Introduction to Geographic Information Systems

A course to introduce users to the basic concepts and application of GIS

This course introduces the basic concepts of geographic information systems (GIS). It will present fundamental geographic and cartographic principles that are the foundation of GIS and current state-of-the-art information technology tools that bring GIS to users' desktops.

Attendees will come away from the course with a general understanding of the science and technology behind GIS

Introduction to Geographic Information Systems

Course Content

What is GIS?

- Introduction to GIS
- Definition of GIS
- Components of a GIS

Spatial Data

- Relationship between Data and Information
- What is Spatial Data
- Main Characteristics of Spatial Data
- Sources of Spatial Data
- GIS Data Standards

Spatial Data Modelling

- Spatial Data Models
- Spatial Data Structures
- Modelling Surfaces
- Modelling Networks
- 3D Modelling

Introduction to Geographic Information Systems

Course Content

Data Capture, Storage and Management

- Methods of Data Input
- The Database Approach
- Database Management System

Data Analysis

- Queries and Analysis
- Buffering and Neighbourhood Functions
- Integrating Data - Map Overlay
- Analysis of Surfaces

GIS Target Markets

- GIS in Business
- Utilities
- Transport
- Local Government
- Environmental Industry

What Is A Geographic Information System?

Introduction to GIS

Context: Why GIS?

- Many of the issues in our world have a critical spatial component!
  - Land management
  - Property lines, easements, right of ways
  - Data on land values, taxation assessment
  - Business site selection, advertising
  - Proximity of ‘our’ land to other facilities (pollution, hunting, municipal, federal, state)
    - “I don’t know what’s over that hill” is a common problem. What is adjacent to the land we are using?

Enter GIS

A computer-based system for:

Capturing,

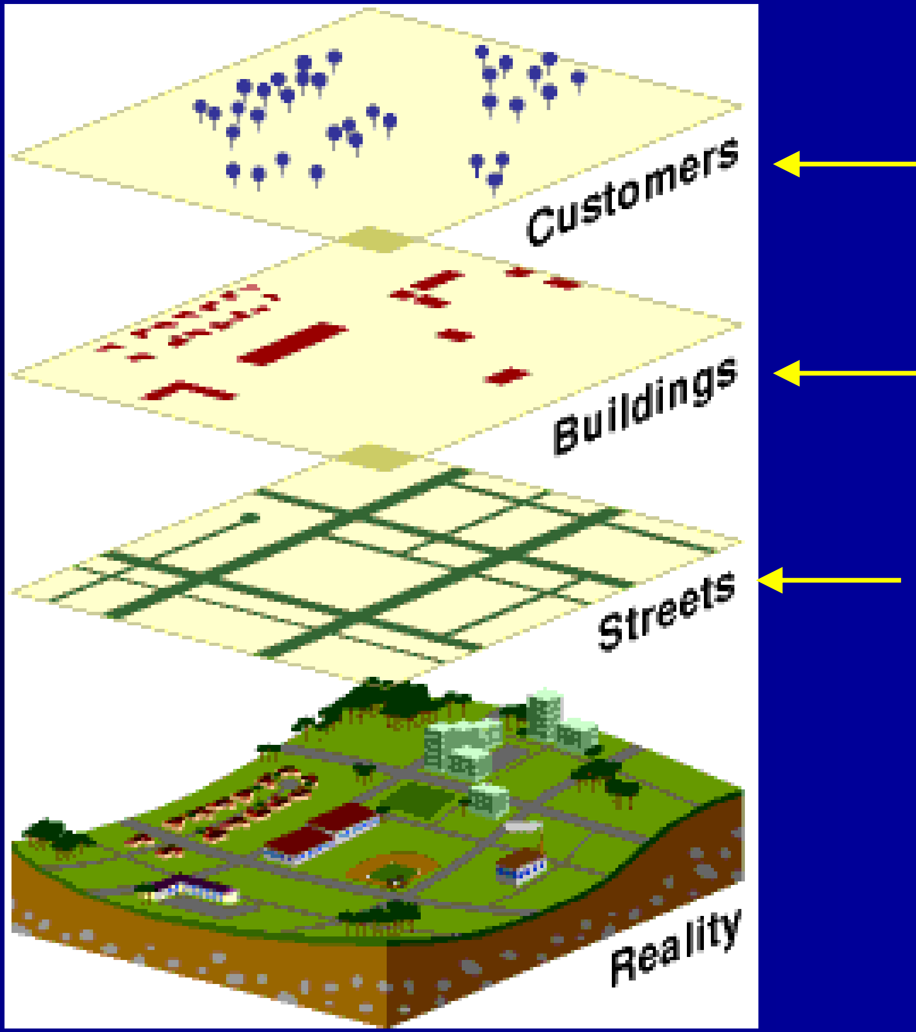
Storing,

Manipulating,

Analysing and

Displaying,

huge amounts of spatial data.



Geographic Information Systems

Computer Mapping

Capture

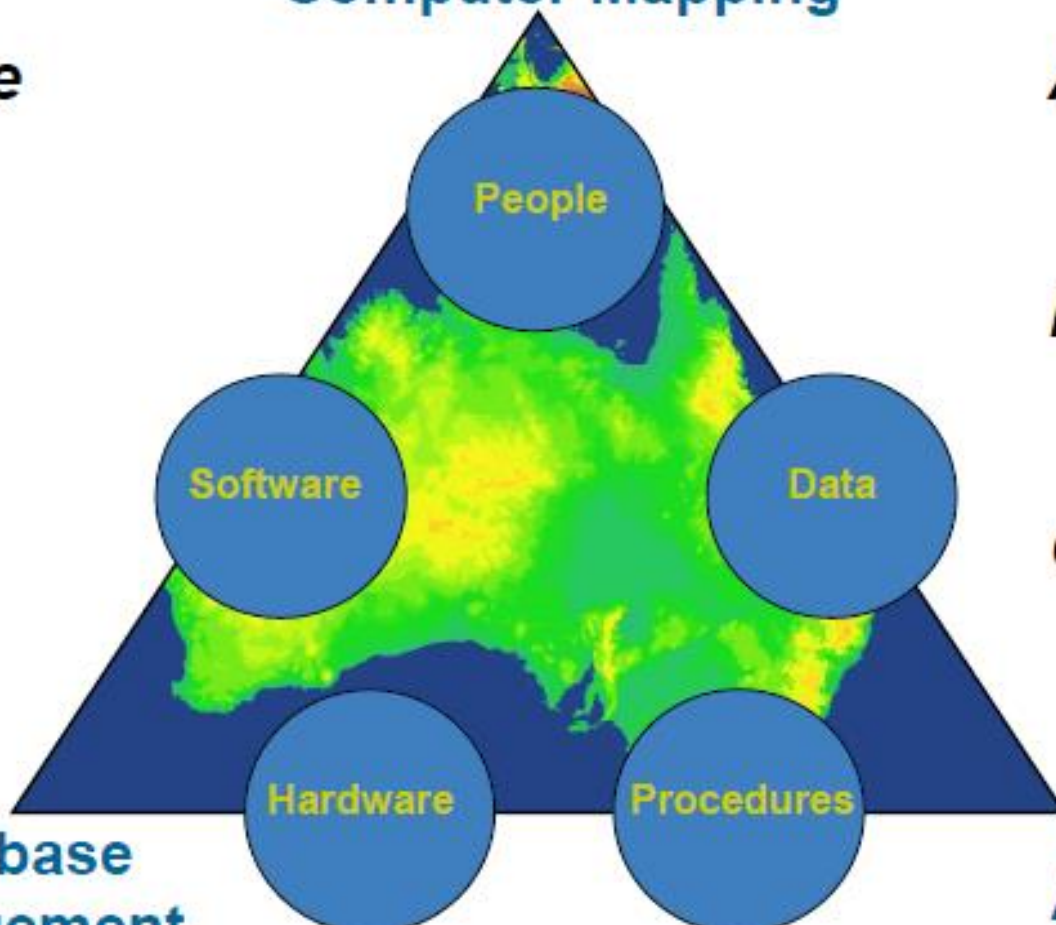
Analyze

Store

Display

Query

Output



Database Management

Spatial Analysis

Components of a GIS

Components of a GIS

A working GIS integrates five key components: hardware, software, data, people, and methods.

Hardware

Hardware comprises the equipment needed to support the many activities of GIS ranging from data collection to data analysis. The central piece of equipment is the workstation or PC, which runs the GIS software and is the attachment point for ancillary equipment.

INTERGRAPH Autodesk ESRI MapInfo

Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are:

- Tools for the input and manipulation of geographic information
- A database management system (DBMS)
- Tools that support geographic query, analysis, and visualization
- A graphical user interface (GUI) for easy access to tools

GIS Software Functions

- Data Entry
  - Digitizing, Data Conversion, Attribute Entry
- Data Management
  - Efficient, Non-redundant Storage
- Data Manipulation and Analysis
  - Projection Management
  - Buffers and Overlays
  - Query and Selection
- Map Updating
  - Graphic and Attribute Editing
- Display and Output
  - Cartographic Design, Plotting, Reporting

Data

Possibly the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider.

