Chapter 4

Different Methods of Data Capture

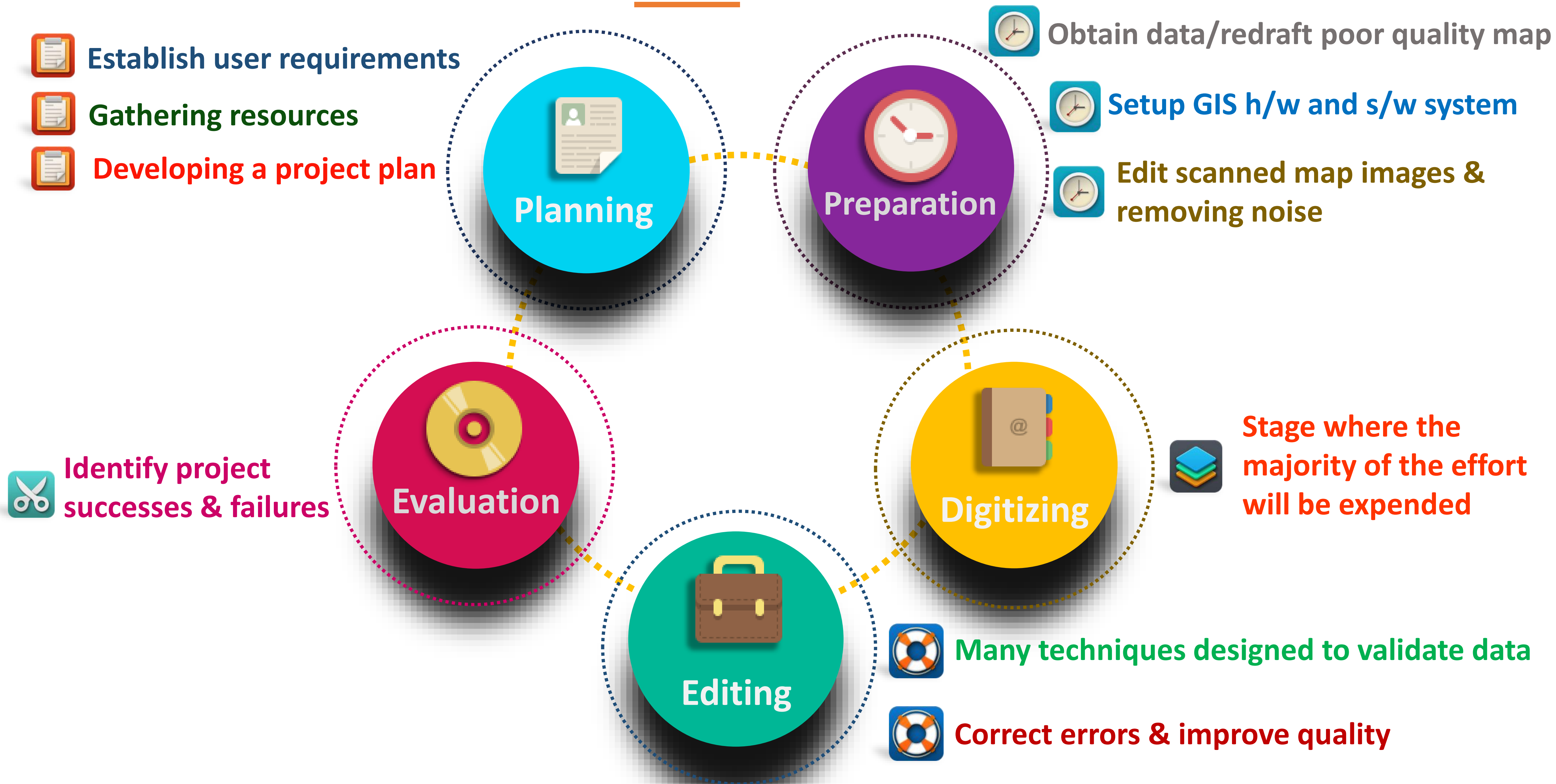
Map Projection & Spatial Reference

Data Preparation, Conversion & Integration

GPS
Remote Sensing

Quality aspects of Spatial Data

STAGES IN DATA COLLECTION PROJECTS



DATA CAPTURE METHODS

is a technique in which the information on various map attributes, facilities, assets, and organizational data are digitized and organized on a target GIS system in appropriate layers.

