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GRACE

world-changing research from The University of Nottingham

Introduction to GIS

Suchith Anand

EMBRACE East Midlands Business and Research satellite Applications Centre of Excellence

ingenuity

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SABRE

EUROPEAN UNION Investing in Your Future

European Regional Development Fund 2007-13

Fundamentals:

- Different views on the nature of space
- Geo-referencing & Discrete georeferencing
- Locational co-ordinates
- Euclidean space - Cartesian and polar co-ordinate systems
- Latitude and longitude system
- Major types of map projections
- Representing Real world geography in digital *world*
- Vector vs. Raster
- Topology
- Cartography Design Principles

What is space? Different perspectives

Medical imagery pespective (eg MRI scans)
Mathematics perspective (eg fractals)
Physics perspective
Astronomy perspective

Geography perspective
Human views (mental maps)

A small exercise before we start

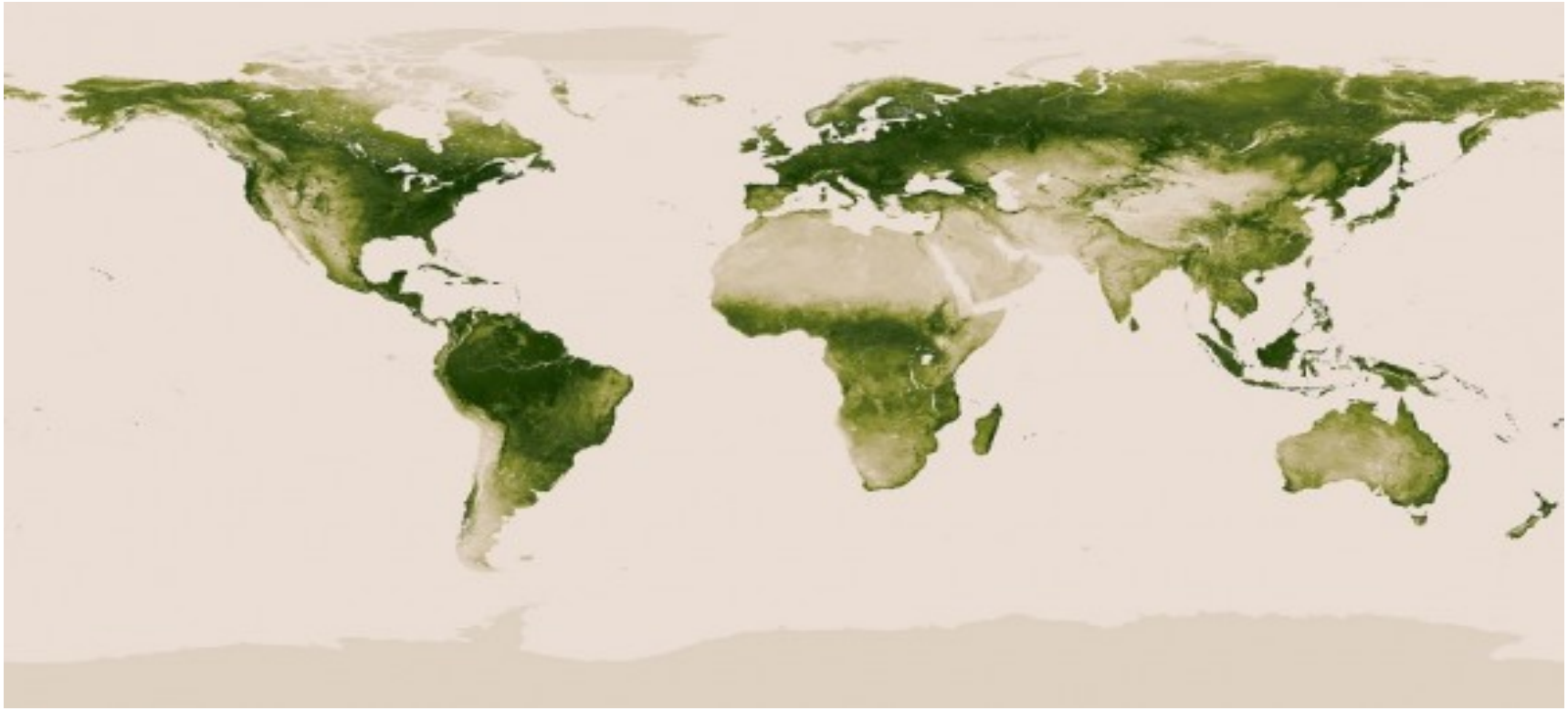
Think of 3 reasons why it might be handy to use GIS instead of paper maps.

What is a Map?

A **map** is a visual representation of an area (can be for any space not just geographical)

More importantly, Maps helps us make sense of the world

World Map of Vegetation on Earth



World map of vegetation data collected by the Suomi NPP satellite (National Polar-orbiting Partnership) in a partnership between NASA and the National Oceanic and Atmospheric Administration (NOAA). Image Credit: NASA/ NOAA
Herbal Earth: Spectacular Vegetation Views of Our Home Planet and the Natural World of Living Green Life by Ken Kremer