A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data.

People

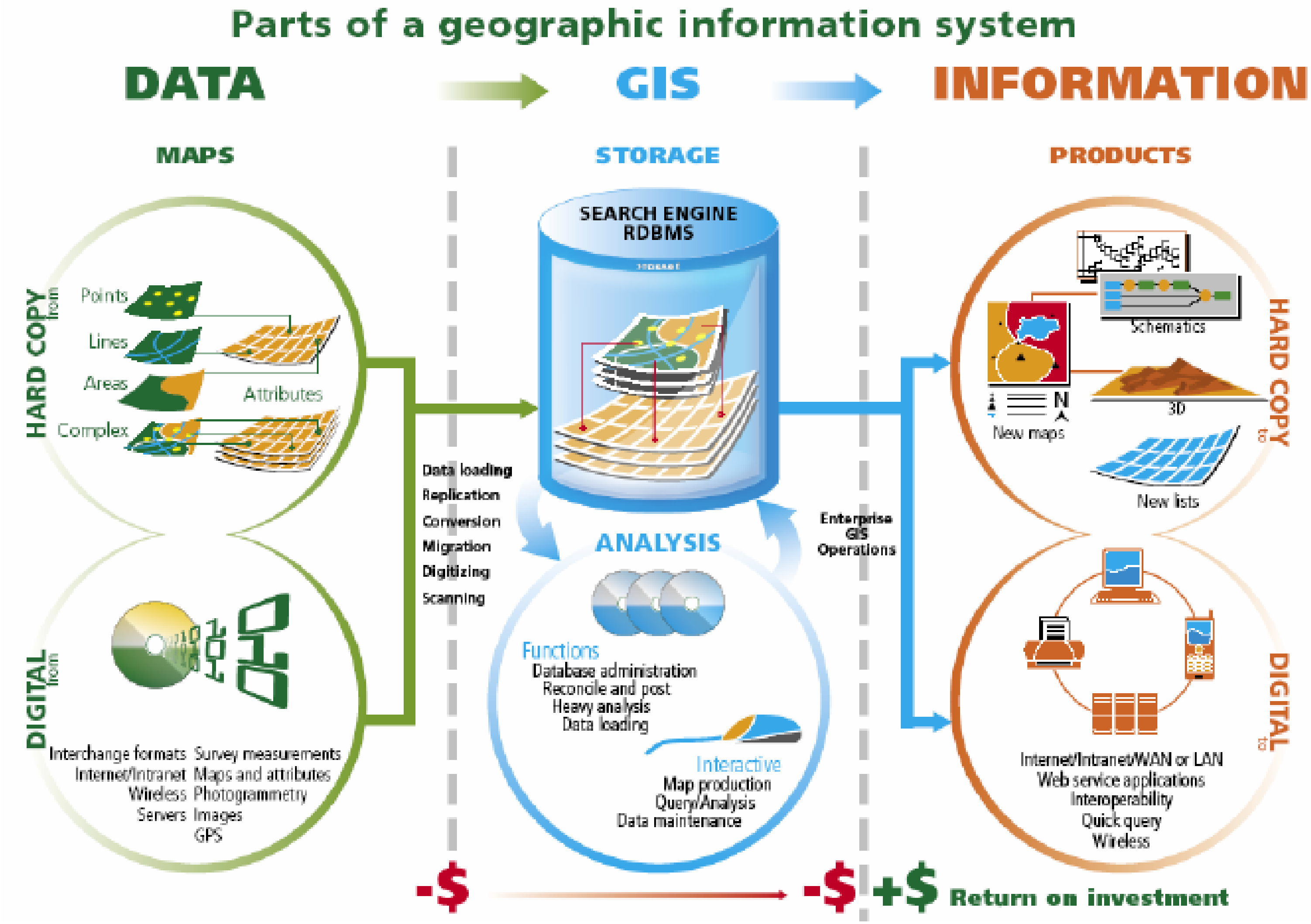
GIS technology is of limited value without the people who manage the system and develop plans for applying it to real-world problems.

GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work.

Methods

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

Steps in a GIS process



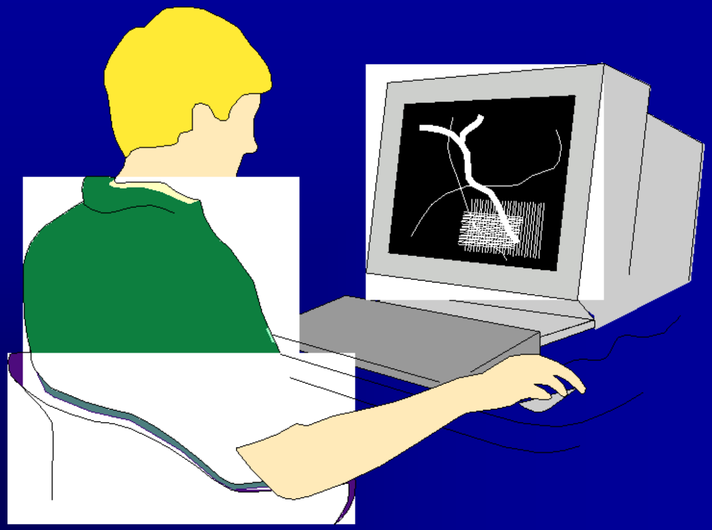
Benefits of Using GIS

- Typical Benefits of Using Automation (Cost Savings)
- Better Data Management (Efficient Storage and Updating)
- Faster Information Access (Better Decisions)
- Operational Efficiencies
- New Applications

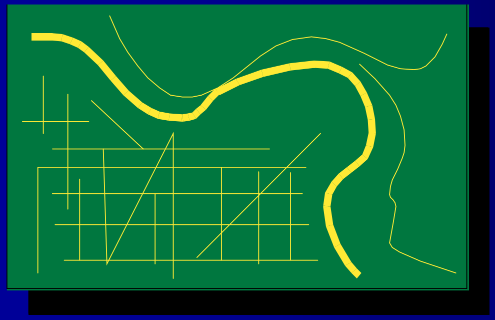
GIS Application Areas

- Base Mapping
- Oil and Gas Exploration
- Planning and Zoning
- Forest Resource Inventory
- Demographic Analysis
- Water Resources
- Demographic Analysis
- Tax Assessment
- Cartographic Production
- Geologic Mapping
- Public Safety
- Land Records
- Transportation
- Legislative Redistricting
- Environmental Analysis
- Teaching and Research
- Many Others

High-End GISs Do Far More Than Just Display Maps



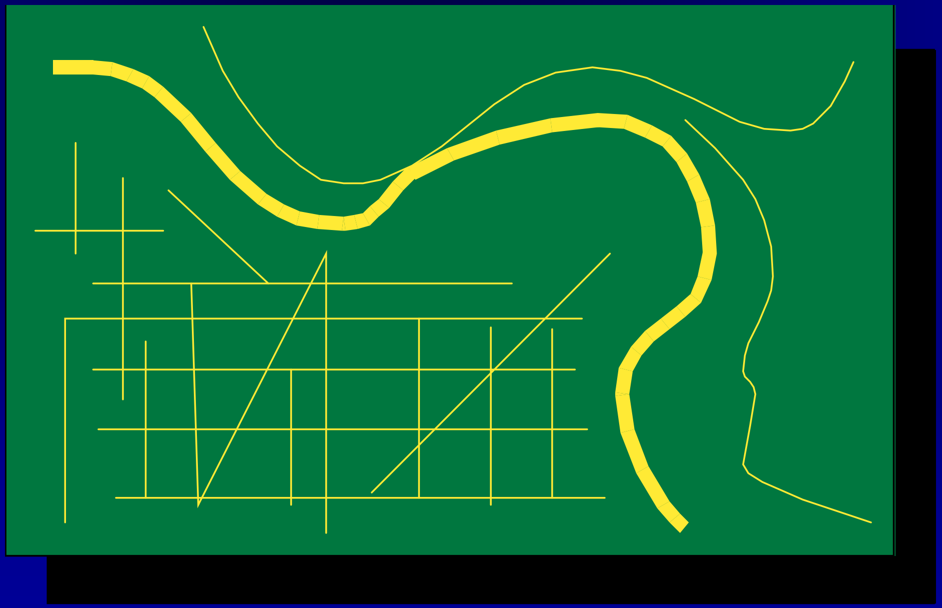
High-End Desktop GISs



Low-End Mapping Systems

- ❑ Analysis
- ❑ Modelling
- ❑ Data Integration
- ❑ Networking
- ❑ Customizable Displays

Low-End Mapping Systems Have Very Limited Capabilities



What Is Spatial Data

Relationship between Data and Information

Data are **observations** we make from monitoring the real world. Data are collected as **facts or evidence** that may be **processed** to give them **meaning** and turn them into **information.**

Information is therefore data with meaning and context added.