Two broad types of collection

1. Data capture (direct collection)
2. Data transfer

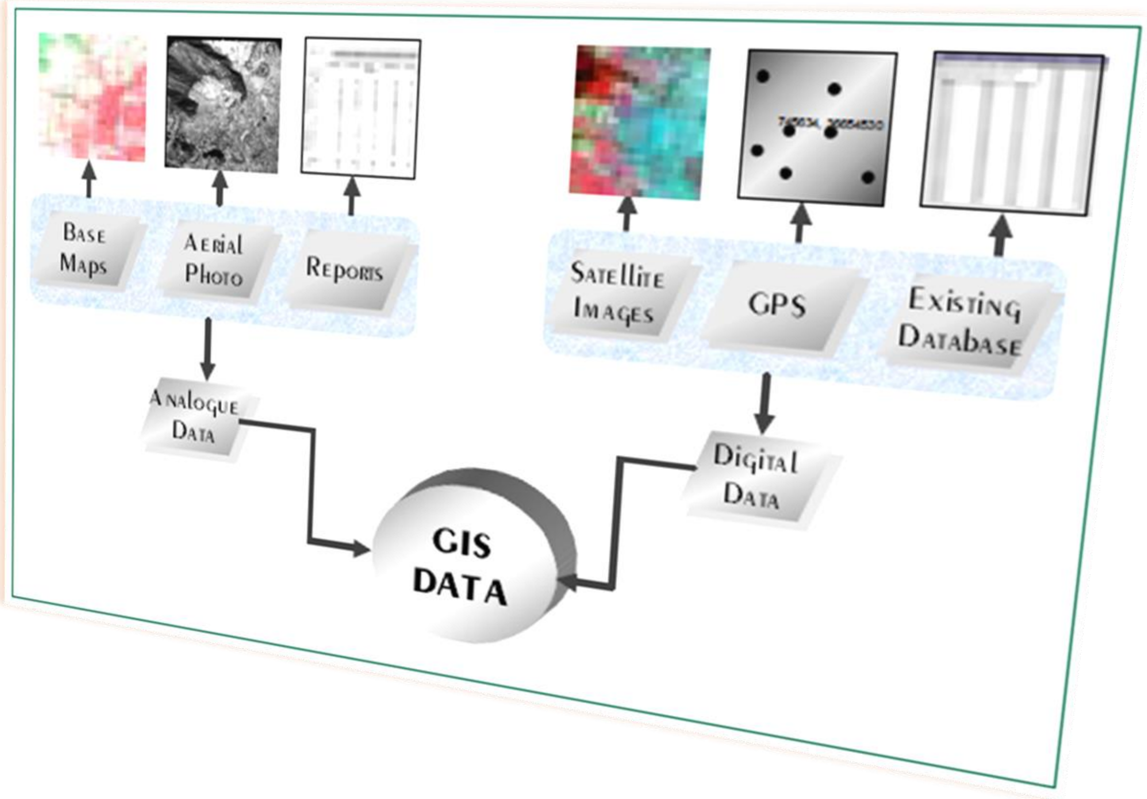
Two broad capture methods

1. Primary (direct measurement)
2. Secondary (indirect derivation)

DATA COLLECTION TECHNIQUES

	Raster	Vector
Primary	Digital Remote Sensing images	GPS measurements
	Digital aerial photographs	Survey measurements
Secondary	Scanners	Topographic surveys
	DEMs from maps	Digitizing

