relative cost range	low	Medium-high	low	High

Hardware for Computer Graphics

Input devices

- Five basic logic devices:
  - The locator – to indicate a position or orientation
  - The pick – to select a displayed entity
  - The valuator – to input a single real number
  - The keyboard – to input a character string and
  - The choice – to select from a set of possible actions or choices
- The logical device concept defines equivalence classes of devices on the basis of the type of information the devices provide to the application programme

Locator devices

- The tablet
  - Is a flat surface which cab detect the position of a movable stylus or puck held in the users' hand
  - Several types of tablets are transparent and so can be back lit for digitising x-ray films and photographic –ves
- Mouse
  - Is a small hand held device whose relative motion across a surface can measured
  - Mechanical mouse
  - Optical mouse
- Trackball
  - Often described as an upside down mechanical mouse
  - Motion of the trackball is sensed by potentiometers or shaft encoders
  - Joystick
  - Can be moved left or right, forward or backward
  - Motion is sensed by potentiometers
  - Springs bring the joystick to its home position
  - Have third degree freedom – can be twisted clockwise and counterclockwise

Locator devices

- **Touch panel**
  - Mice, trackballs and joysticks all take up workspace area
  - The touch panel allows the user to point at the screen directly with a finger to move the cursor around the screen
  - Low resolution panels can provide up to 50 resolvable positions
  - Capacitively coupled touch panel about 100 resolvable positions in each direction
  - High resolution panel about 500 resolvable positions in each direction
- **Light pen**
  - Were developed early in the history of interactive computer graphics
  - The pen is misnamed; it detects the light pulses rather than emitting light as the name implies
  - When used with a vector display it acts as a pick

Keyboard devices

- The alphanumeric keyboard is a prototypical text input device
- Several technologies are used to detect key depression including
  - Mechanical contact closure
  - Change in capacitance
  - Magnetic coupling
- Important functional characteristic – it creates a code uniquely corresponding to a pressed key
- It is sometimes desirable to allow chording to give experienced users rapid access to many different commands – not possible on standard coded keyboards

Valuator devices

- Most based on potentiometers like the volume and tone controls of a stereo
- Usually rotary potentiometers (dials)

Choice devices

- Function keys are the most common choice devices
- May be built separately but more often are integrated with a keyboard
- Others are the buttons found on pucks and mouse
- Used to enter commands or menu options in a graphic programme
- Dedicated purpose systems can used function keys with permanent key-cap labels

Image Scanners

- Provide an efficient solution to digitising existing line drawings manually
- Photo scanner
- CCD scanner
- Vectorising is the process of extracting lines, characters and other geometric primitives

Production Management

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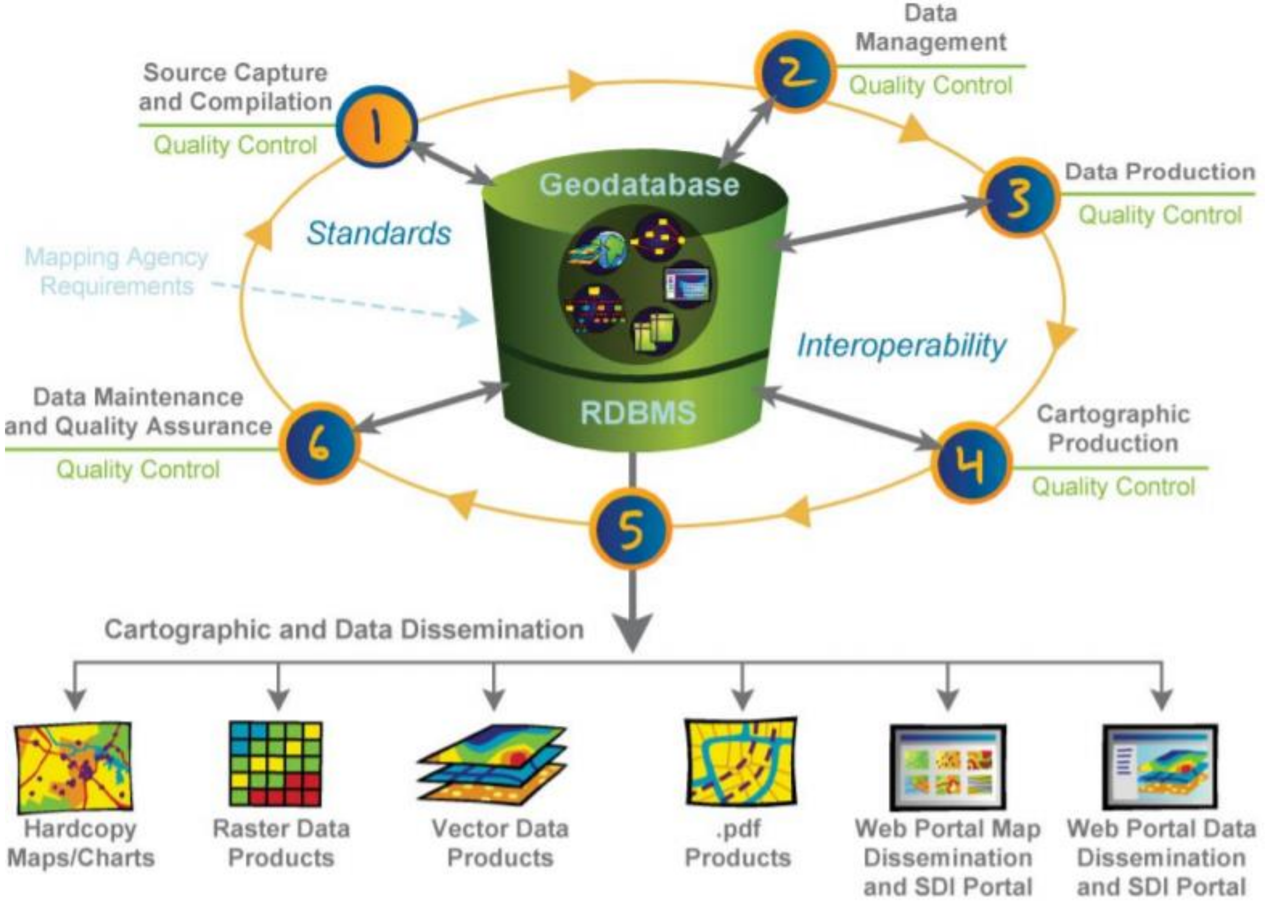
Map Production