All data have **three modes or dimensions:**

Temporal – 1 January 2009
thematic – car accident, type of accident, casualty; and
Spatial – location – map coordinate (Nkrumah Circle)

All three dimensions of data are not mutually exclusive

What is Spatial Data

Spatial Data is data that is characterized by:
- information about location;
- connections with other features; and
- details of non-spatial characteristics (attributes).

Example of spatial data about a motor accident

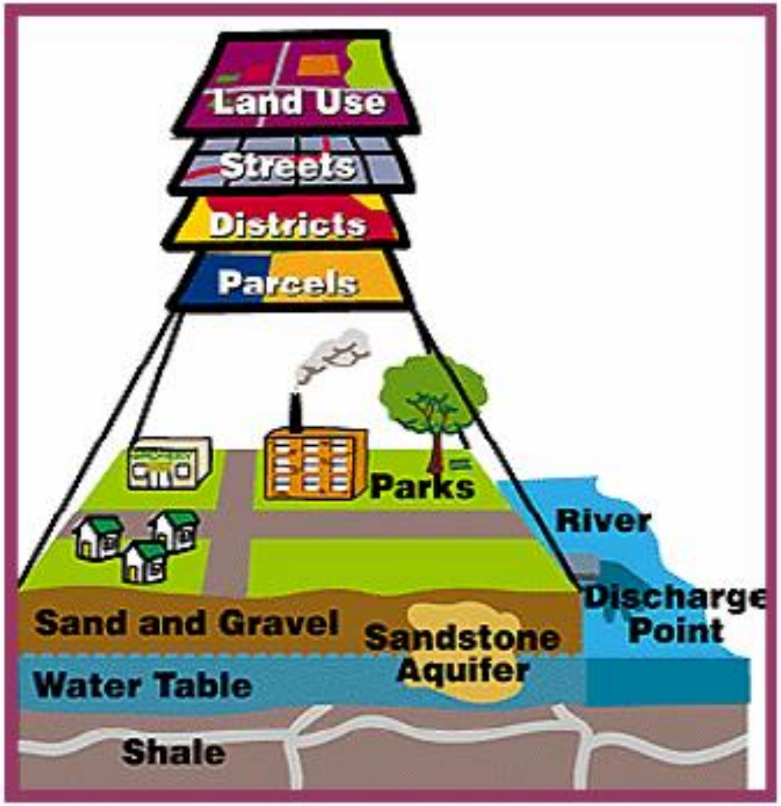
- Where = Nkrumah Circle (latitude and longitude)

- Connection details such as which service roads would allow the police access

- attribute data e.g. nature of accident, number injured, vehicle model, sex of driver etc.

Spatial Data = Spatial (Where) + Data (What)

Organizing Spatial Data in a GIS



- A GIS works with thematic layers of spatial data
- Allows to ask and answer questions by comparing and integrating different layers of data
- Static view of the world – mapping tradition
- Main focus – space

Understanding mapping
representing the world

Main Characteristics of Spatial Data

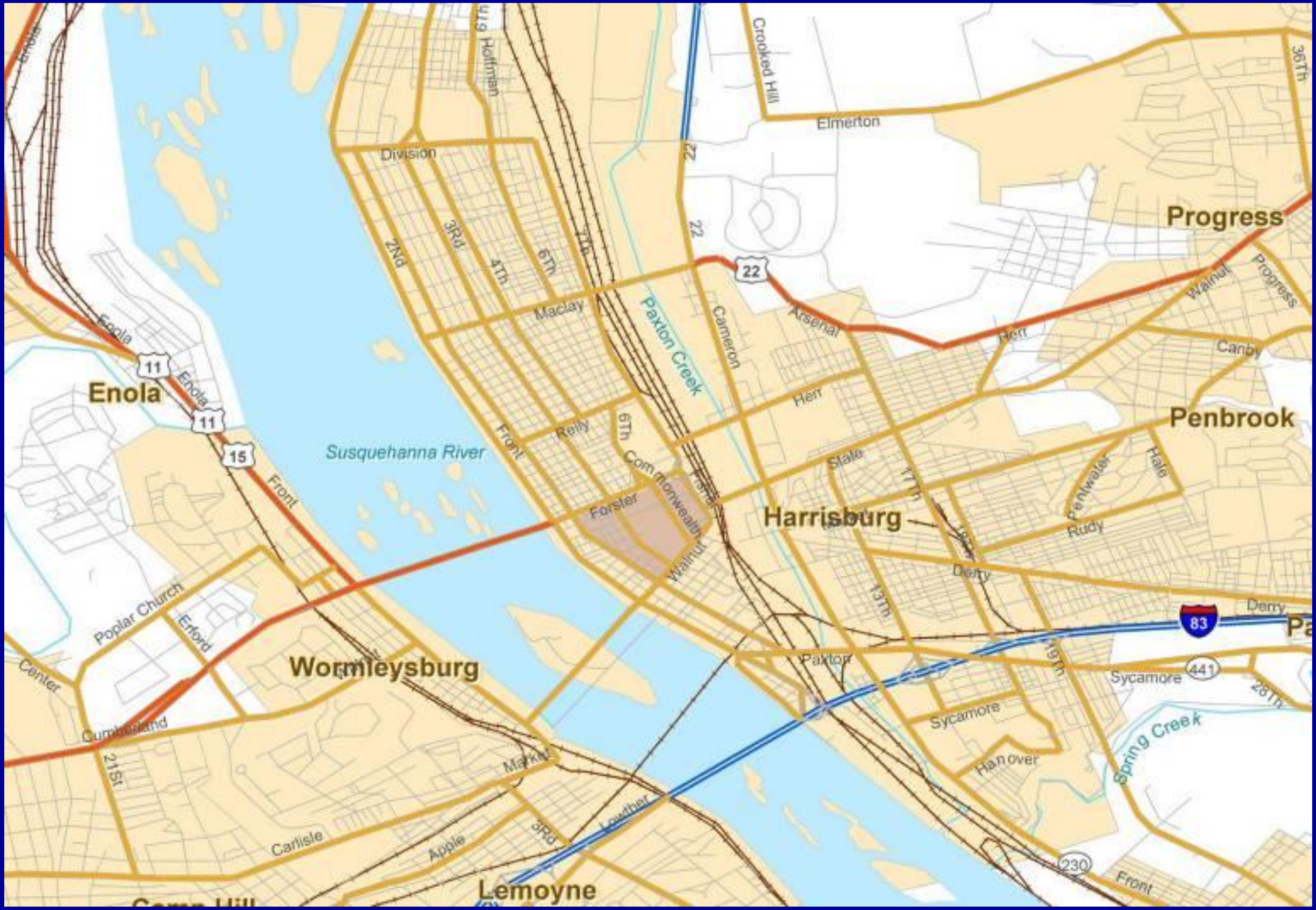
Scale

Virtually all sources of spatial data, including maps , are smaller than the reality they represent.

Scale gives an indication of how much smaller than reality a map is.

