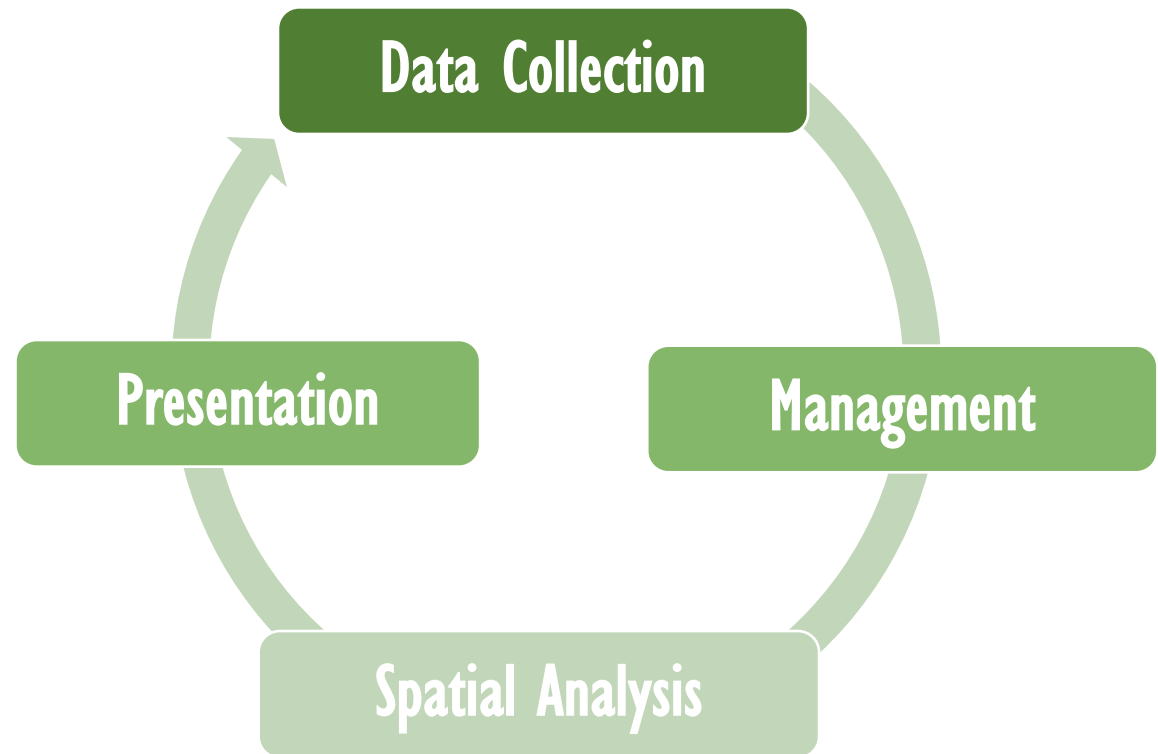


# **Introduction to GIS**

# What is GIS

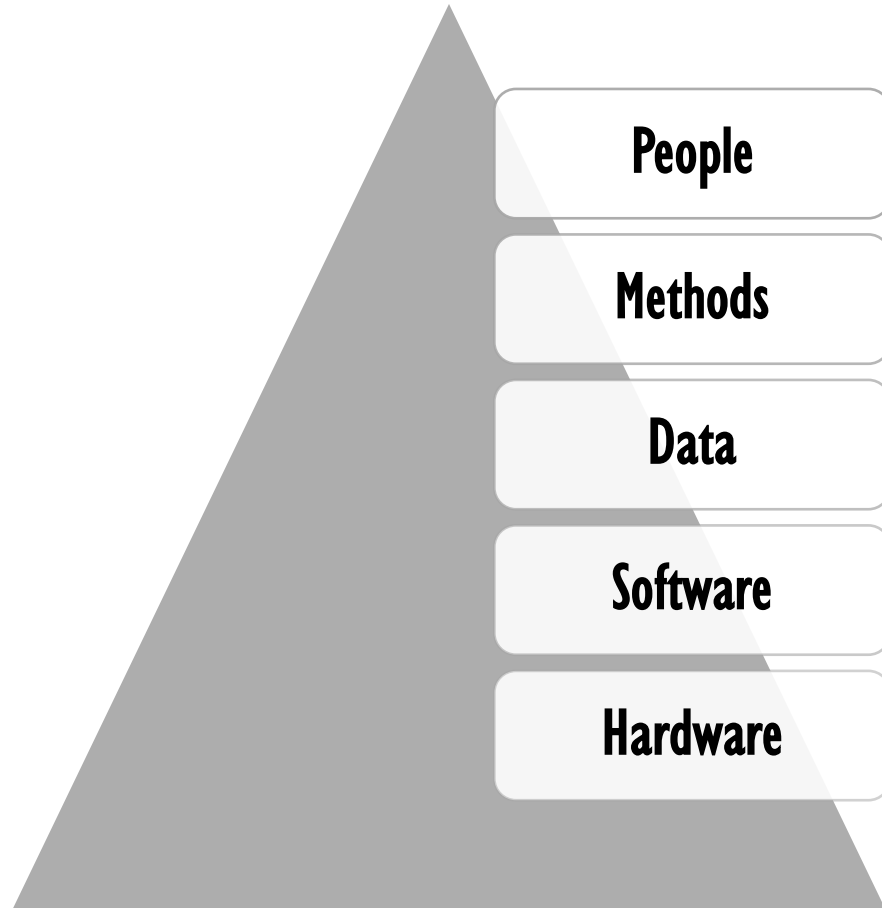
- A GIS is a computer-based system to aid in the collection, maintenance, storage, analysis, output, and distribution of spatial data and information.
- Data vs Information