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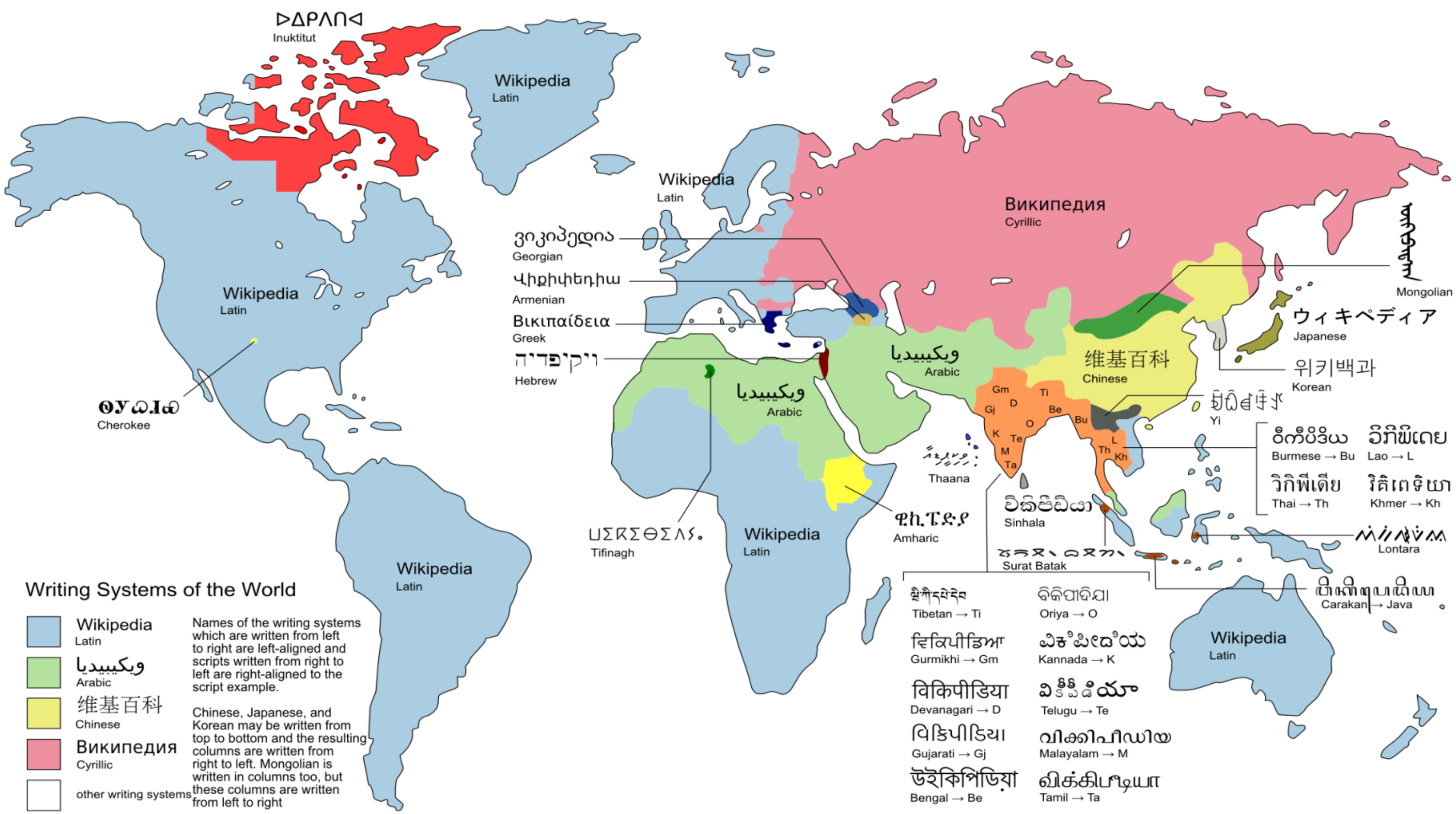
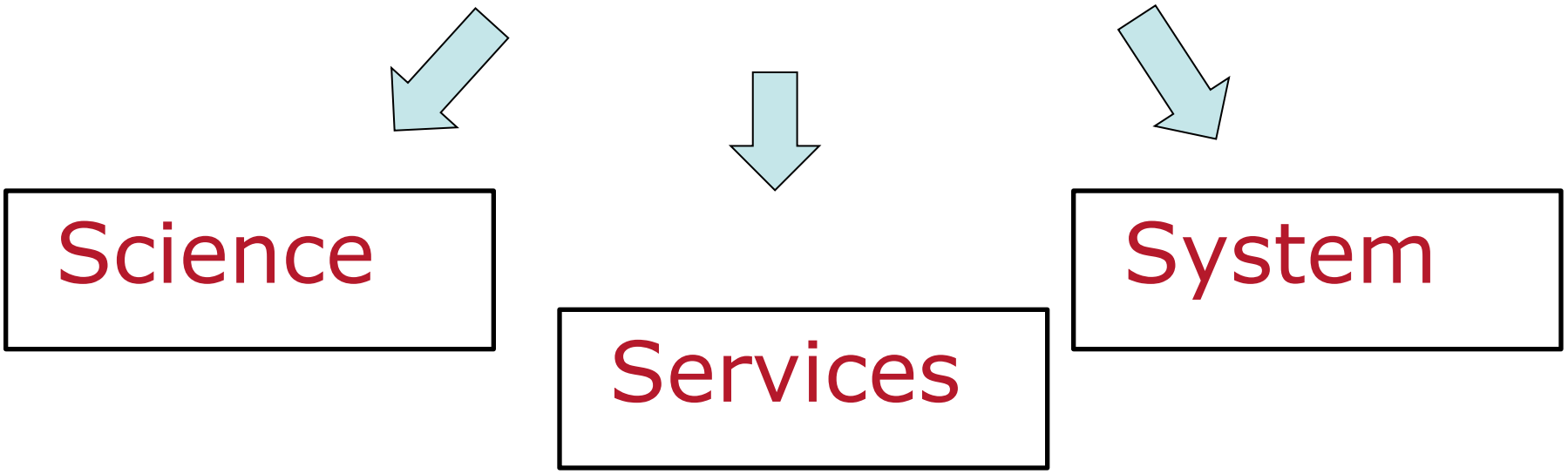
World Map of the Different Writing Systems



Map by Maximilian Dörrbecker (Chumwa) on Wikimedia Commons

What is GIS



GIS is multidisciplinary (Engineering, Computer Science, Statistics, Mathematics, Geography, Psychology, Philosophy…)

Geographic Information Science

Multidisciplinary research that addresses the nature of geographic information and the application of geospatial technologies to basic scientific questions (Goodchild, 1992).

Based primarily in the discipline of geography, but drawing upon insights and methods from philosophy, psychology, mathematics, statistics, computer science, landscape architecture, and other fields.

Examples:

Map generalization
Ontologies

Geographic Information Systems

Refers to the specialized set of information technologies that handle georeferenced data