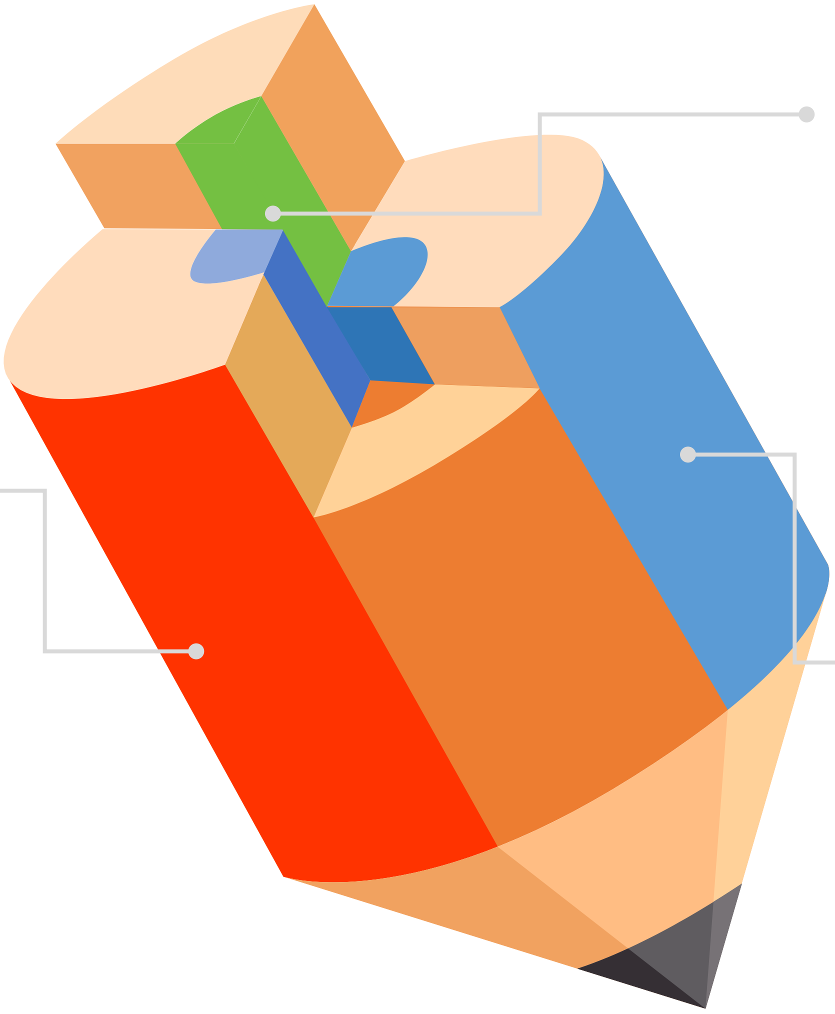
DATA COLLECTION TECHNIQUES



RASTER DATA : REMOTE SENSING

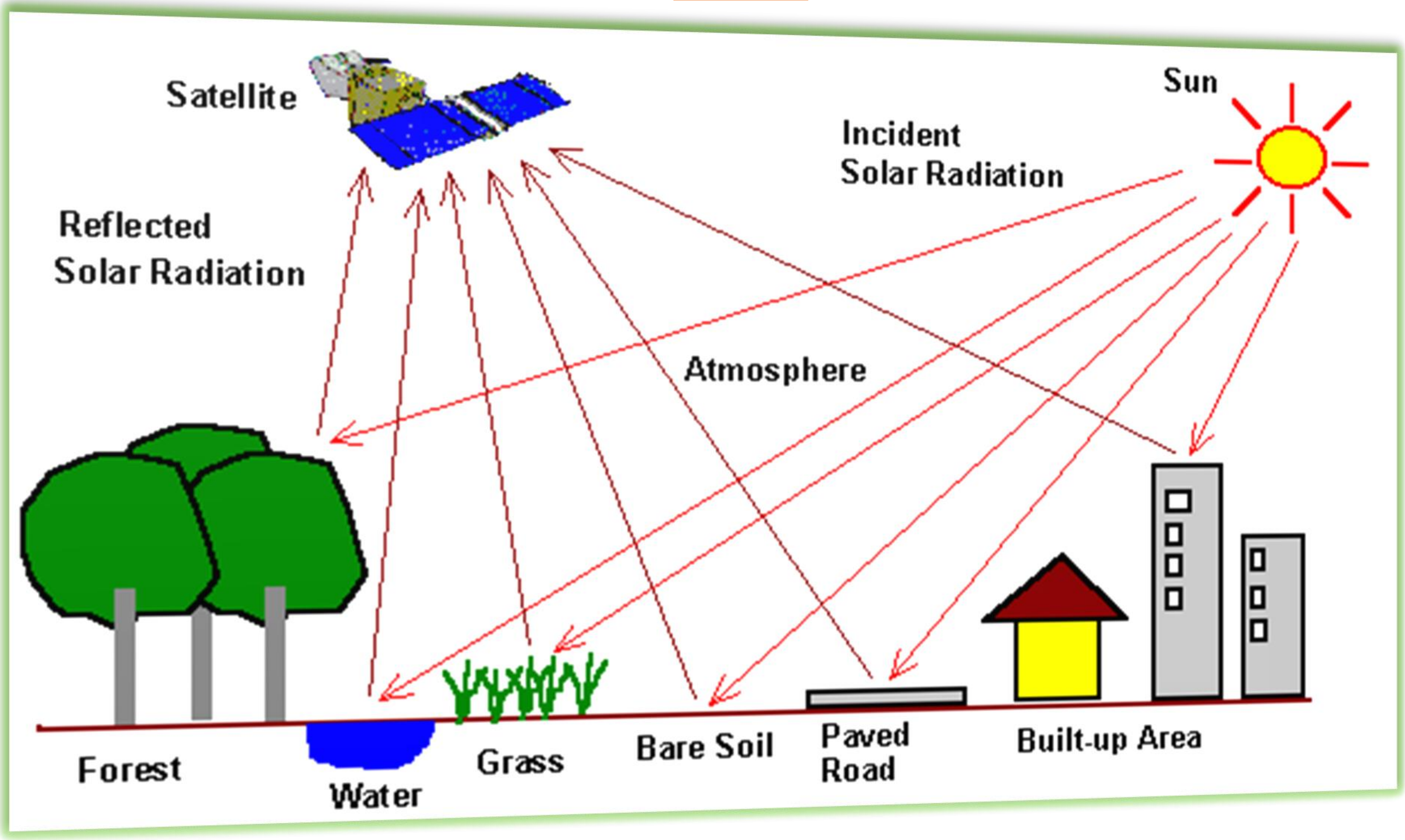
Information is derived from measurements of the amount of electromagnetic radiation reflected, emitted, or scattered from objects.

Technique used to derive information about the physical, chemical, & biological properties of objects without direct physical contact