Phases of Map Production

- **Preparation**
  - Digital data collection
    - Scanned data
    - Digitised data
    - Existing databases
    - Text files
  - Analogue data collection
    - Hardcopy maps
    - Hardcopy photos
    - Hardcopy text files
  - Assessment of collected materials
    - Is data up-to-date
    - Their projection and scale
    - Is it what we need
    - Is correct conversion possible



Preparation

- Hardware requirements
  - Graphic screen size (better at least 19”)
  - PC (as powerful as possible)
    - RAM based on chosen PC but must be better
    - Keyboard (extended) and mouse
  - Digitiser
  - Output devices (paintjet, laserjet, plotter, etc.)
  - Transport medium for digital data
    - Network
    - External hard drive
    - Optical disc
    - Flash drives
    - Zip drives
    - Etc.
  - Good workplace (chair, illumination, enough space)

Preparation

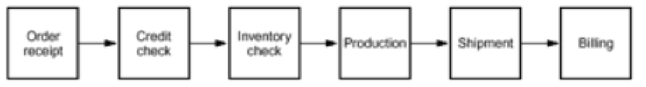
- Software requirements
  - Correct drivers for digitiser, scanner, printers, plotters
  - Correct fonts
  - Correct versions of software with manuals
- Output Specifications (as per output)
  - Multimedia on screen
  - Softcopy (inserted atlas, brochure, report, print on demand)
  - Hardcopy (one, few, many, colour or white & black)
  - Map size (is output device available)
  - Printing devices (offset, laserjet, etc)

Preparation

- Personnel requirements
  - Who is needed and when
    - What qualifications should they have
    - Is there need for extra personnel
    - Is there need for overtime
  - List all elements in map production
    - **Preparation**
    - Design
    - Reproduction (re-scaling, scanning, output)
    - Digitising
    - Cartographic production
    - Administration
    - Checking

Preparation

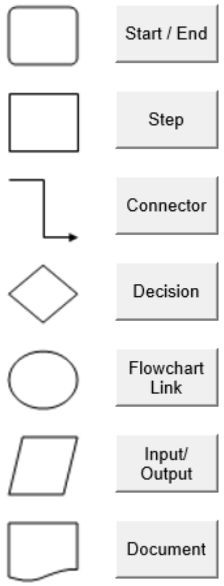
- Time and cost calculation
  - Staff time
  - Hardware and software
  - Time each stage will take to accomplish
  - Time calculation must be done on the basis of a sample job if no previous experience is available
- Flow diagrams