Data acquisition

- Aerial imaging
- GNSS
- Remote sensing
- Land surveying

Data analysis

- Statistical analysis
- modeling

Data storage &manipulation

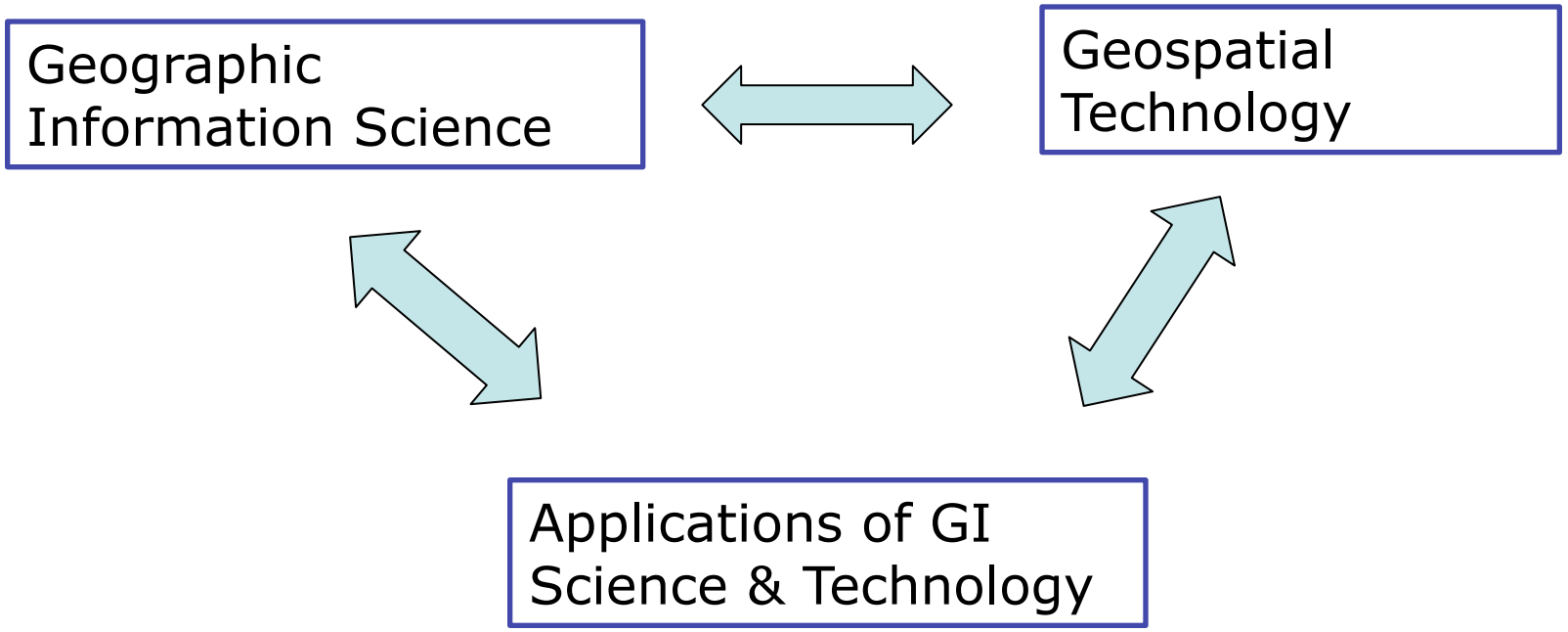
- image processing
- DBMS

Data visualization

- Geovisualization
- imaging

UCGIS GI S&T Body of Knowledge

10 knowledge areas
73 units
329 topics
1,600 formal educational objectives



Applied GIS examples

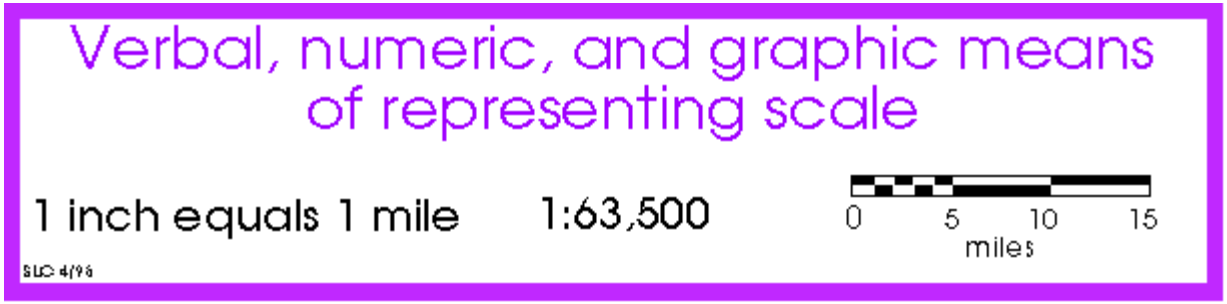
Network of European Regions Using Space Technologies

The NEREUS video "The voice of regions for Space“ regional examples of space based services (EO/GMES, GNSS, Telecommunication etc.) for the benefits of regions and their citizens.

http://www.nereus-regions.eu/NEREUS_videopage

Fundamental GIS example

Map generalization is one of the fundamental research areas of GI Science



Scale

•Maps can be thought of as collections of scaled graphic representations of earth features.

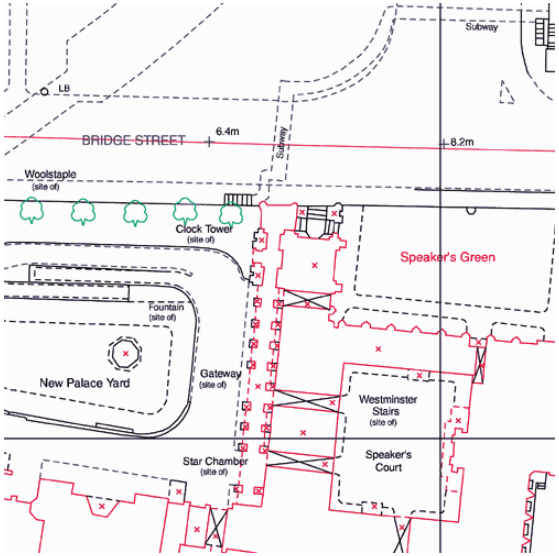
•Dimensions on a map can be related to actual dimensions by a scale value which may be expressed by the ratio between graphic dimension and actual dimension.

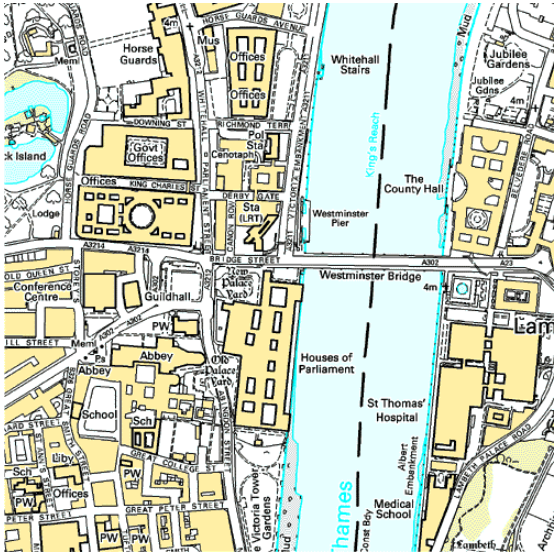
•If a scale value is given as a fraction in which the numerator is 1, it is called the representative fraction (e.g. 1/50000).

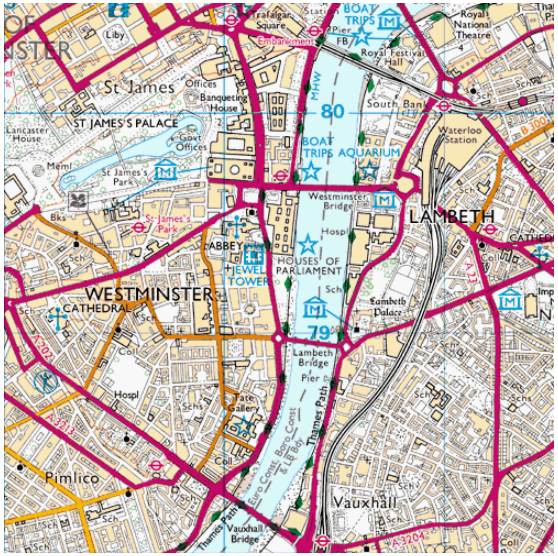
•If the representative fraction is relatively large (e.g. 1/2500), the map is referred to as large scale.

•If the representative fraction is relatively small (e.g. 1/2000000), the map is referred to as small scale.