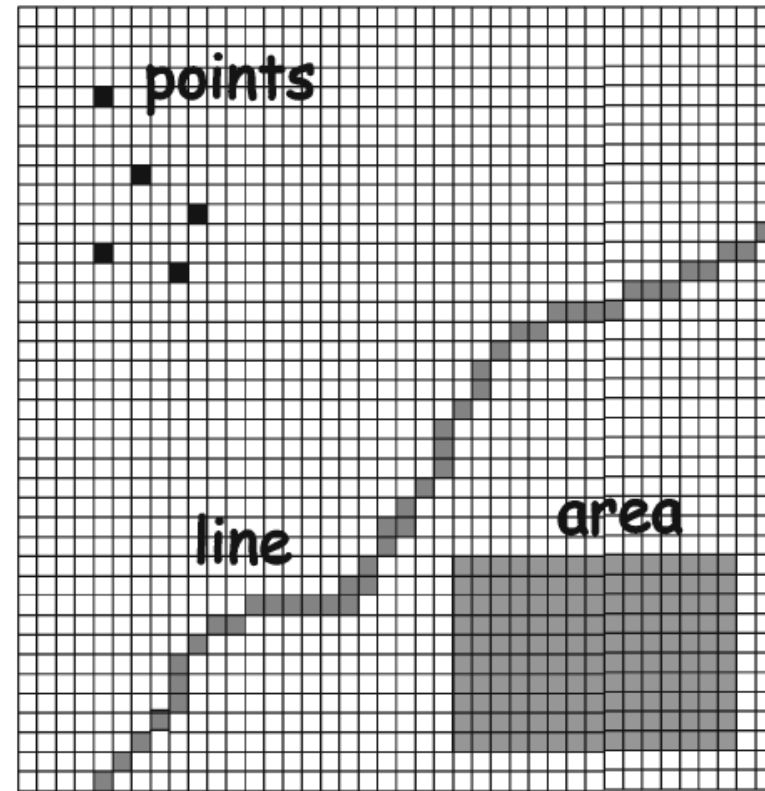
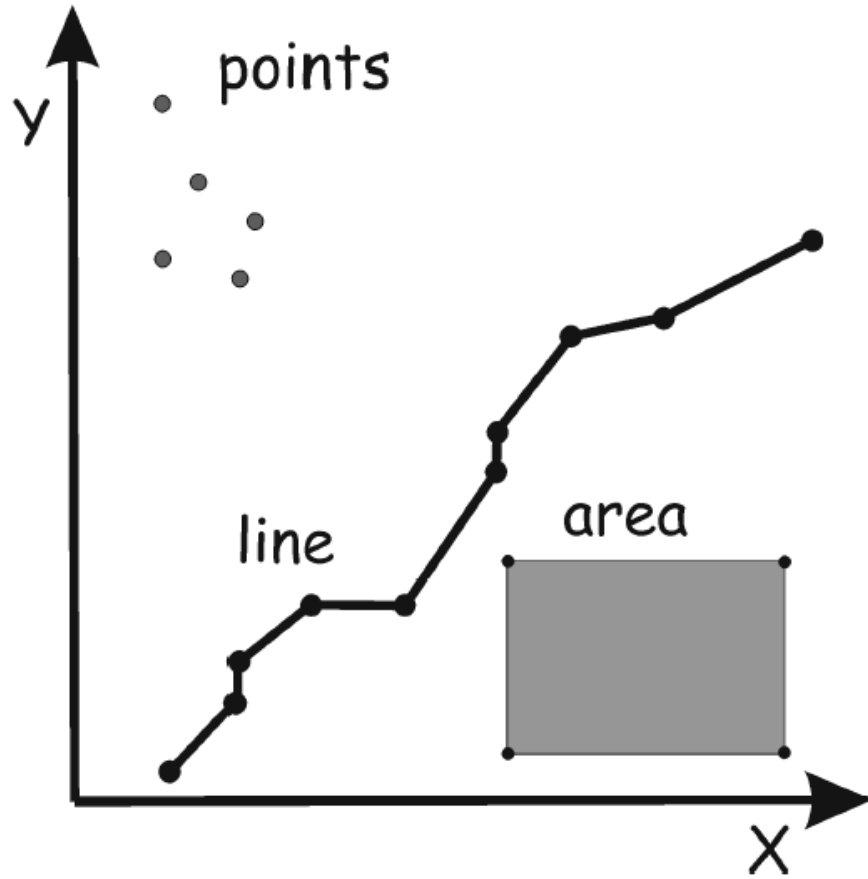
# GIS History