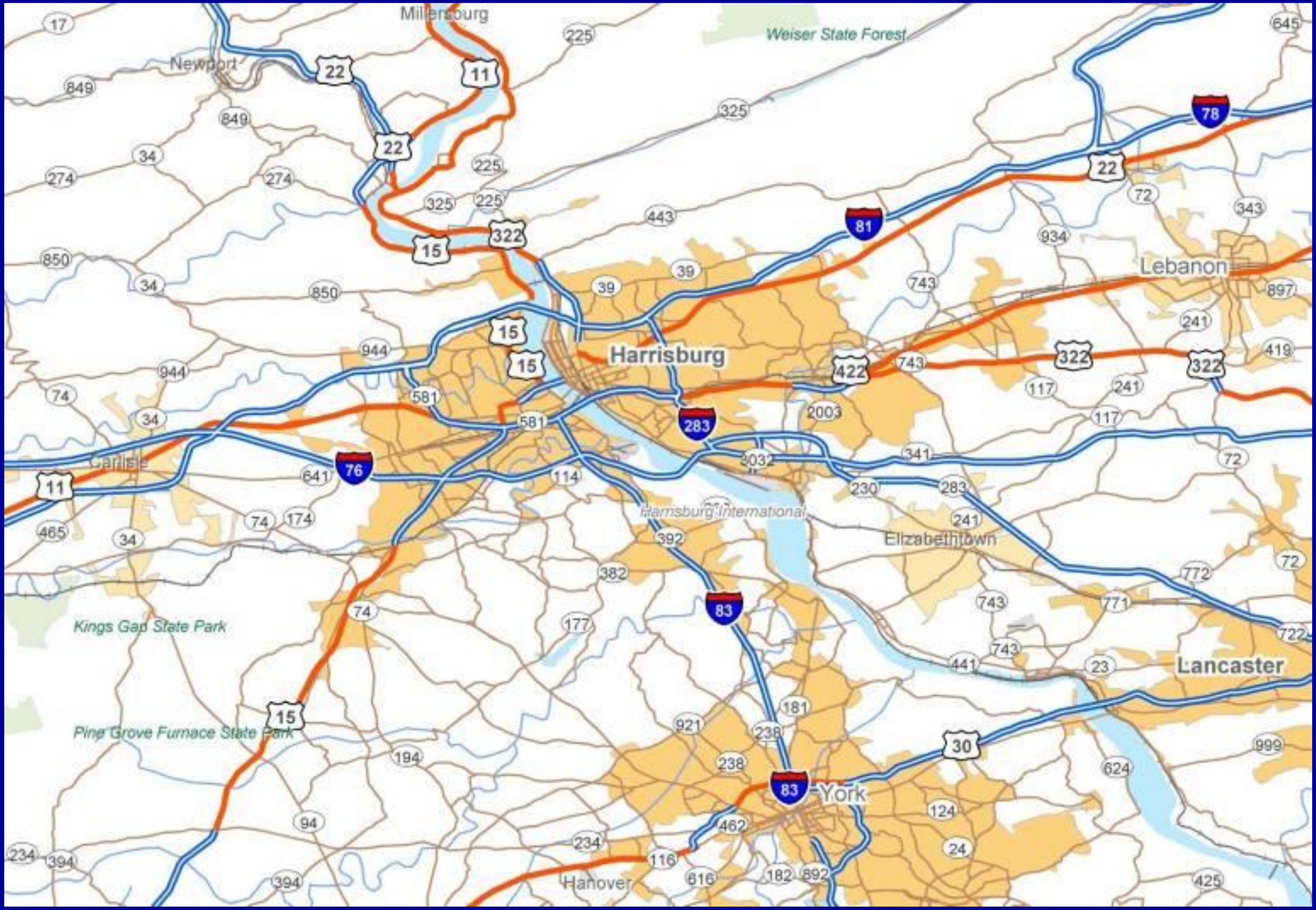
Scale can be defined as the ratio of distance on the map to the corresponding distance on the ground.

1:50,000 scale map of Harrisburg



Larger scale e.g. 1:50,000 Shows less area and more detail

1:500,000 scale map of Harrisburg

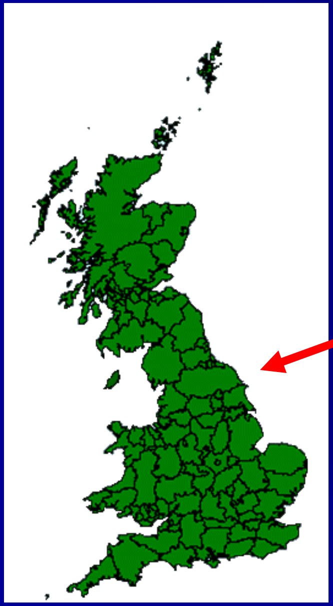


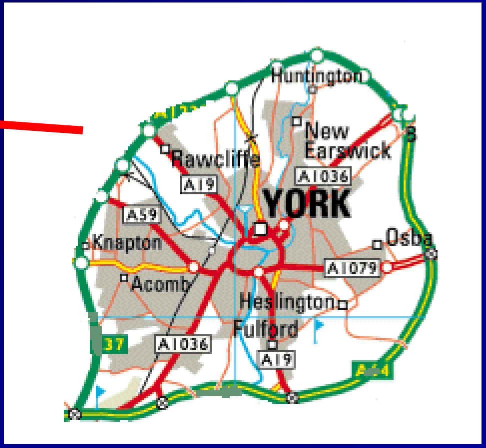
Smaller scale e.g. 1:500,000 Shows more area and less detail

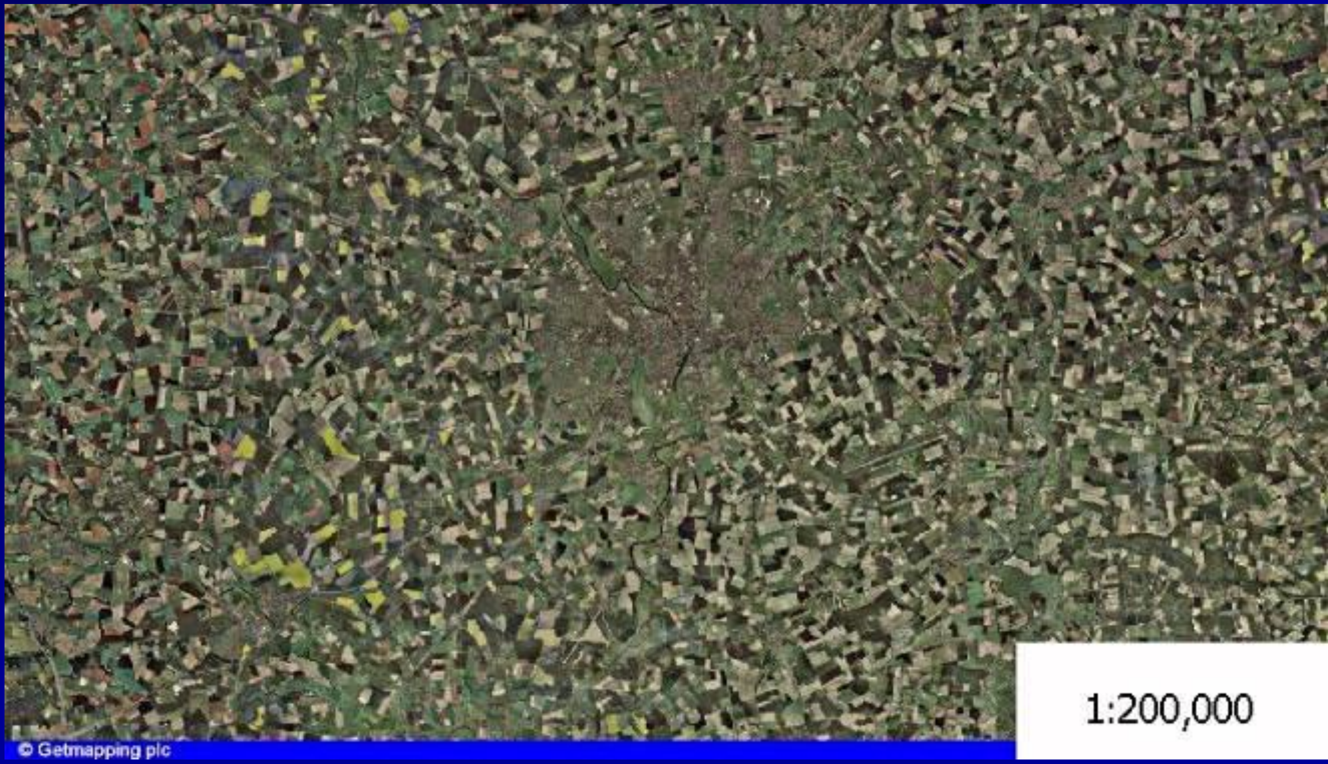
Understanding mapping:

generalisation

For mapping to be useful certain known elements of the world are discarded. The greater the scale, the more is discarded. Shape, direction and connection may be lost.