Scale


BRIDGE STREET
6.4m
8.2m
Subway
Woolstaple
Clock Tower
Speaker's Green
Fountain
New Palace Yard
Gateway
Westminster Stairs
Star Chamber
Speaker's Court

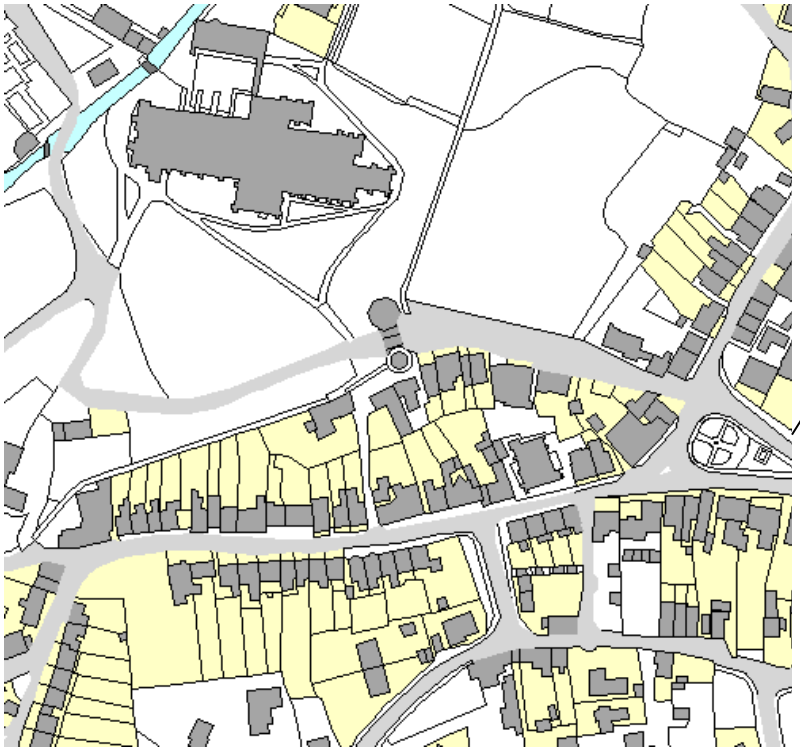

Horse Guards
Whitehall Stairs
Jubilee Gardens
Offices
Govt Offices
The County Hall
Westminster Pier
Lodge
Conference Centre
Guildhall
Westminster Bridge
Houses of Parliament
Abbey
School
St Thomas' Hospital
Medical School
Victoria Tower Gardens
Albert Embankment
Thames


St James
ST JAMES'S PALACE
BOAT TRIPS AQUARIUM
LAMBETH
WESTMINSTER
CATHEDRAL
HOUSES OF PARLIAMENT
JEWEL TOWER
Lambeth Palace
Pimlico
Vauxhall
Thames Path


WESTMINSTER
LAMBETH
Buckingham Palace
St James's Park
Victoria
Pimlico
Vauxhall
Chelsea Bridge
Nine Elms

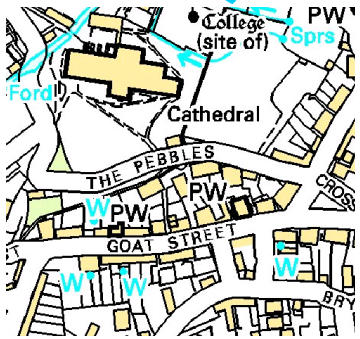

FINCHLEY
WOOD GREEN
TOTTENHAM
WALTHAMSTOW
WOODFORD
HENDON
HORNSEY
STOKE NEWINGTON
LEYTON
WEMBLEY
HAMPSTEAD
HACKNEY
WILLESDEN
CAMDEN TOWN
ISLINGTON
STRATFORD
PADDINGTON
MARYLEBONE
CITY OF LONDON
ACTON
WESTMINSTER
KENSINGTON
CHELSEA
LAMBETH
HAMMERSMITH
BERMONDSEY
POPLAR
GREENWICH
CHISWICK
FULHAM
BARNES
BATTERSEA
CAMBERWELL
DEPTFORD
CLAPHAM
BRIXTON
LEWISHAM
RICHMOND
PUTNEY
WANDSWORTH
CATFORD
STREATHAM
WIMBLEDON
KINGSTON UPON THAMES
MERTON
PENGE
BECKENHAM
MITCHAM
MORDEN
SURBITON


Luton
Stevenage
Bishop's Stortford
Dunstable
Hertford
Hemel Hempstead
St Albans
Hatfield
Harlow
Chelmsford
Amersham
Watford
LONDON
Brentwood
Billericay
Slough
Dagenham
Basildon
Heathrow Airport
Bracknell
Staines
Richmond
Greenwich
Tilbury
Esher
Sutton
Orpington
Gravesend
Woking
Croydon
Surrey Hills
Leatherhead
Maidstone
Sevenoaks
Dorking
Redhill
Guildford
Reigate
Tonbridge
Godalming
Gatwick Airport
Crawley
Royal Tunbridge Wells



Reduce scale

Generalize



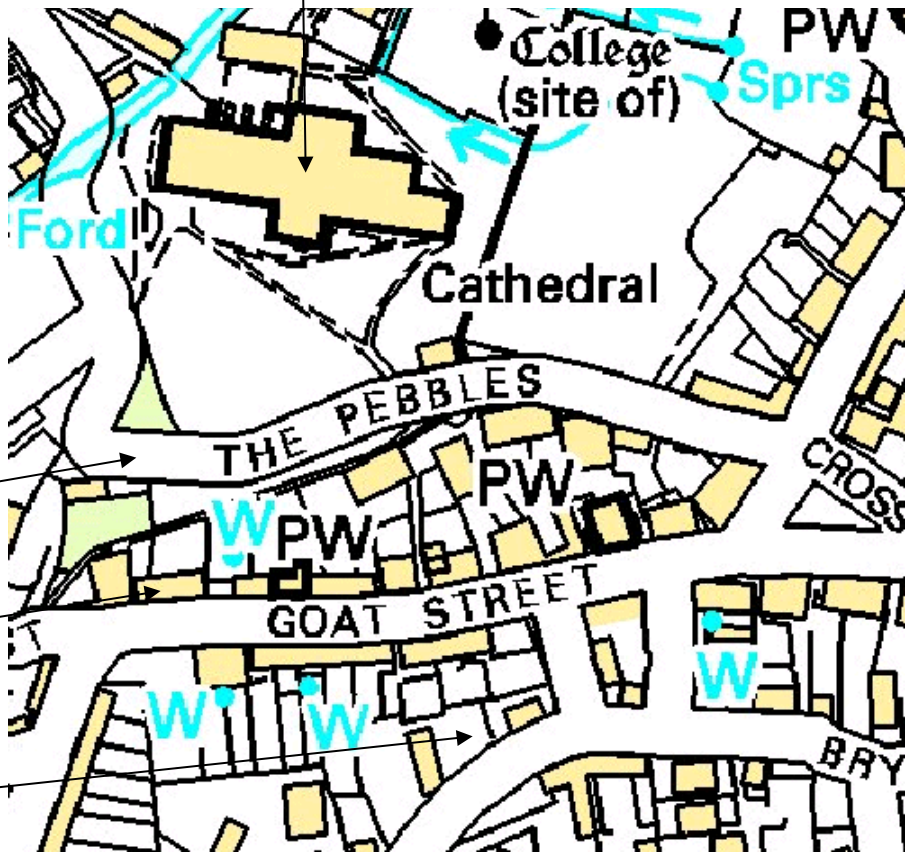
Simplification

Displacement

Exaggeration

Aggregation

Deletion



GEOREFERENCING

The key requirements:

Unique

Understandable

Unchanging

Discrete Georeferencing

Practically, it means, Many options to do your search:

- Street name
- Postcode
- Place name
- OS grid reference
- Lat/Long etc

Map projections

Portray the surface of the earth on a two-dimensional, flat piece of paper or computer screen.