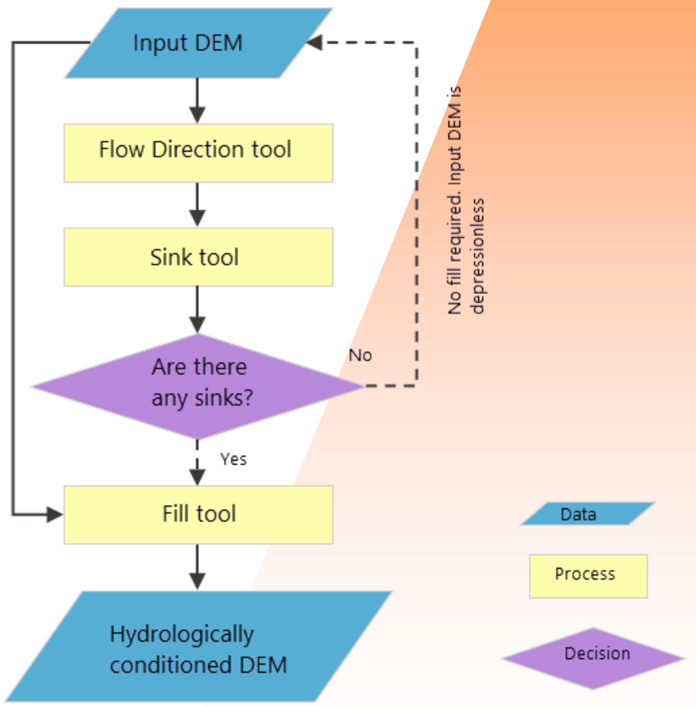


  - These must be produced in advance preferably
  - They are a scheme that shows in symbols and short descriptions
    - How the production flows
    - Which hardware and software is to be used at each stage
    - Which personnel are involved at those stages

Preparation – Flow diagrams

- Function of flow diagrams
  - Control work flow
  - Create shortest route (critical path)
  - Estimate time required for each task
  - Estimate and control cost
  - Detect problem areas in the process
  - Know hardware and software availability
  - Control staff input
  - Detect lack of training for staff
  - Provide guidelines
- Flow diagrams symbols
  - Products, processes, production stages, links, platforms





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Document Pre-processing

- To ease digitising
  - Speedup digitising
  - Resolve uncertainties
  - Ensure that correct data is digitised
  - Relieve operator from non-essential operations
- On printed maps
  - What has to be digitised and how
    - Double line symbols
    - Point symbols
    - Junctions in road networks
    - Generalise or not and where
    - Encoding of digitised data

Scanning

Resolution

- Depends on original and use of scanned data
- 125 – 200 dpi for on screen digitising
- For vectorising the scanning resolution should be 1/3 of the thinnest line or narrowest space
- For images and photos for output, double the resolution of the output screen ruling or printer resolution
- High resolution generates large files and slows down the process

Output Preparation

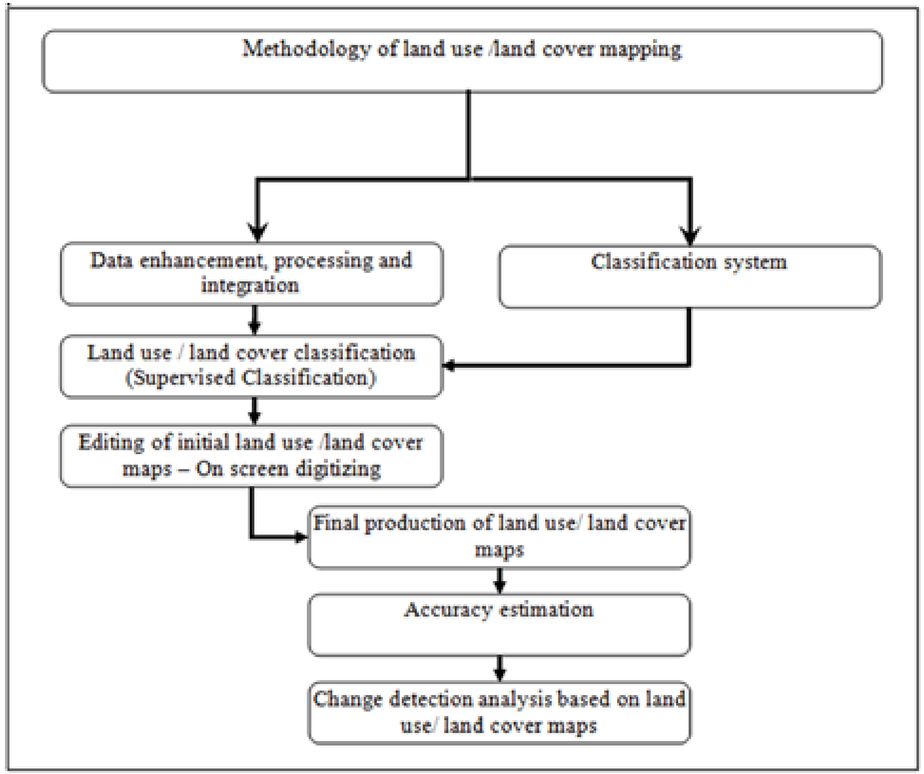
- Check colour settings
- Are all images available
- Are all fonts available
- Specify
  - Output size
  - Screen ruling
  - Printer resolution
  - Paper or film use
  - Printer type
  - Media transport type

Output

- Resolution of printers is in DPI (dots per inch)
- Resolution for screen is in LPI (lines per inch)

Sample GIS Mapping Project

- LANDSCAPE LEVEL MONITORING USING GIS AND REMOTE SENSING IN MUNYAMADZI GMA, ZAMBIA



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