- 1960s: John Snow, Minard's Map (Napoleon)
- First GIS — Roger Tomlinson 1960, operational from 1971
- USA — Government Organisations: USGS, US Forest Services, others incl. CIA
- Academia
  - Edinburgh — GIMMS 1970s (Sold from 1973), MSc GIS 1985
  - Harvard — Computer Graphics and Spatial Analysis Lab 1965
- ESRI 1969 Env. Consultancy — Arc/Info 1982 - ArcView Desktop 1995 - ArcGIS 1999
- Demographics Consultancy — MapInfo 1986
- OpenSource — GRASS, Quantum GIS (QGIS), gvSIG, ...
- Web GIS — WMS, WFS, Google Maps, Google Earth, OGC, OpenStreetMap

# Components of GIS



# Data Models



# Vector Data

## Point

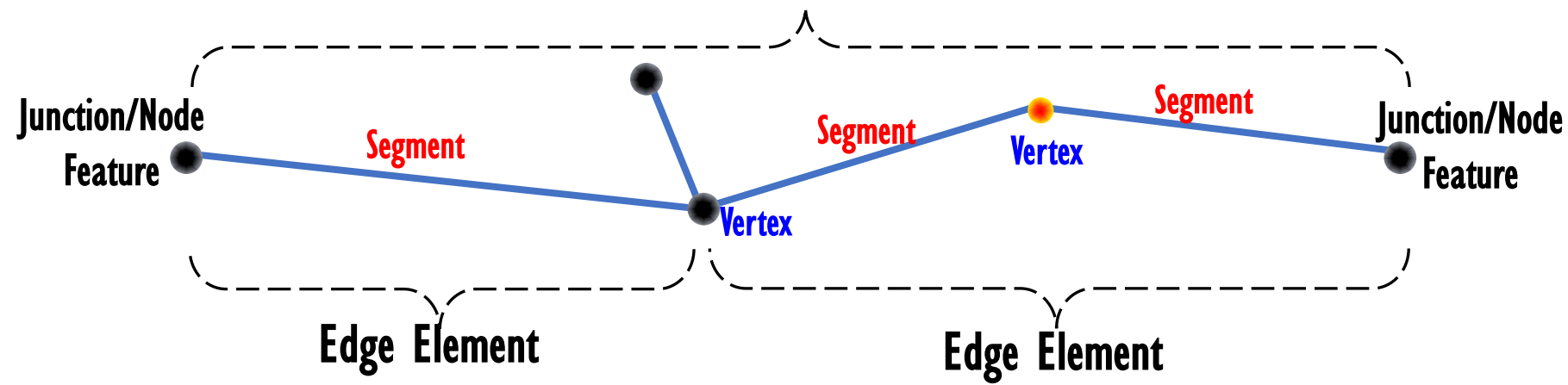
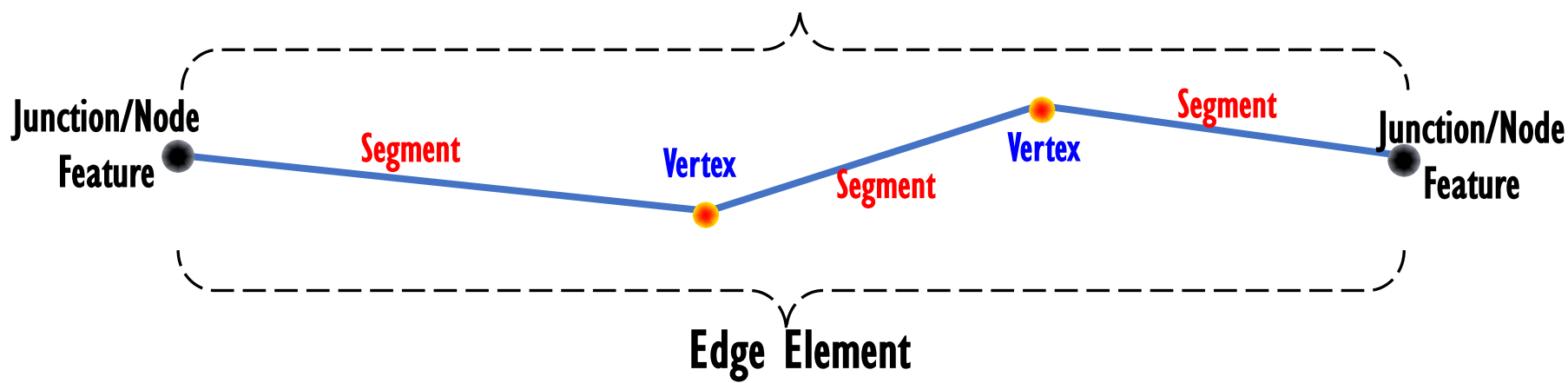
- Discrete locations in 0-dimension with a single x,y coordinate pair and zero area.
- Eg. — tree, oil well, label location

## Polyline

- Set of at least two ordered, connected coordinates in 1-dimension.
- Eg — roads, water pipelines

## Polygon

- Closed figures that encompass a homogenous area in 2 dimensions. It should have three or more ordered and connected x,y pairs.
- Eg — lakes, districts



- FeatureID / OID\*
- Geometry\*
- Length\*
- Name
- State
- StartPlace
- EndPlace
- \*Default fields*