There are global map projections, but most map projections are created and **optimized to project smaller areas** of the earth's surface.

Map projections are never absolutely accurate representations of the spherical earth. They show **distortions of angular conformity, distance and area.** It is impossible to preserve all these characteristics at the same time in a map projection.

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Co-ordinate Systems for recording spatial location

Plane Systems: Cartesian Co-ordinates

Plane Systems: Polar Co-ordinates

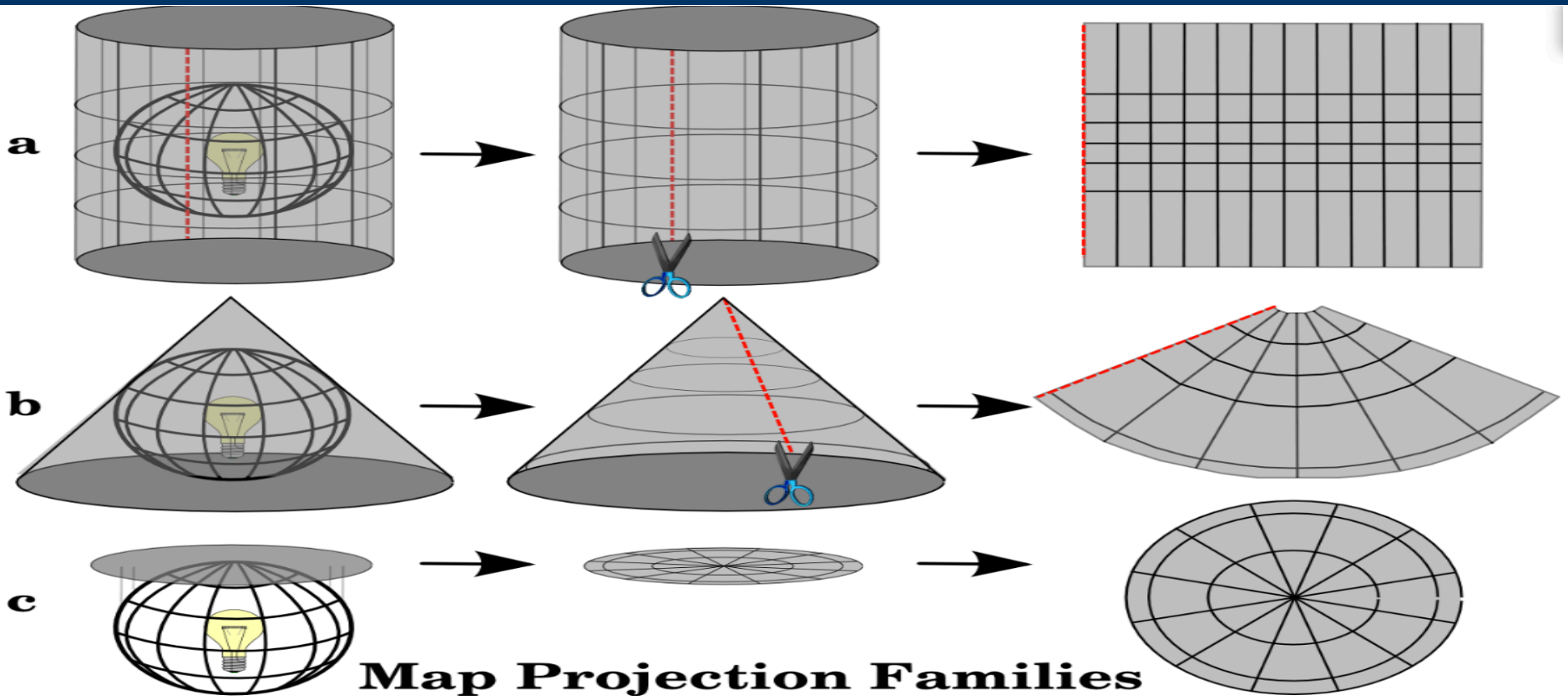
Global Co-ordinates: Latitude And Longitude

Projection-based Co-ordinate Systems and Map Projections

A **Coordinate reference system** (CRS) defines, with the help of coordinates, how the two-dimensional, projected map is related to real locations on the earth.

There are two different types of coordinate reference systems: **Geographic Coordinate Systems** and **Projected Coordinate Systems**.

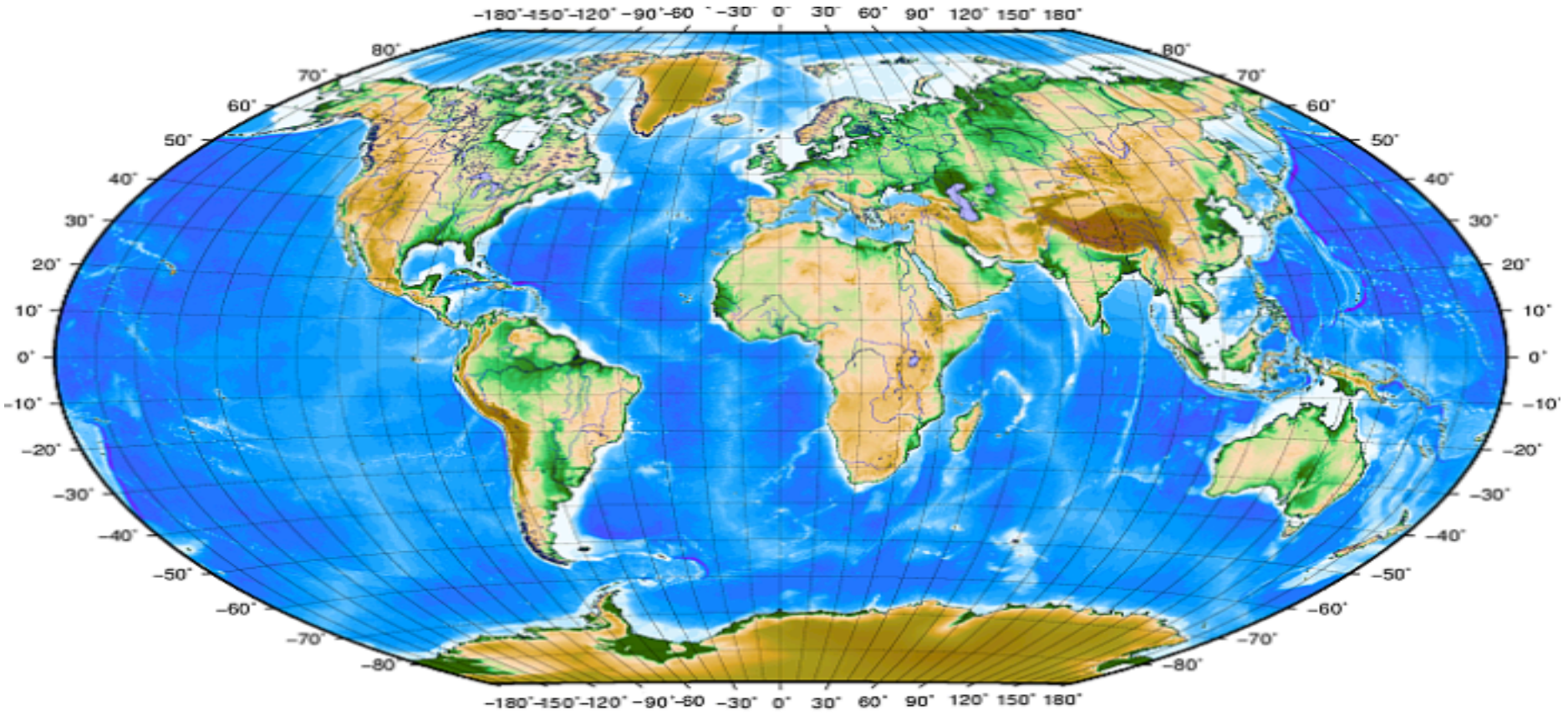
On the Fly projection is a functionality in GIS that allows us to overlay layers, even if they are projected in different coordinate reference systems