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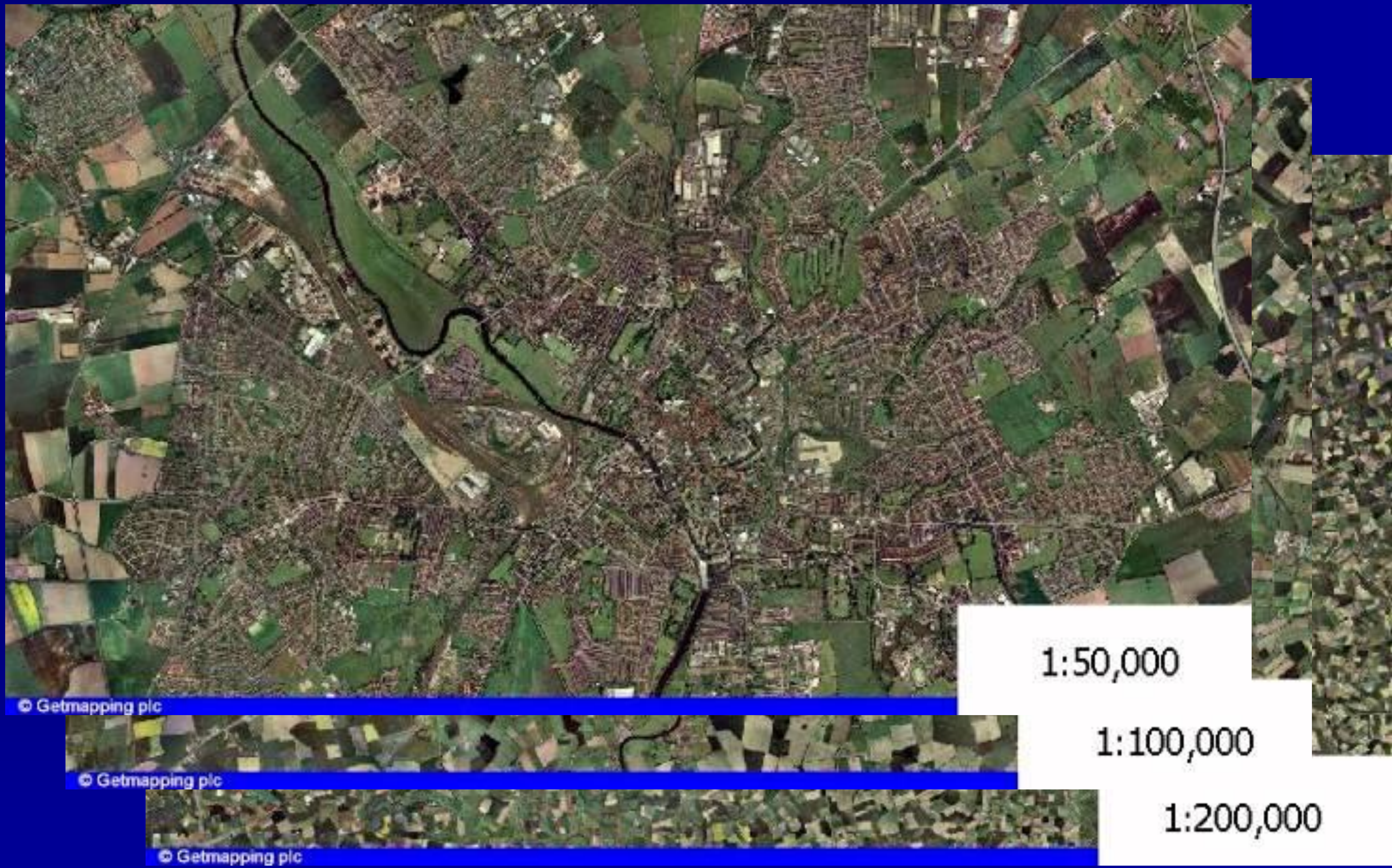
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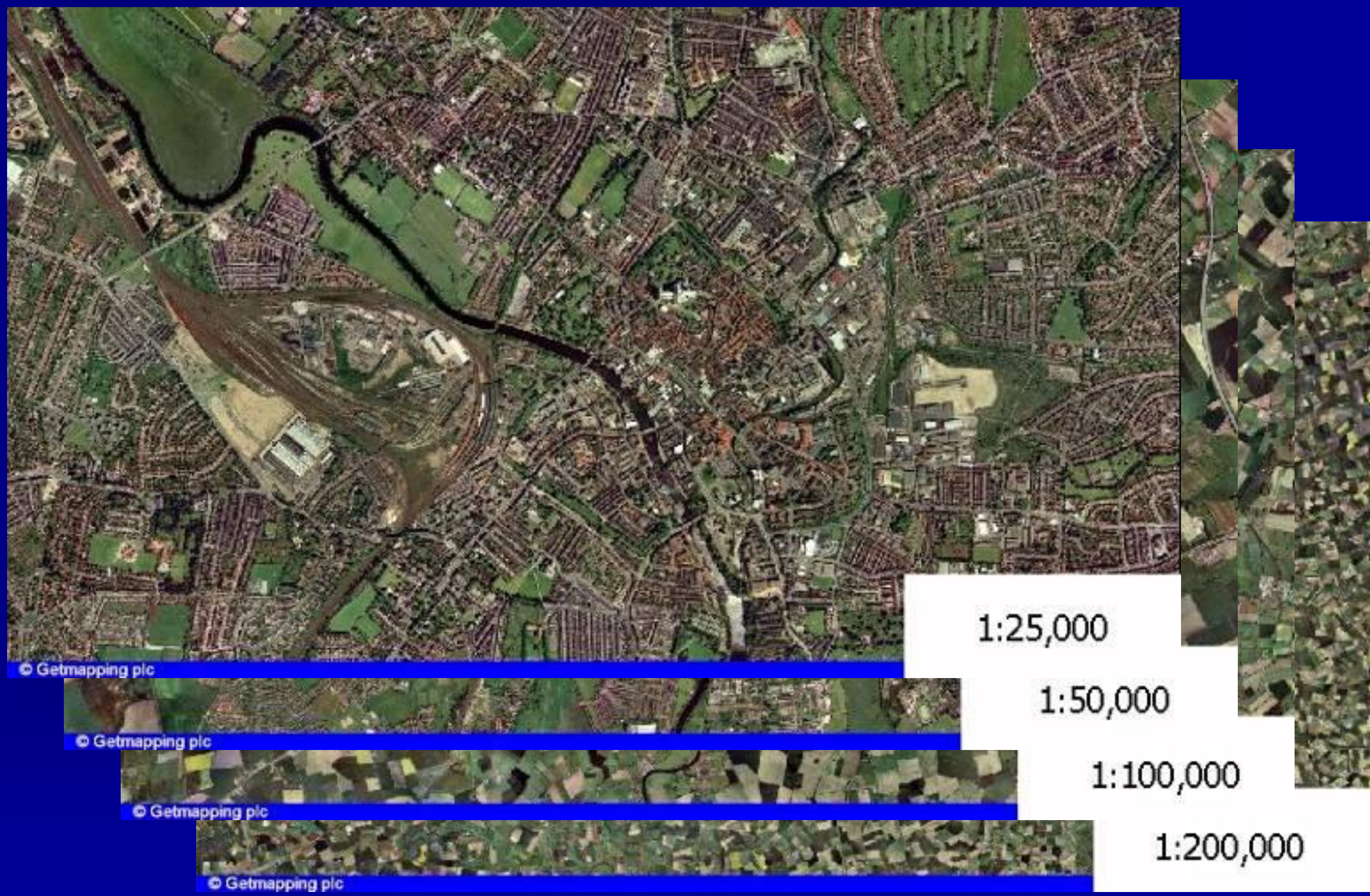