# Attributes & Field Data Types

Shapefile

- Integer
- Float
- Double
- String
- Date

Geodatabase /  
File Geodatabase

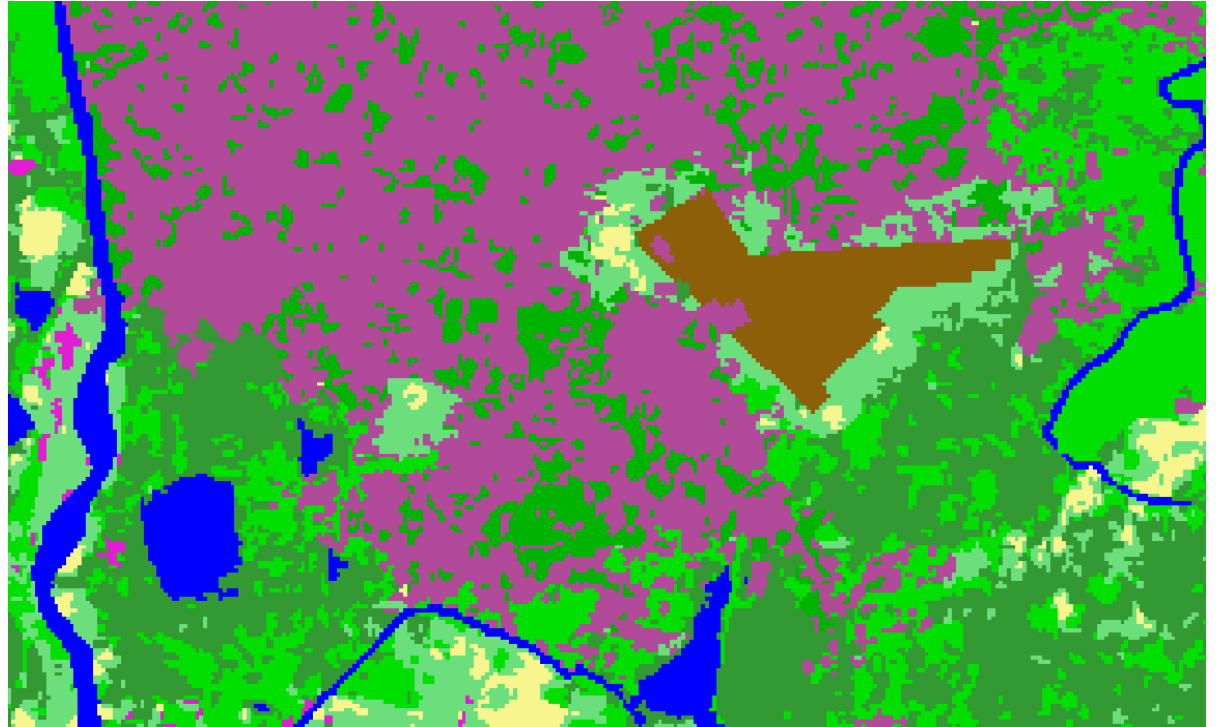
- Integer
- Float
- Double
- String
- Date
- Blob
- GUID
- Raster

| Data Type               | Examples                           |
|-------------------------|------------------------------------|
| Short Integer (16 Bits) | -32,768 to 32,767                  |
| Integer (32 Bits)       | 4,29,49,67,296                     |
| Long Integer (64 Bits)  | 1,84,46,74,40,73,70,95,51,616      |
| Float (32 Bits)         | 3.4E +/-38                         |
| Double (64 Bits)        | 1.7E +/-308                        |
| String                  | "A", "GIS World"                   |
| Date                    | 09.08.2024 14:15:00                |
| Blob                    | Unstructured data in binary format |
| GUID                    | {12345678-1234-1234-1234}          |
| Raster                  | .jpg, .PNG, .TIF                   |



# Raster Data

- Raster data is generally represented in a grid format and the cells are generally called **pixels**.
- Attributes are recorded by assigning each cell a single value
- easy to do overlays/analyses, just by ‘combining’ corresponding cell values: **“yield= rainfall + fertilizer”**
- simple data structure: directly store each layer as a single table



# Attributes

- **Vector — Multiple Attributes (Properties)**
  - Attributes are of each feature (point, line, poly)
- **Raster — Single Attribute (Value) e.g. pH**
  - Each cell has a different value of this attribute
  - **BUT! Can also have in turn Value Attributes e.g.**  
**1 = Acid, 7 = Neutral, 14 = Alkaline**
  - **BUT! Again only one per value!**