Resolution is a key physical characteristic of remote sensing systems

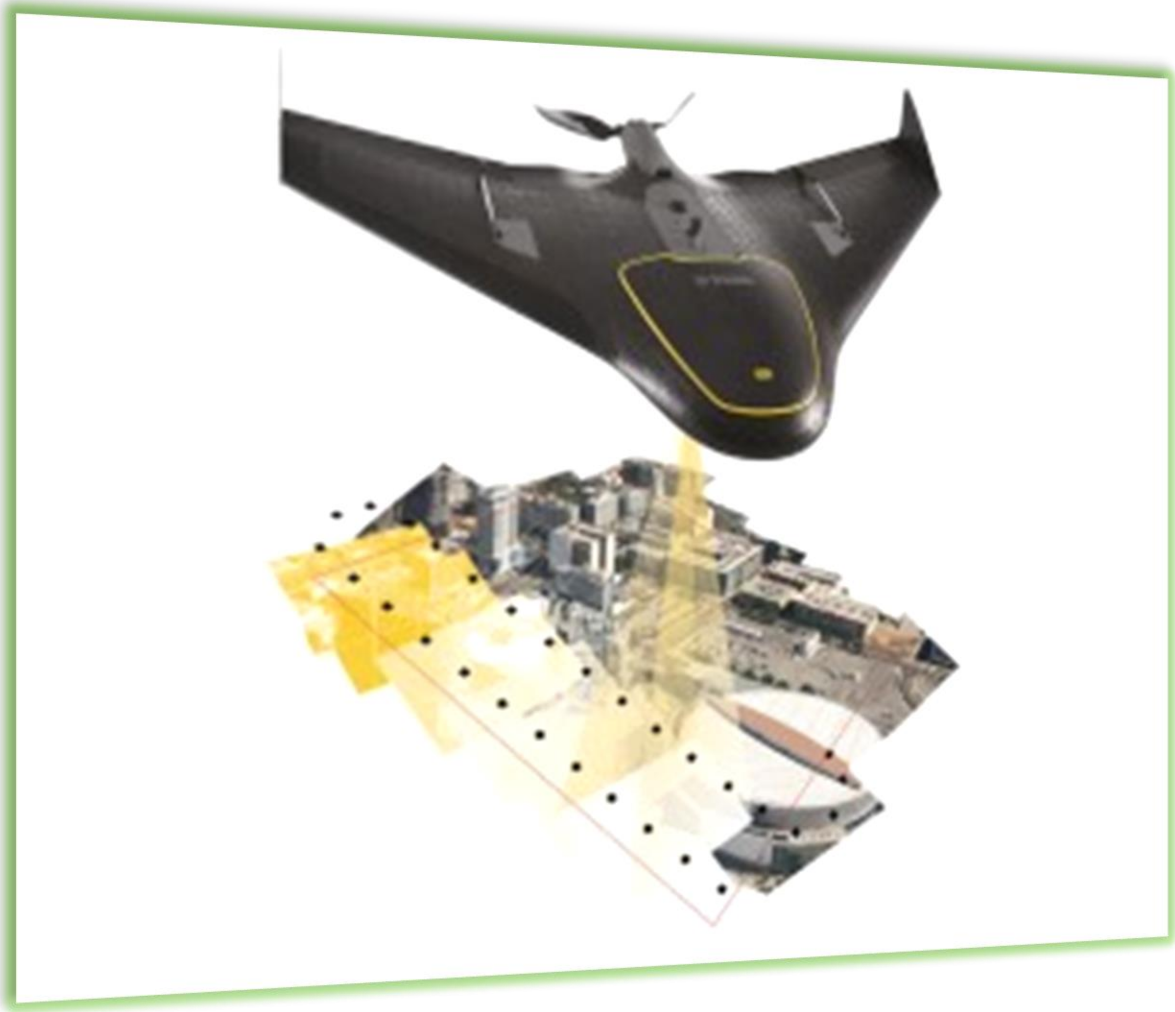
RASTER DATA : REMOTE SENSING



RASTER DATA : AERIAL PHOTOGRAPHY

- It is important in medium scale projects 01
- Collected by analog cameras & later scanned 02
- Use a stereo plotter to project overlapping aerial photos 03
- This is known as photogrammetric model 04

RASTER DATA : AERIAL PHOTOGRAPHY



RASTER DATA : AERIAL PHOTOGRAPHY

ADVANTAGES

- Consistency of the data
- Availability of systematic global coverage
- Regular repeat cycles

DISADVANTAGES

- Resolution is often too coarse
- Many sensors are restricted by cloud cover

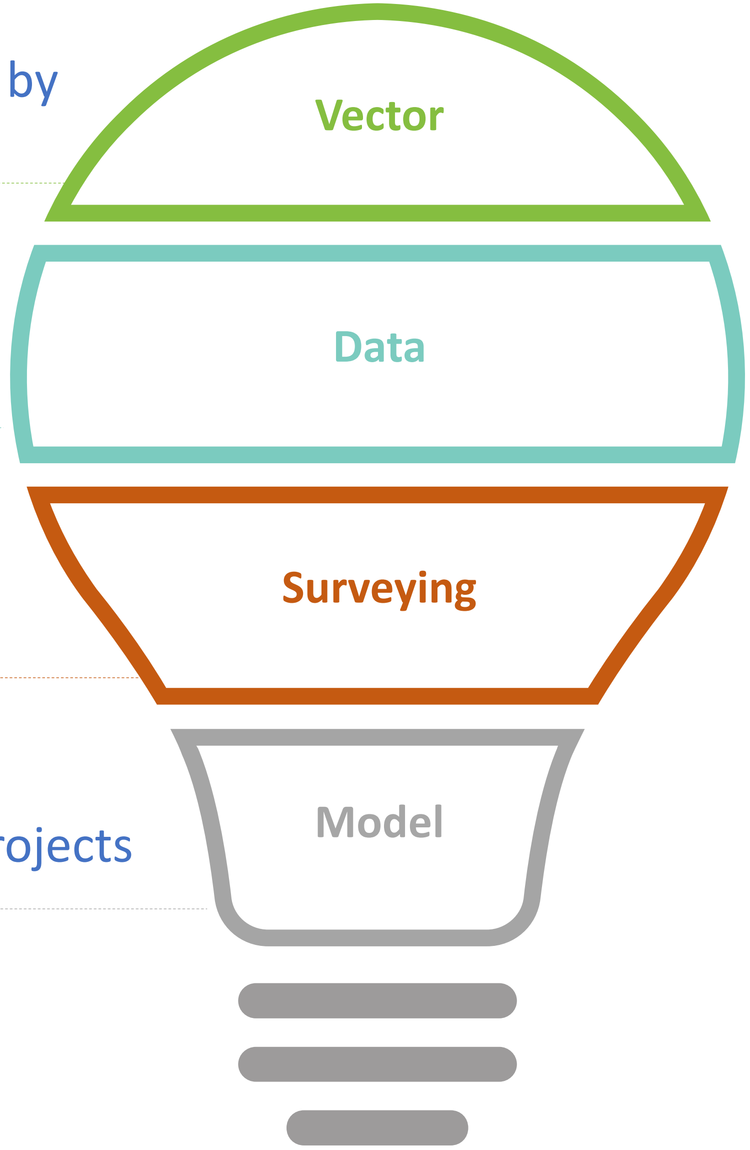
VECTOR DATA : SURVEYING

Based on the principle: 3-D location of any point can be determined by measuring angles and distances from other known points