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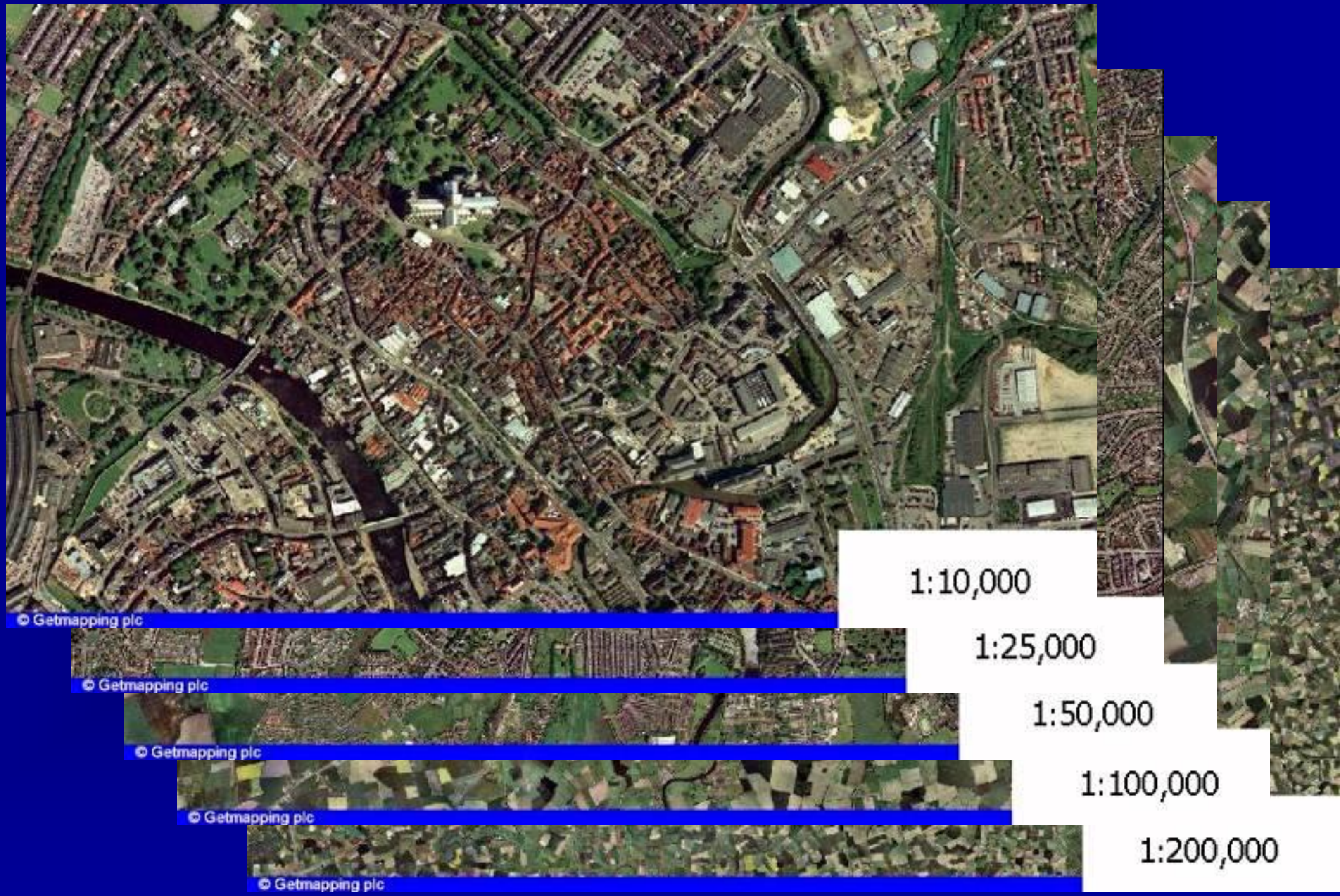
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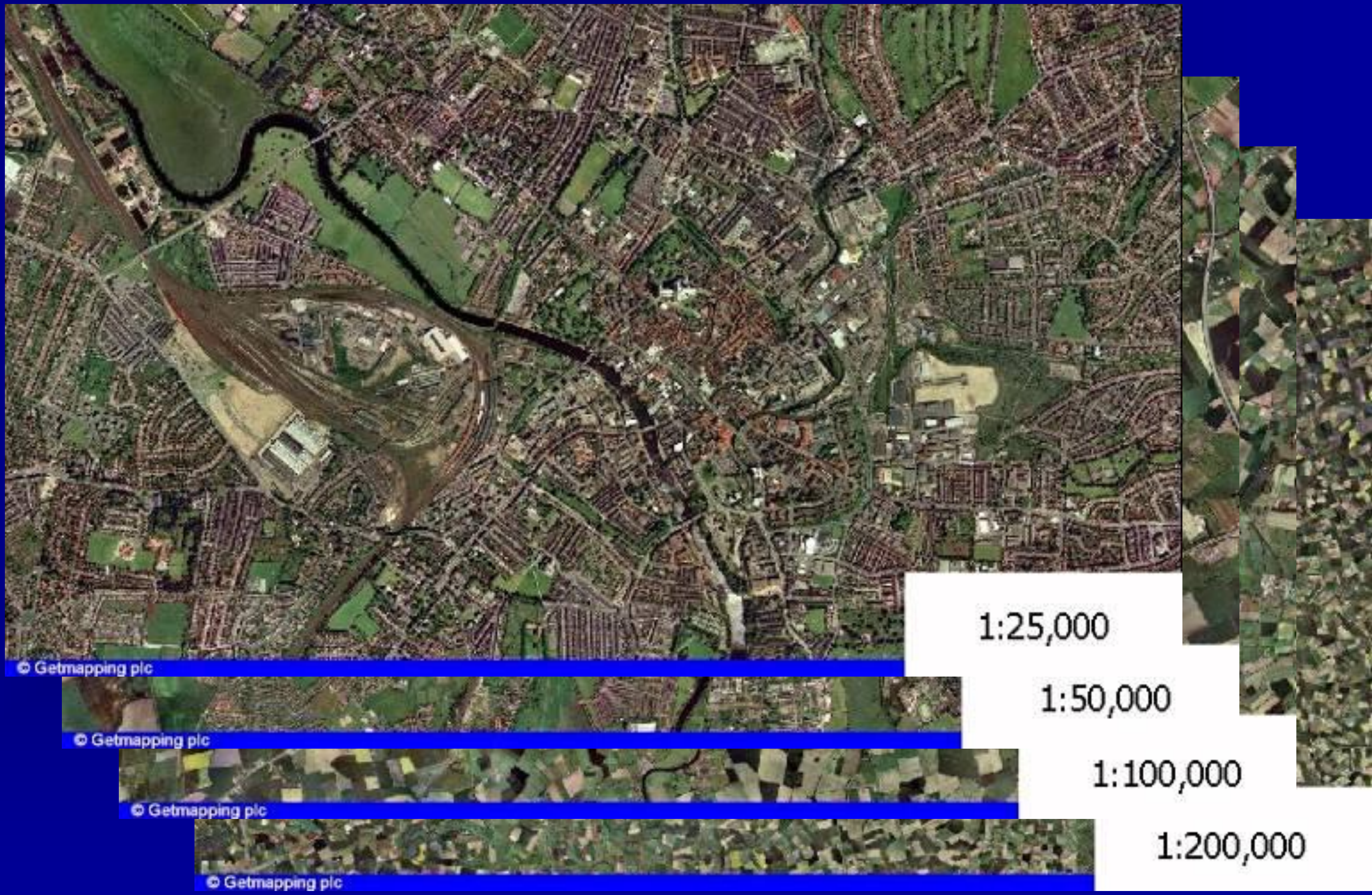
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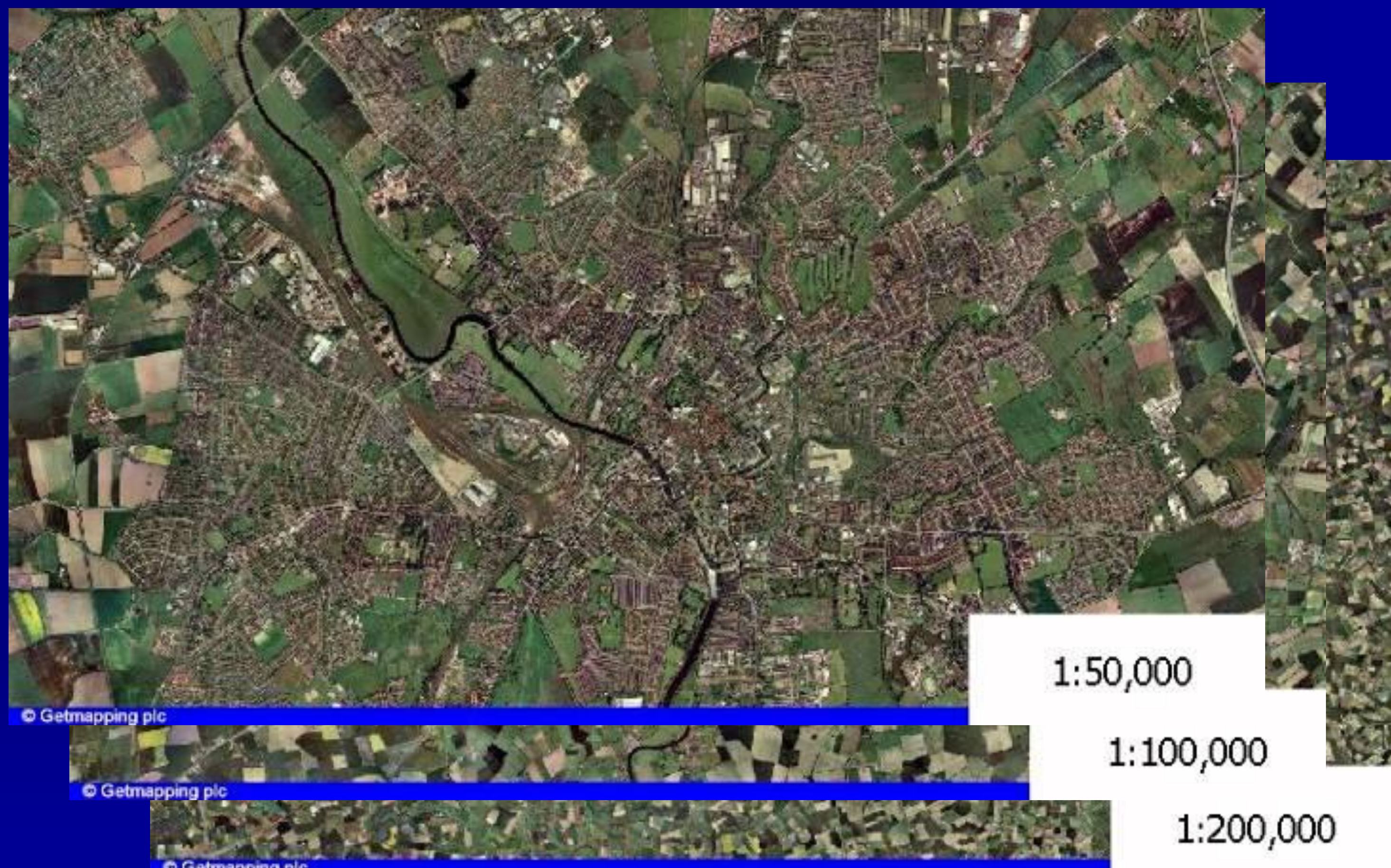