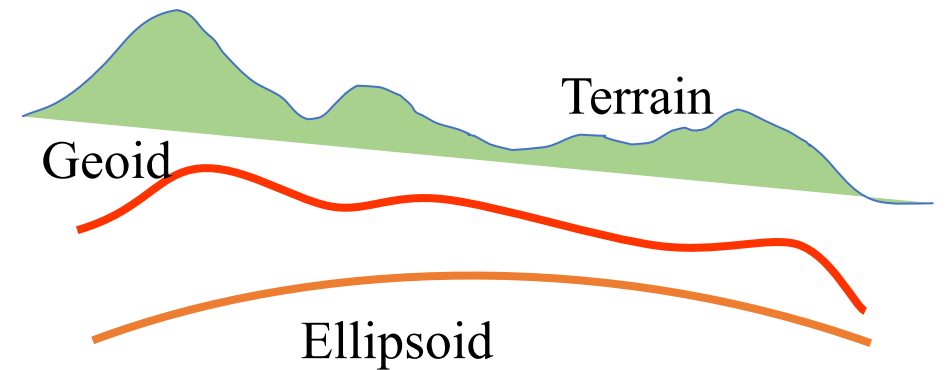
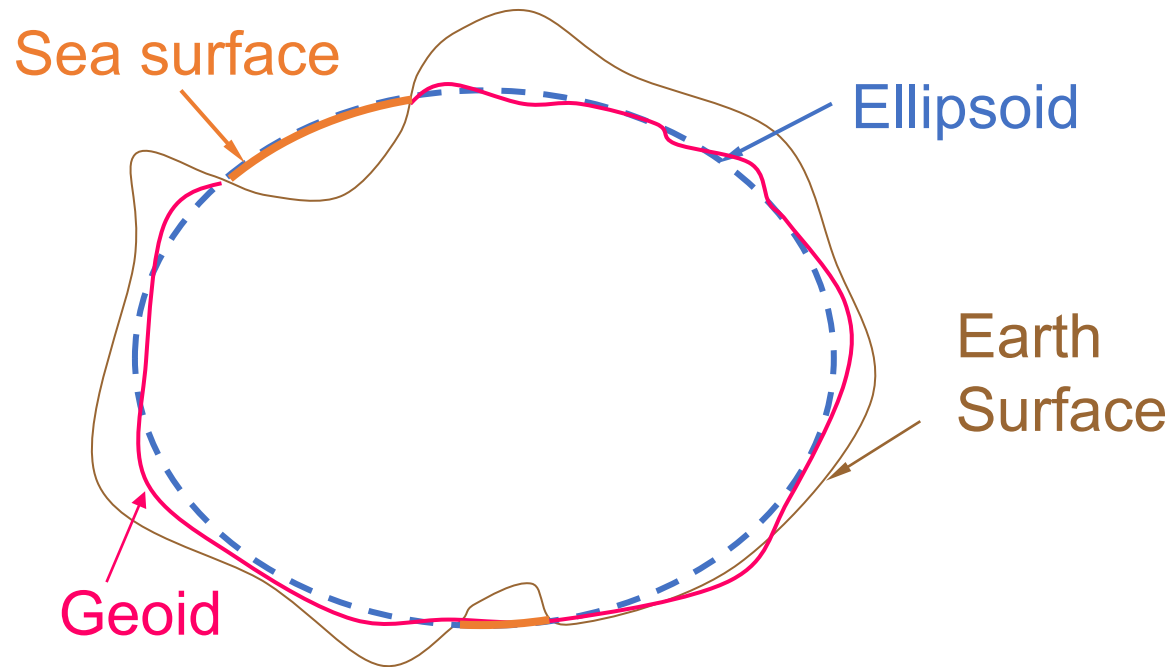
| Attributes Table |       |      |
|------------------|-------|------|
| Point ID         | model | year |
| 1                | a     | 90   |
| 2                | b     | 90   |
| 3                | b     | 80   |
| 4                | a     | 70   |
| 5                | c     | 70   |

| Coordinates Table |   |   |
|-------------------|---|---|
| Point ID          | x | y |
| 1                 | 1 | 3 |
| 2                 | 2 | 1 |
| 3                 | 4 | 1 |
| 4                 | 1 | 2 |
| 5                 | 3 | 2 |

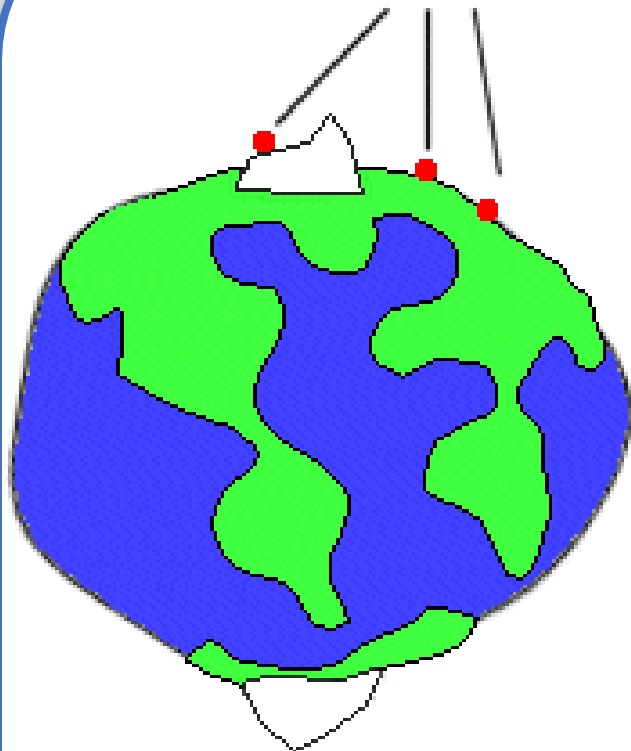
Also there is a geometry/shape definition file/table for each features.