The three families of map projections.

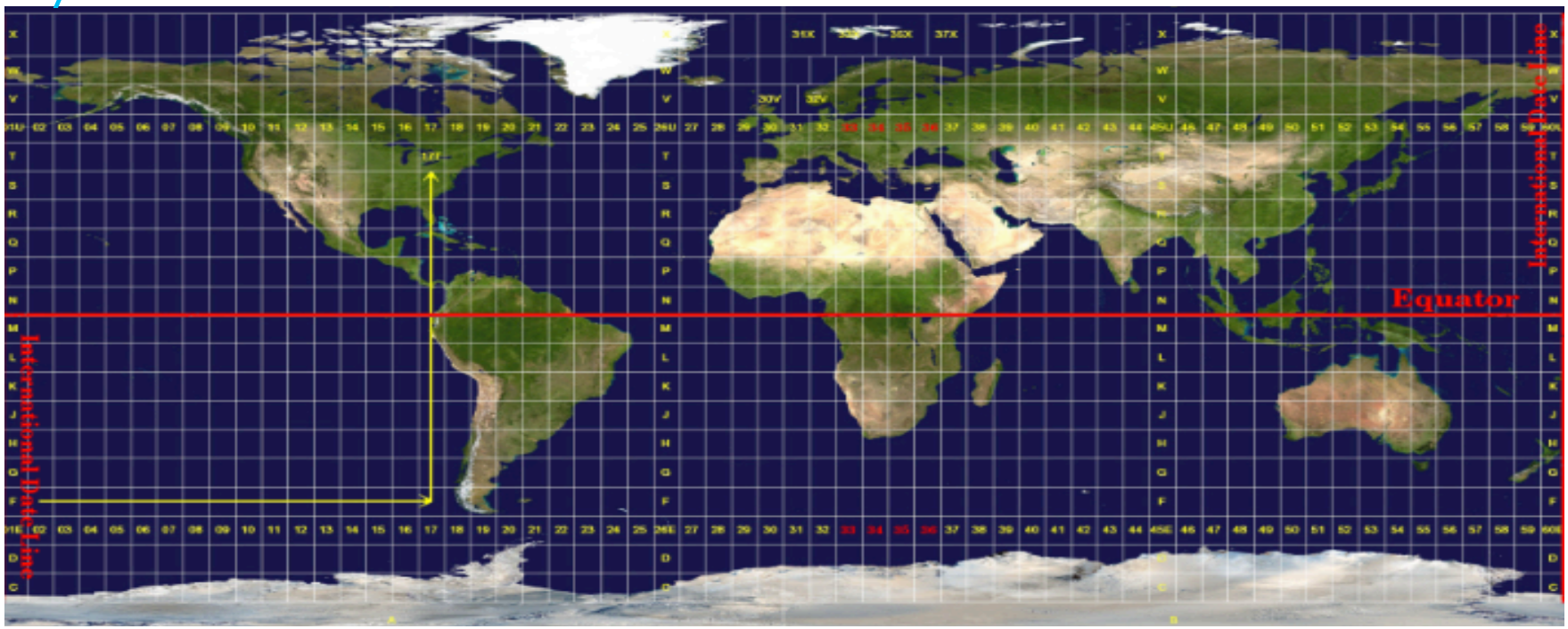
a) cylindrical projections
b) conical projections
c) planar projections

Geographic Coordinate Systems



They use degrees of latitude and longitude and sometimes also a height value to describe a location on the earth's surface. The most popular is called **WGS 84**.

Universal Transverse Mercator (UTM) coordinate reference system



The world is divided into **60 equal zones** that are all **6 degrees** wide in longitude from East to West. The **UTM zones** are numbered **1 to 60**, starting at the **international date line** (**zone 1** at 180 degrees West longitude) and progressing East back to the **international date line** (**zone 60** at 180

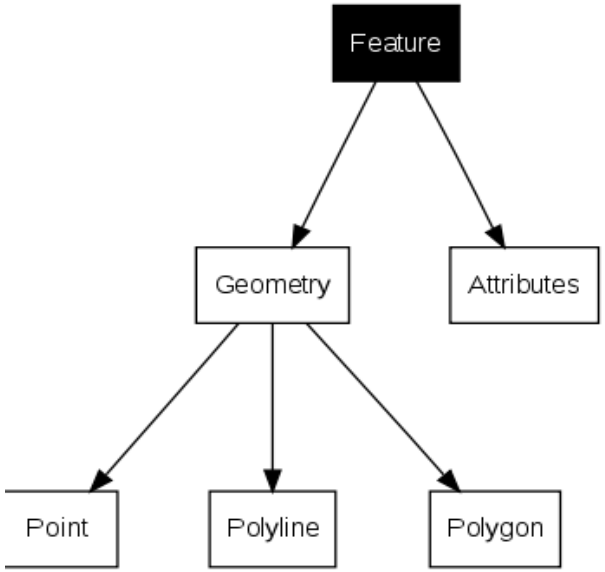
VECTOR VIEW

Follows an object view of the world in which space is seen to be occupied by different sorts of object