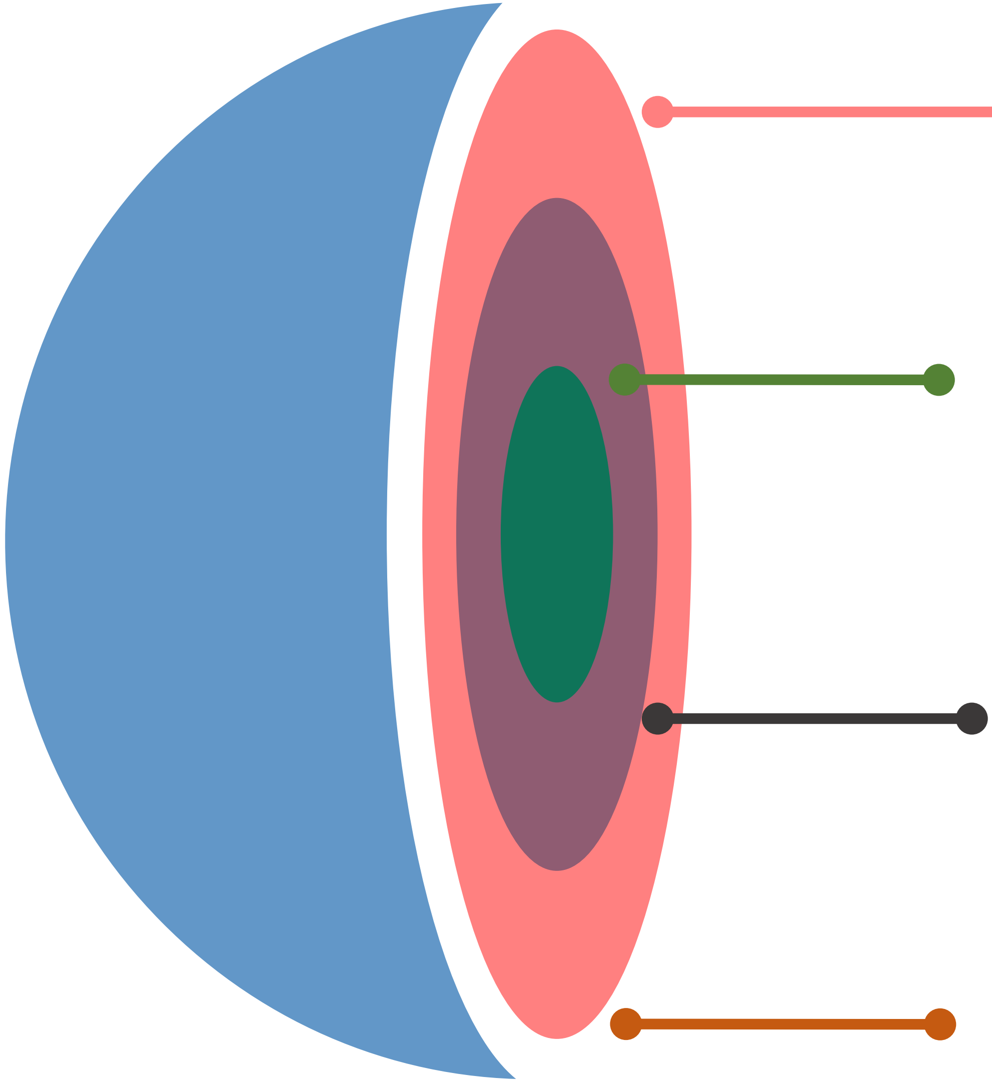
Ground survey is a very time-consuming and expensive activity

Used for capturing buildings, land and property boundaries & other objects that need to be located accurately