# Shape of the Earth

- Geoid is the shape that the *surface of the oceans* would take under the influence of Earth's gravity and rotation

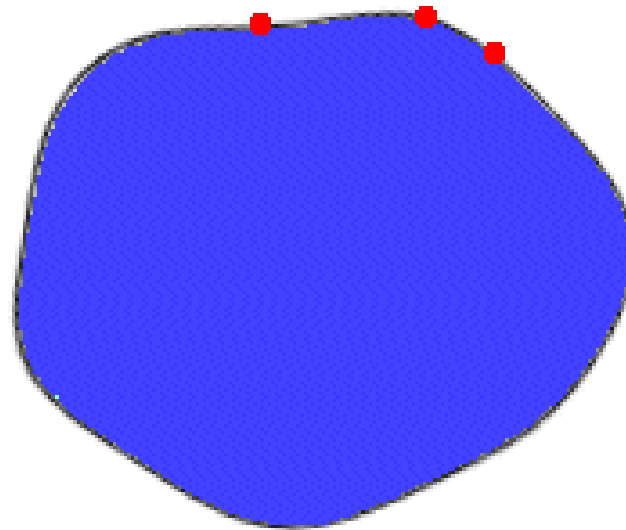


Locations measured  
on the earth...



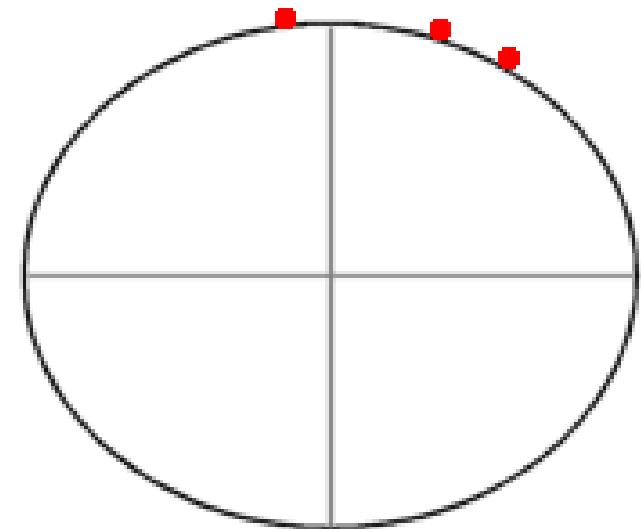
**Earth**

are leveled to the geoid...



**Geoid**  
(like earth without  
topography)

and transferred  
to the ellipsoid.



**Ellipsoid**  
(simplification  
of the geoid)

# Datum

- In geodesy, a datum is a set of reference points on the earth's surface and an associated model of the shape of the earth (reference ellipsoid) to define a Coordinate System
- **Horizontal datum:** are used for describing a point on the earth's surface, in latitude and longitude or another coordinate system
- **Vertical datum:** measure elevations or depths

# Map Projections & Coordinate Systems

## Map Projection

- Map projections in surveying are methods used to transform the spherical surface of the earth into a two-dimensional plane.
- A map projection minimizes distortions in the representation of the earth's surface

## Coordinate System

- Coordinate systems are sets of mathematical rules used to locate positions on the earth's surface.
- A coordinate system provides a consistent and standardized way to locate and measure positions



• • •

**Spatial Data can be measured/located in:**

- Angular Units — Latitude, Longitude, e.g. 56°23'4" (DMS) / 56.38° (DD)
- Linear Units — Flat Grid-based: Easting, Northing, e.g. 100025 metres / feet

**Coordinates:**

- Spherical (Angular)/Geographic Coordinate = 'Geographic' CRS e.g. Polyconic
- Cartesian (Linear)/Projected Coordinate = 'Projected' CRS e.g. UTM
- All CRS are based on a reference datum — a model of the Earth's surface/shape. This MUST be correctly defined, for any later projection (curved to flat) to work correctly.