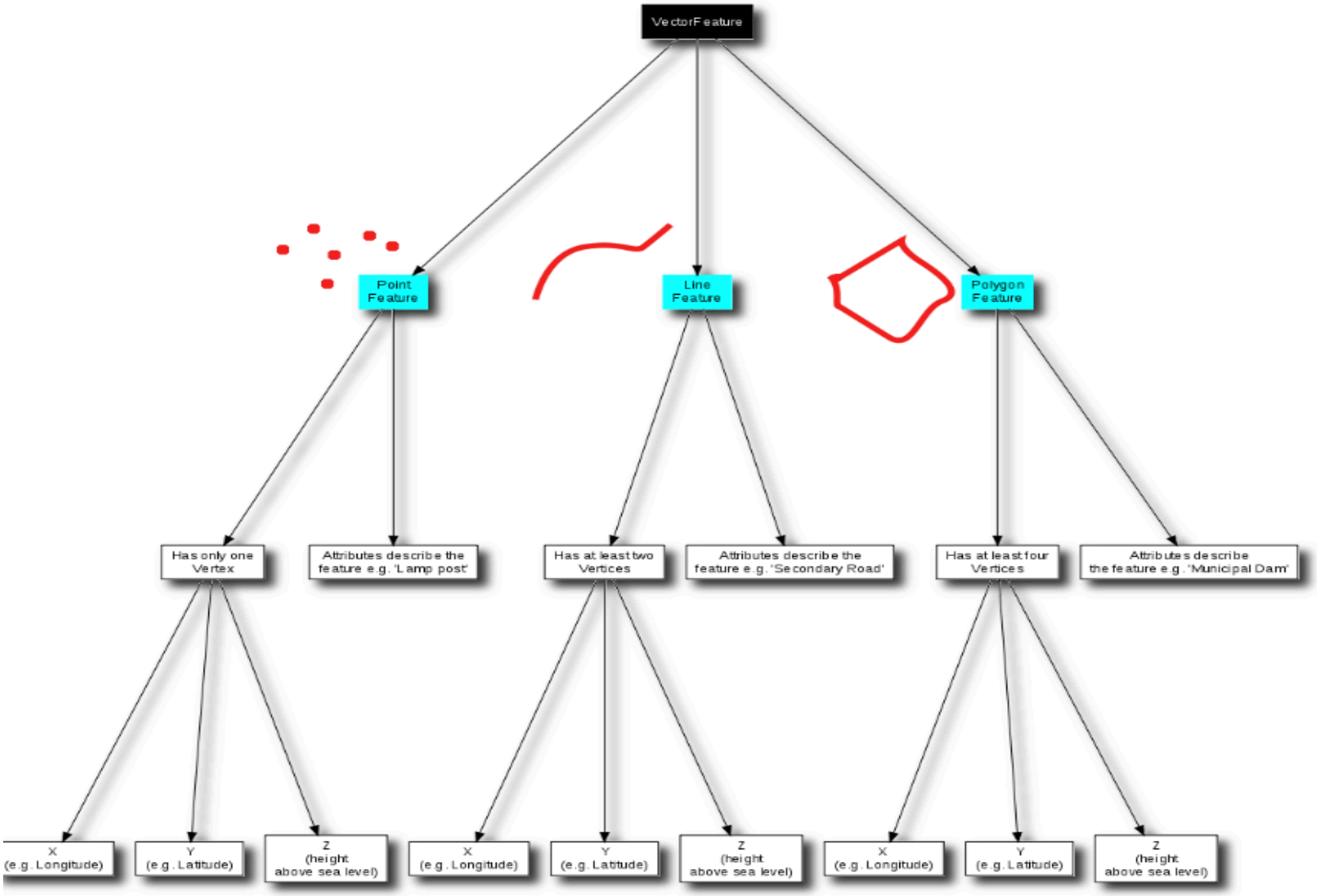
- Records exact locational co-ordinates of the points, lines and areas that make up a map.
- List the features present on the map and represent each as a point, line or area *object*

Exercise :

Think of how vector data could be useful?



Vector features

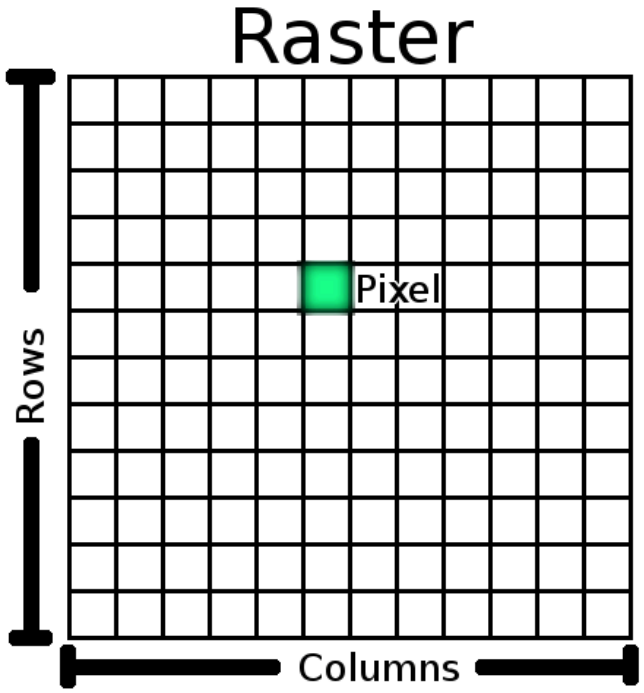

VectorFeature
Point Feature
Line Feature
Polygon Feature
Has only one Vertex
Attributes describe the feature e.g. 'Lamp post'
Has at least two Vertices
Attributes describe the feature e.g. 'Secondary Road'
Has at least four Vertices
Attributes describe the feature e.g. 'Municipal Dam'
X (e.g. Longitude)
Y (e.g. Latitude)
Z (height above sea level)
X (e.g. Longitude)
Y (e.g. Latitude)
Z (height above sea level)
X (e.g. Longitude)
Y (e.g. Latitude)
Z (height above sea level)

RASTER VIEW

Originated mostly in the world of image processing using data from remote sensing platforms

Make use of a grid of small units of the earth's surface (called *pixels*) and for each record the value, or presence or absence, of something of interest

In a raster the map is divided into a sequence of identical, discrete elements and contents listed for each



Exercise :

Think of how raster data from satellites could be useful?

Exercise:

Discuss which situations you would use raster data and in which you would use vector data.

TOPOLOGY

Is the study of properties that are unchanged under transformations such as a stretching or folding

Such properties include

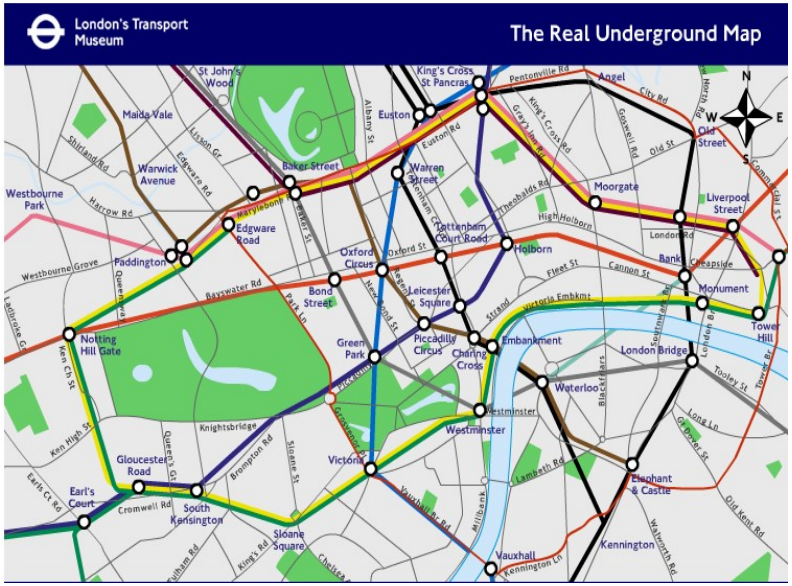
connection

adjacency

containment

London Tube Map

Preserves topology but disregards geometry!