Also done to obtain reference marks for use in other data capture projects



VECTOR DATA : GPS



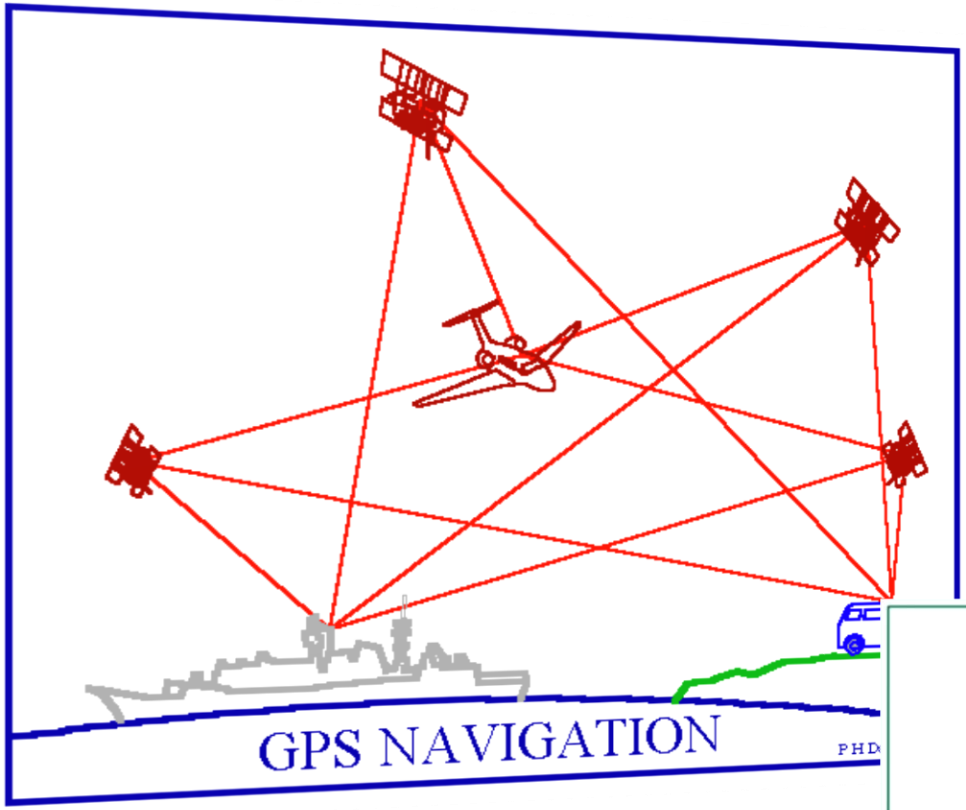
Collection of satellites used to fix locations on Earth’s surface

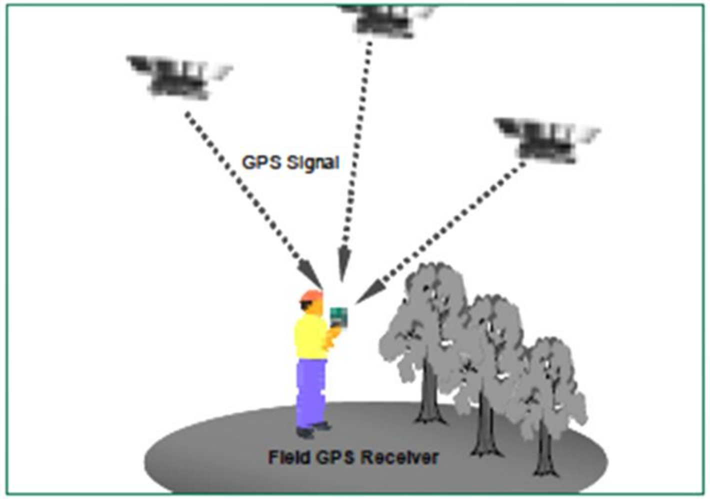
GIS mapping data capture, surveying engineering are main disciplines for GPS for precise positioning (upto mm level)

Precise positioning is possible using GPS receivers at reference locations providing corrections and relative positioning data for remote receivers

Differential GPS used to improve accuracy

VECTOR DATA : GPS





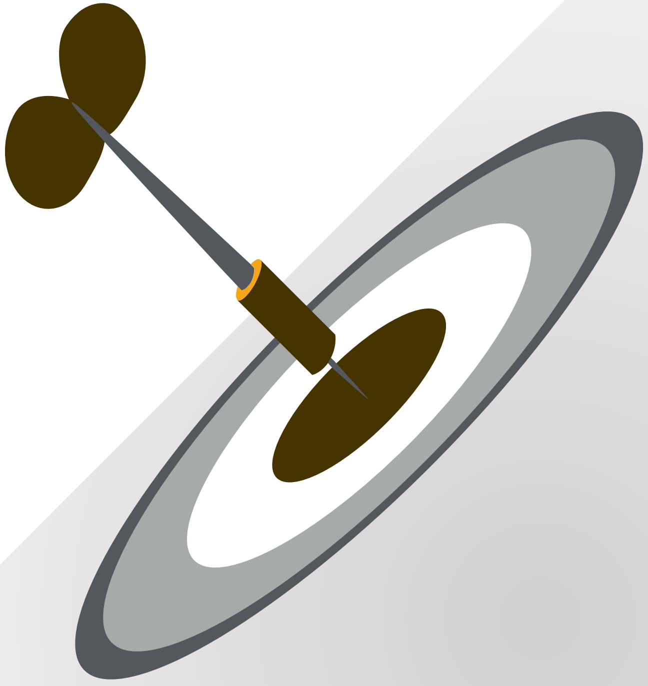
RASTER DATA : SCANNERS

scanned to reduce wear and tear, improve access, provide integrated database storage, and to index them geographically

images are scanned and georeferenced so that they provide geographic context for other data

Maps, aerial photographs and images are scanned prior to vectorization

Most scanning systems provide software to convert raster data to vector format



VECTOR DATA : DIGITIZING

Both the tablet and cursor are connected to computer that controls their functions.