Cylindrical

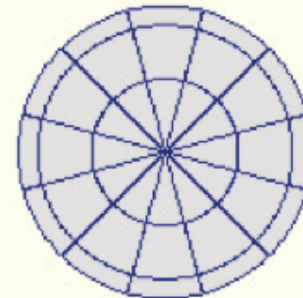
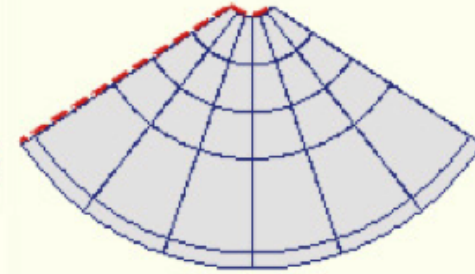
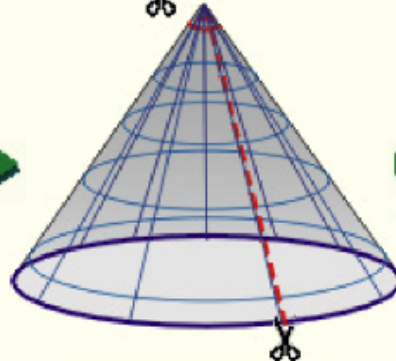
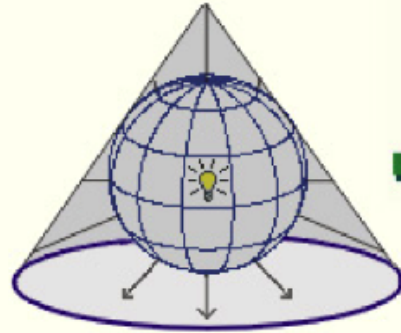
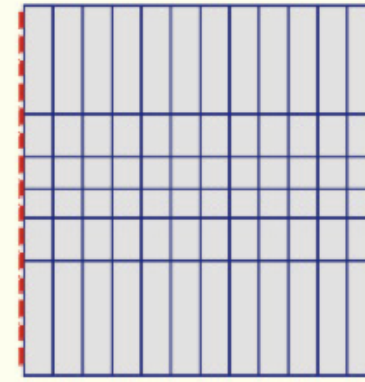
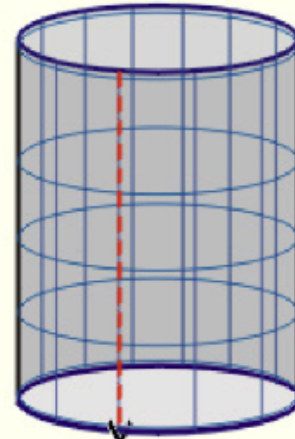
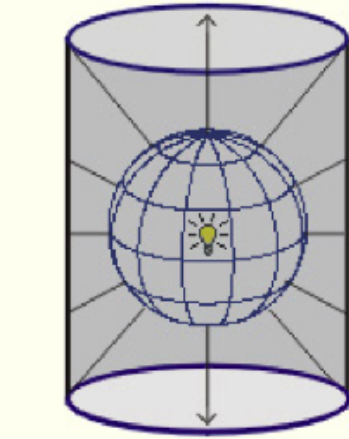
Mercator

Conical

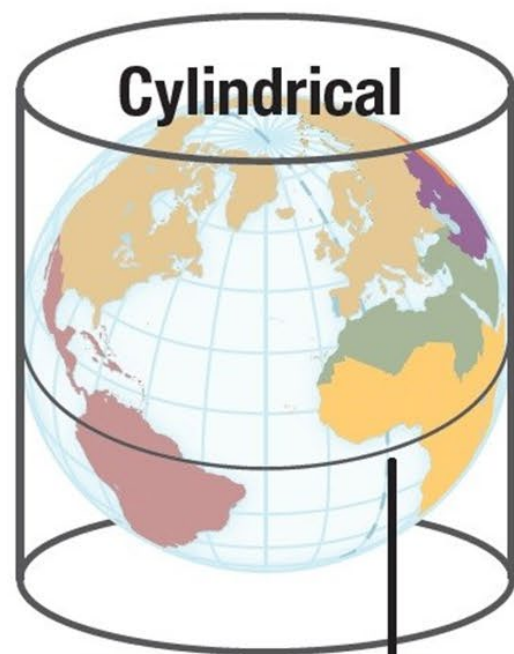
Perspective Conic

Planar

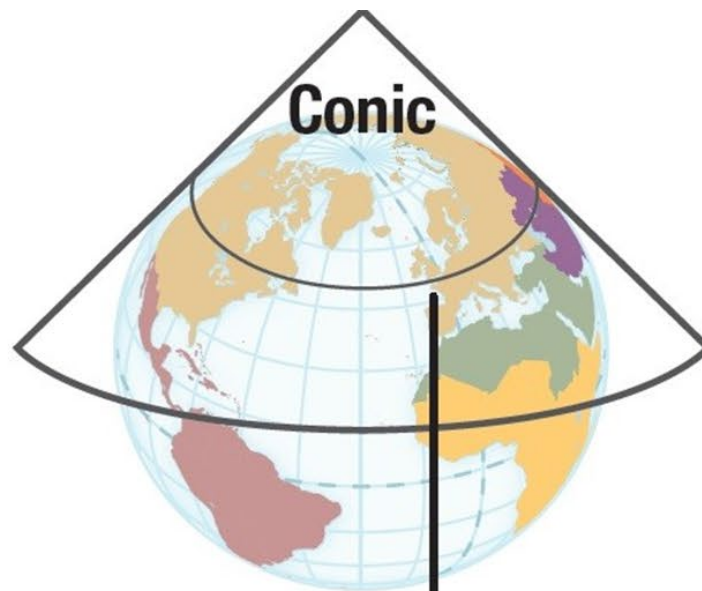
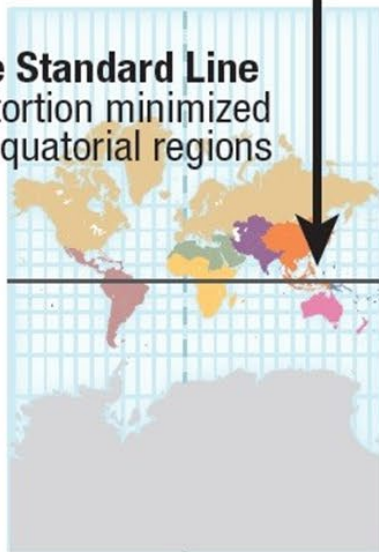
Orthographic