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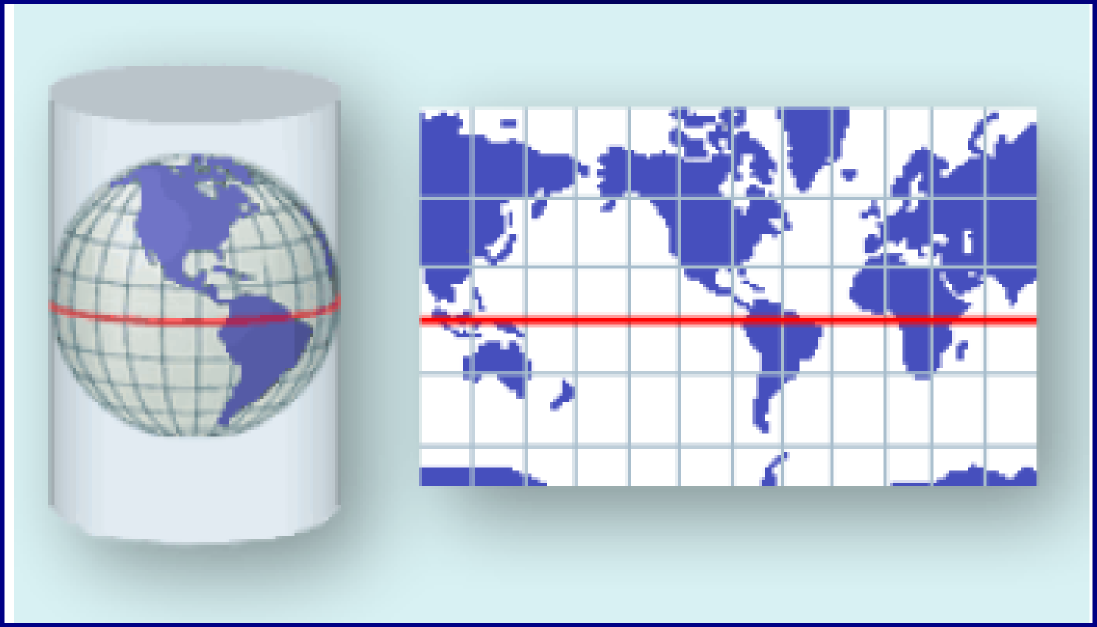
Understanding mapping:
projection

A map projection is a mathematical means of transferring information from a model of the Earth, which represents a three-dimensional curved surface, to a two-dimensional medium -paper or a computer screen.

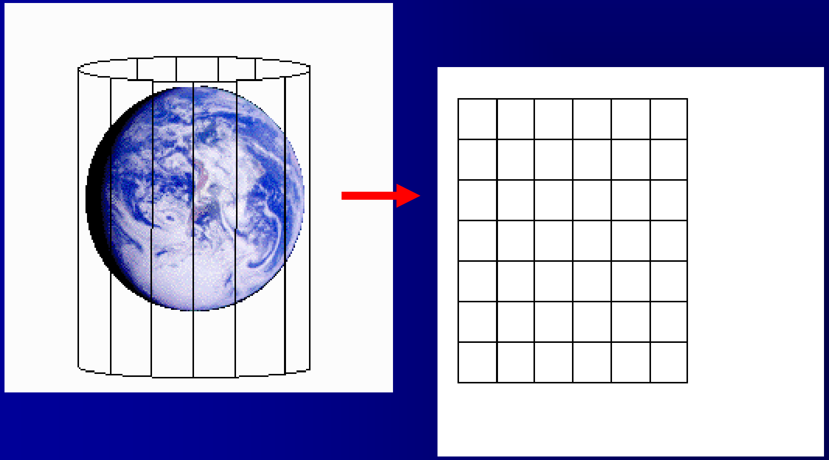


There are a variety of different projections used to turn the 3-dimensional world into 2 dimensions

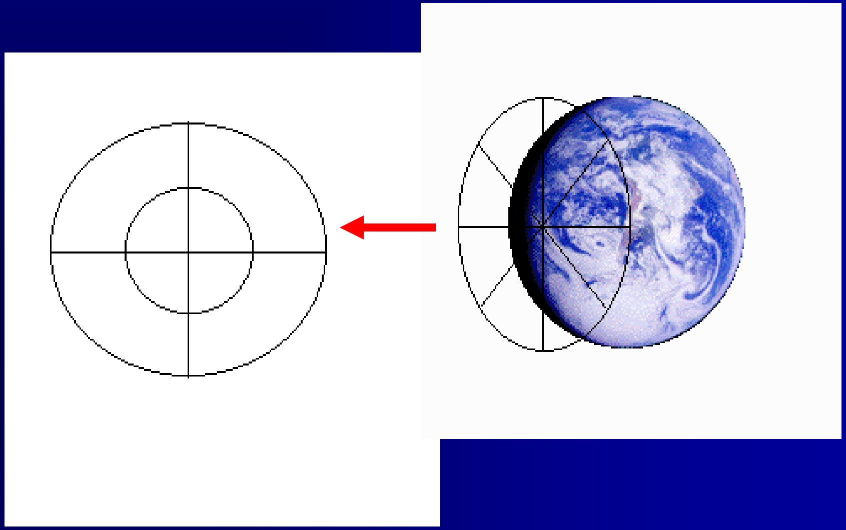
Understanding mapping:

projection

Cylindrical projection

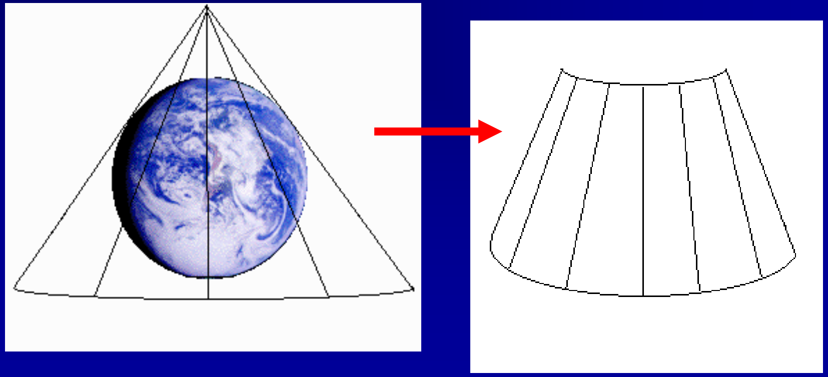


Azimuthal projection



Different projections have their own characteristics and uses. They all distort the properties of the Earth, but do so differently.

Conic projection

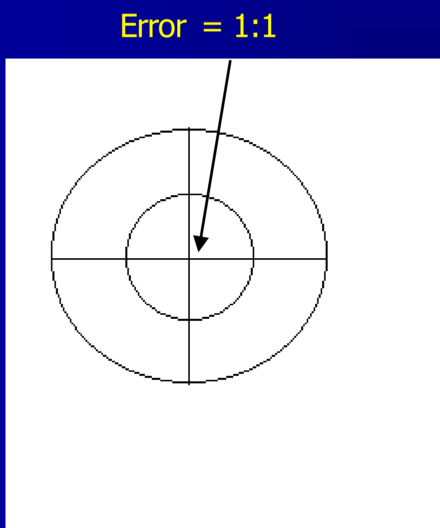


Understanding mapping:

There are six main types of distortion in mapping:

- shape
- distance
- area
- direction
- scale
- angle

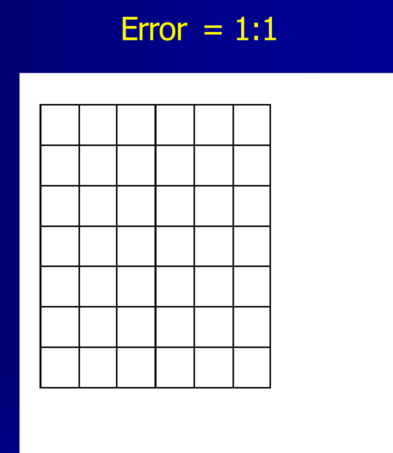
Understanding mapping:



distortion is not constant

Azimuthal projections distort from the centre

Error increases as a function of distance from the equator



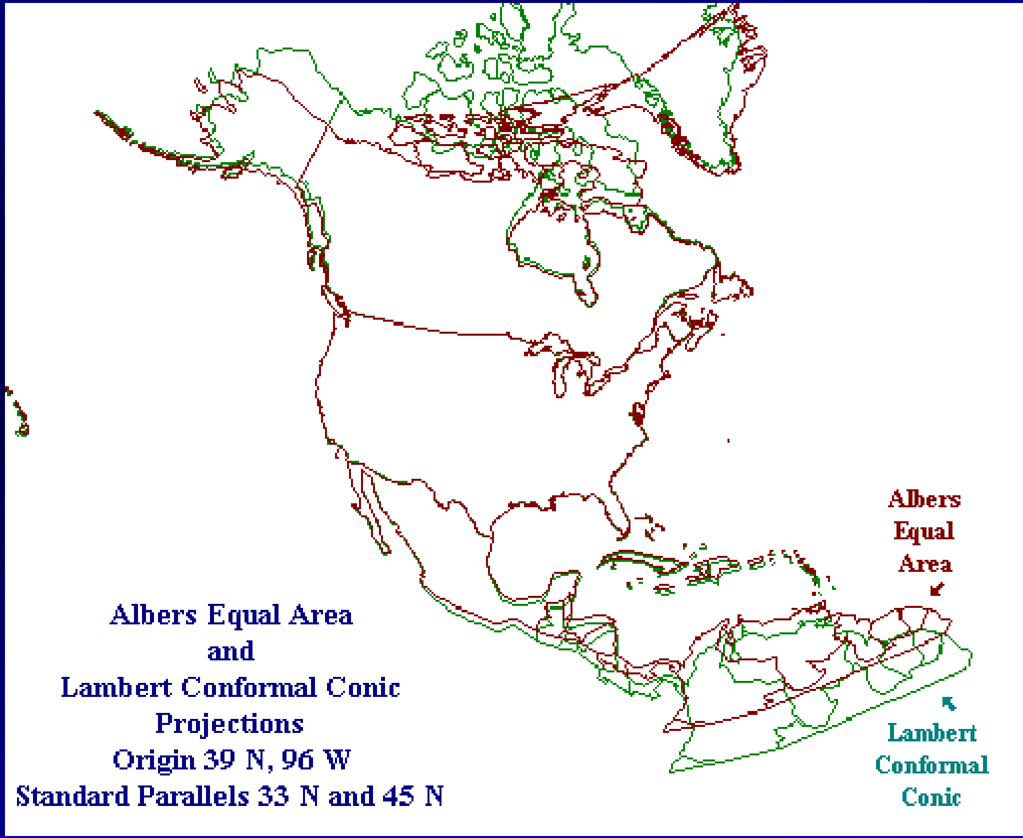
Cylindrical projections distort from the equator

Error increases as a function of distance from the equator

This is what happens when projections mix!

Your map layers will not lay on top of each other but will rather be shifted into different areas

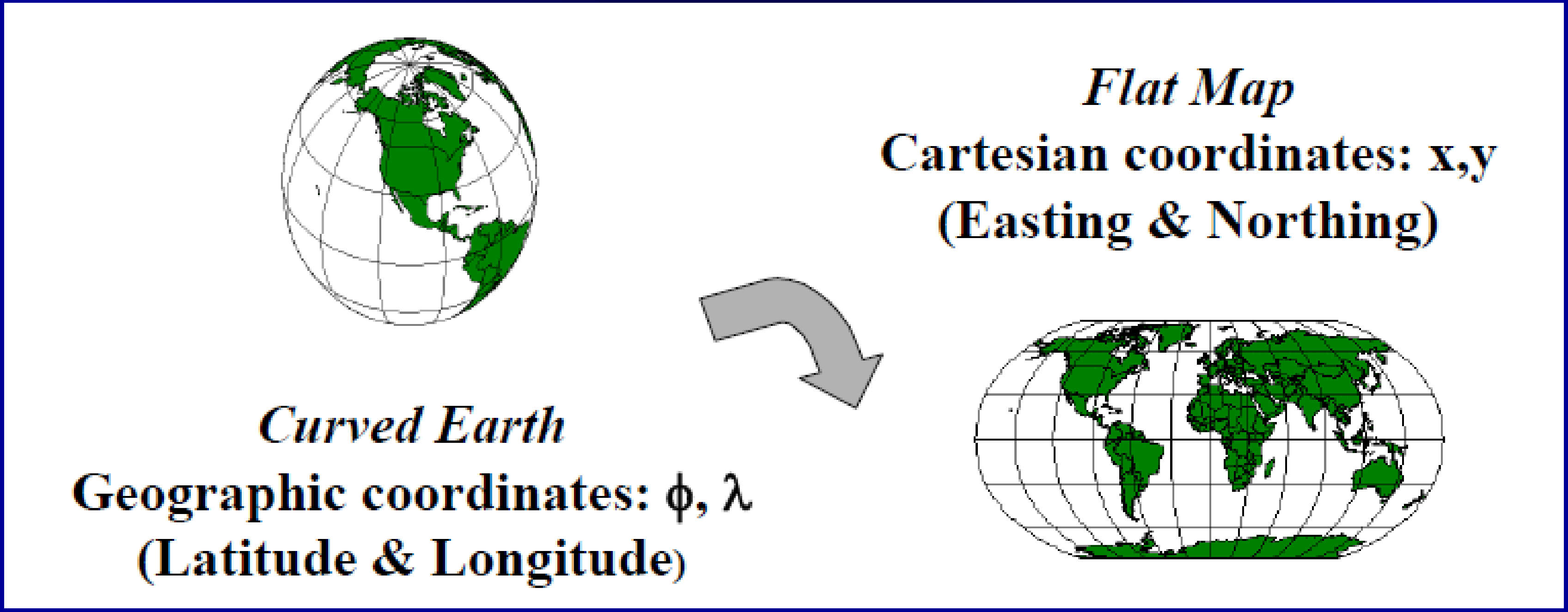
- Notice the boundary lines do not line up
- Points that are placed on the wrong projection will be misaligned as well



When working with GIS systems you have to know about projections in general and what projection the different data you are using are in.

Spatial Reference System

A system used to locate a feature on the Earth's surface or a two-dimensional representation of this surface such as a map. A common coordinate system is used to spatially register geographic data for the same area.

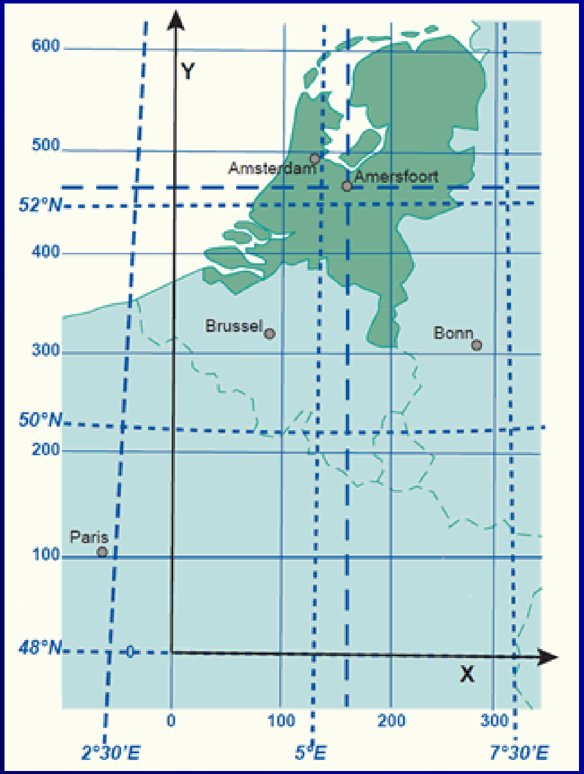


Spatial Reference System

Geographic co-ordinate systems

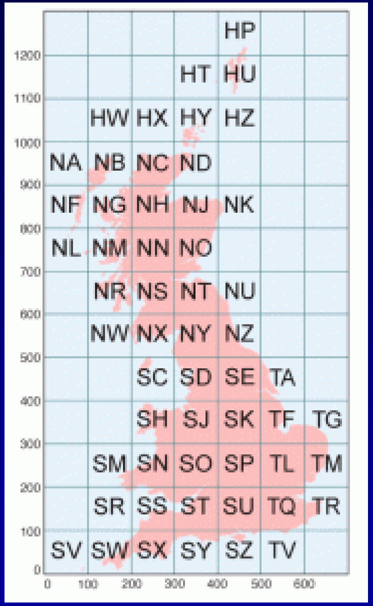
Longitude and Latitude

These 2D Cartesian coordinate systems are derived from a particular map projection



Rectangular co-ordinate systems

UK National Grid, UTM Plane Grid



Non co-ordinate systems

Use a descriptive code rather than a co-ordinate e.g. postal codes

Sources of Spatial Data

- Census and survey data
- Aerial photographs
- Satellite Imagery
- Global Positioning System (GPS)
- Standard survey equipment
- Scanning maps
- Digitizing features by hand (the most time intensive)
- The internet (very fast)
- Electronic - spreadsheets

GIS Data Standards

The number of formats available for GIS data is almost as large as the number of GIS packages on the market.

This makes the sharing of data difficult and means that data created on one system is not always easily read by another system.

This problem has been addressed in the past by including data conversions functions in GIS software and adopting commonly used exchange format.

There is no universally accepted GIS data standard although a steering group is working on a new GIS data standard called the Geographic Markup Language (GML).

GIS Data Quality

The quality of the spatial data used in GIS is crucial. Low or unknown quality of input data sets limitations of the reliability of analysis results and, hence, the usefulness of GIS in such cases may be questioned.

It is therefore very important to establish a quality control procedure that will ensure that quality data is accepted and introduced into the GIS on a consistent basis.