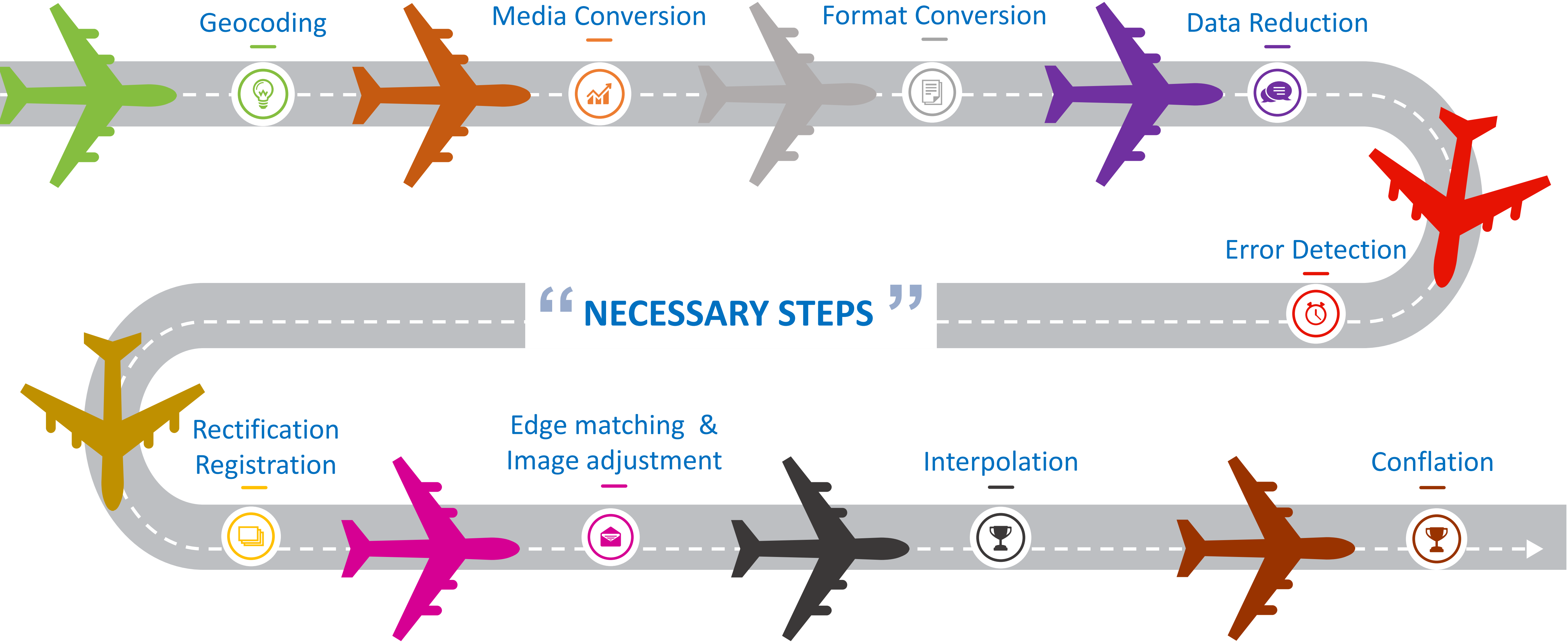
While digitizing; you may input separate features into map layers or attach an attribute to identify the feature.

Digitizing workstation with digitizing tablet & cursor is used to trace digitize.

Most digitizing tables come in standard sizes that relate to engineering drawing(A-E & larger)

VECTOR DATA : DIGITIZING

DATA PREPARATION AND INTEGRATION



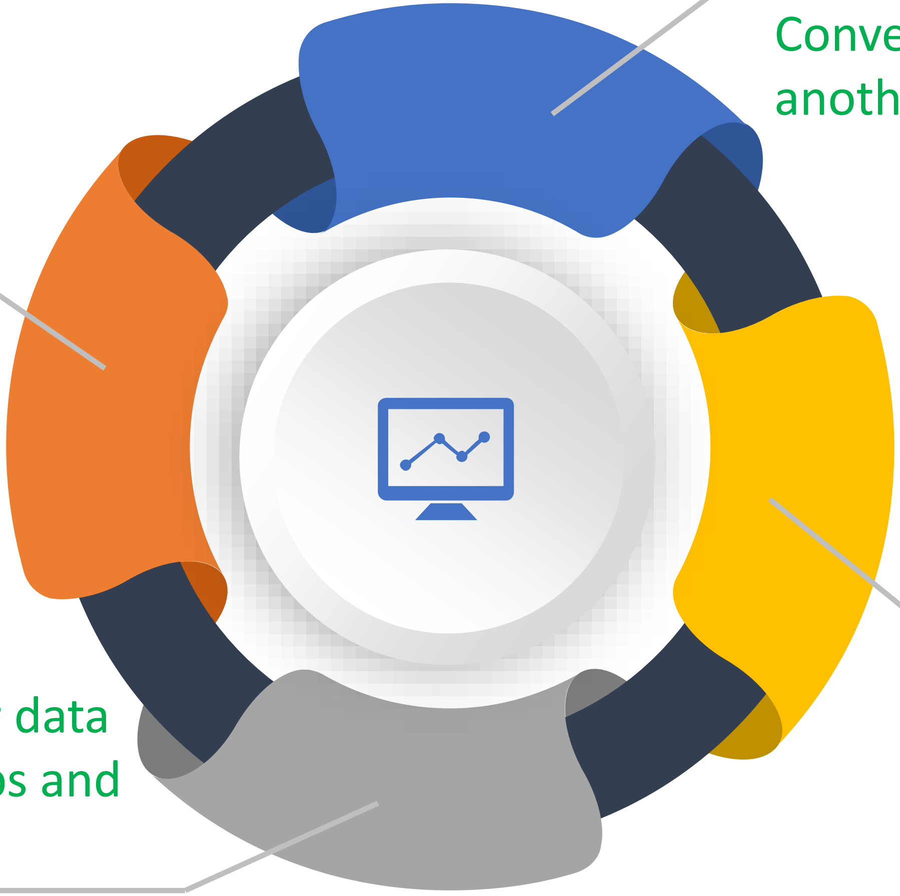
GEOCODING

- most basic form of spatial data entry
- Assigning spatial coordinates to point data
- assigns spatial coordinates (explicit location) to addresses (implicit location)
- It can also be a set of coordinates based on a local reference system, using a horizontal surface through a starting point.