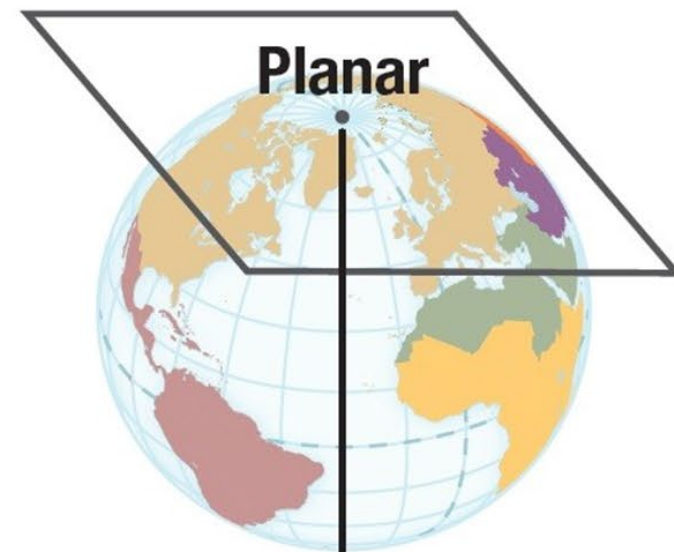
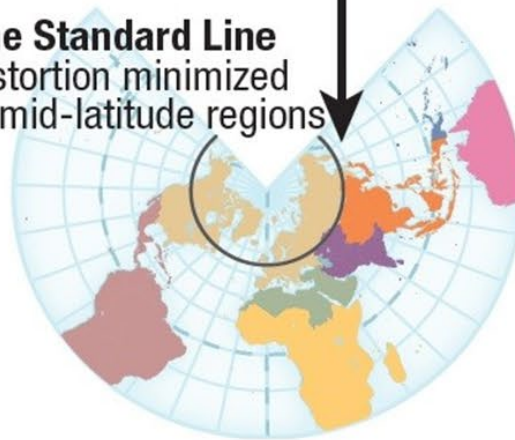
Projection Concepts  
Perspective Examples



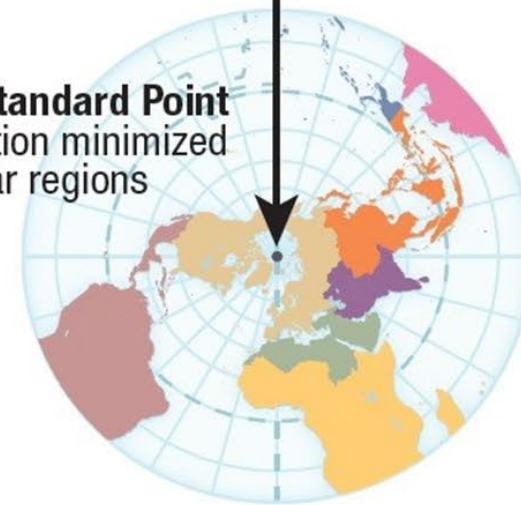
**One Standard Line**  
Distortion minimized  
at equatorial regions



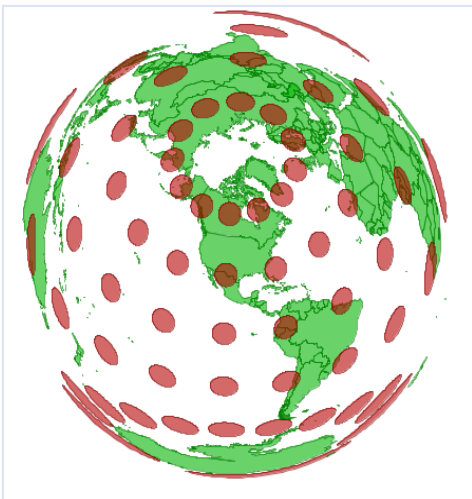
**One Standard Line**  
Distortion minimized  
at mid-latitude regions



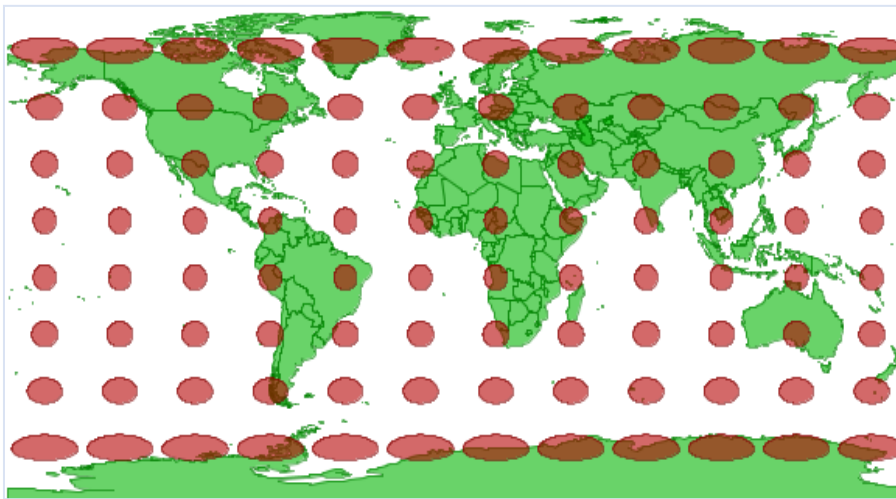
**One Standard Point**  
Distortion minimized  
at polar regions



**Globe**



**Geographic Coordinate System**



**Projected Coordinate System**