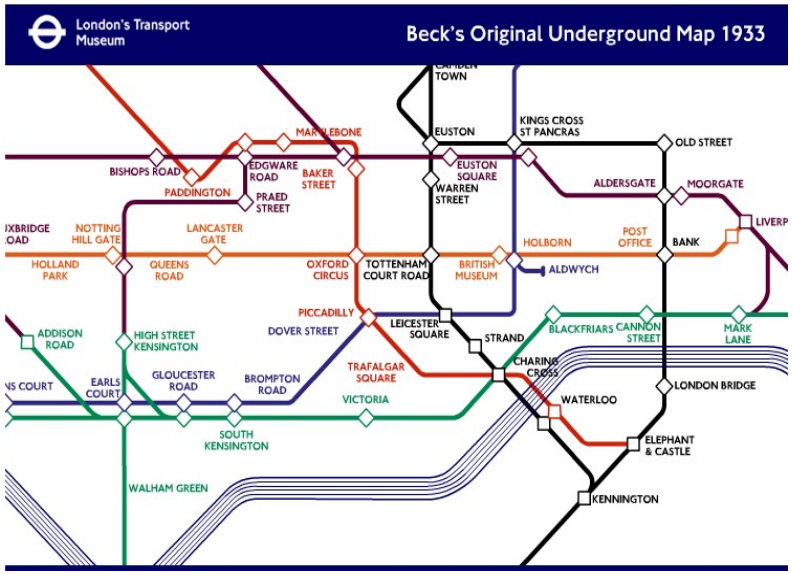


Image Source: LTM Website

Cartographic Design Principles

- Understanding of user requirements
- Consideration of display format
- A clear visual hierarchy
- Simplicity
- Legibility
- Consistency
- Assessibility
- Good composition

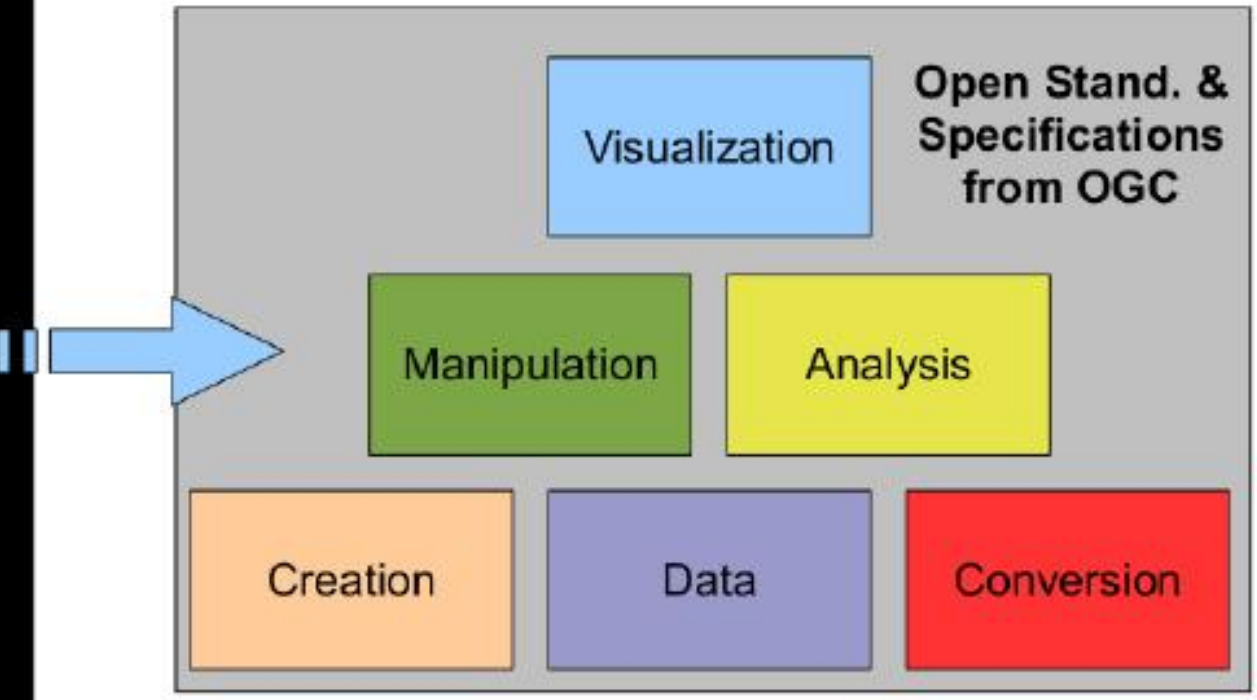
Full details at

http://www.ordnancesurvey.co.uk/resources/carto-design/carto-design-principles.html

https://www.ordnancesurvey.co.uk/resources/carto-design/

Today's Toolkit

Monolithic Black Box



Why is GIS important

GLOBAL URBAN PROBLEMS: access to water, sanitation, traffic congestions, economic sustainability, citizens' health, impact on environment …

Mapping is a critical component to help understand and develop solutions for urban growth problems

Proprietary software tools are very expensive (hence unavailable) for economically poor countries and communities worldwide

Kibera , Kenya

http://www.flickr.com/photos/8485582@N07/7365580810

Dharavi, Mumbai

http://www.flickr.com/photos/36685562@N00/2340042701

GIS tools play a key role in helping find solutions to global societal challenges

Further resources:

http://www.qgis.org/en/site/
http://live.osgeo.org/en/index.html

http://spatialquerylab.com/foss4g-academy-curriculum/

GST 101 – Introduction to Geospatial Technology (QGIS)
GST 102 – Spatial Analysis (QGIS)
GST 103 – Data Acquisition and Management (QGIS) –
GST 104 – Cartographic Design (QGIS and Inkscape) –
GST 105 – Introduction to Remote Sensing (QGIS and GRASS)

Acknowledgements

Dr Mark Ware, University of South Wales

Dr. Rafeal Moreno, University of Colarado Denver

SIGTE, University of Girona

GeoAcademy

Geo for All colleagues

Several of the resources used in this presentation can be found in:

A Gentle Introduction to GIS, a Free and Open Source Software GIS Application for everyone. Sutton, O. Dassau, M. Sutton

http://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/index.html