MEDIA CONVERSION

Converting data from one source into another. This could be analog or digital.

Scanning and Digitizing are 2 methods for media conversion



Scanning produces “dumb” raster data & resolution depends on price

Digitizing produces vector data & are usually done in maps and aerial photo

FORMAT CONVERSION

Vector to Vector

Vector to Raster

Raster to Raster

Raster to Vector

FORMAT CONVERSION

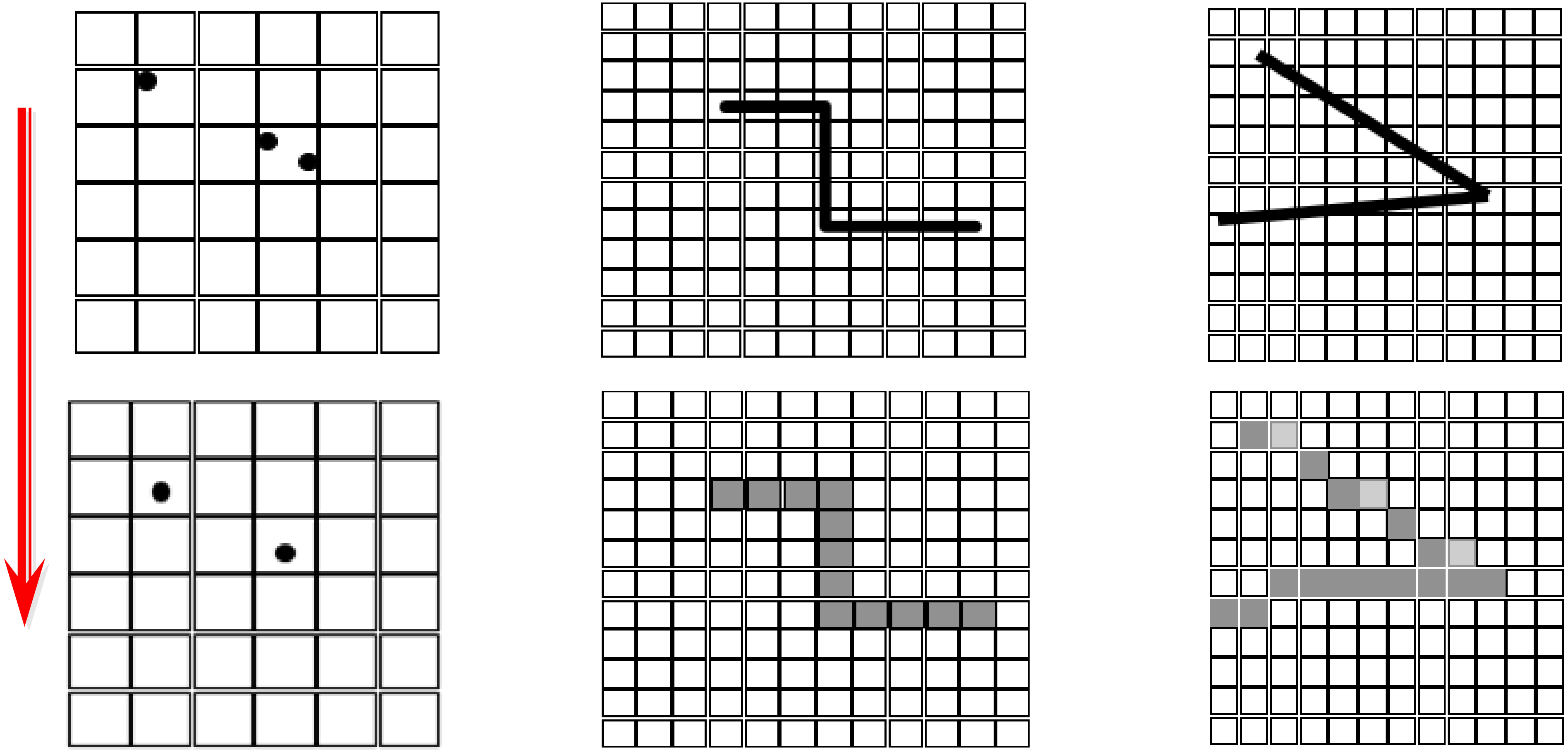
Point

Orthogonal Line

Diagonal Line
(more problemmatic)

Vector

Raster



FORMAT CONVERSION

Raster to Vector Conversion (*Skeletonizing)*

DATA REDUCTION

WHY ??

- Conserve Space
- Conserve Time

use 1 value in a single cell occupying the location of 4 original cells

use mean [interval data]

not transitive!

Resampling

'average' the 4 values in a 2by2 neighborhood

DATA REDUCTION

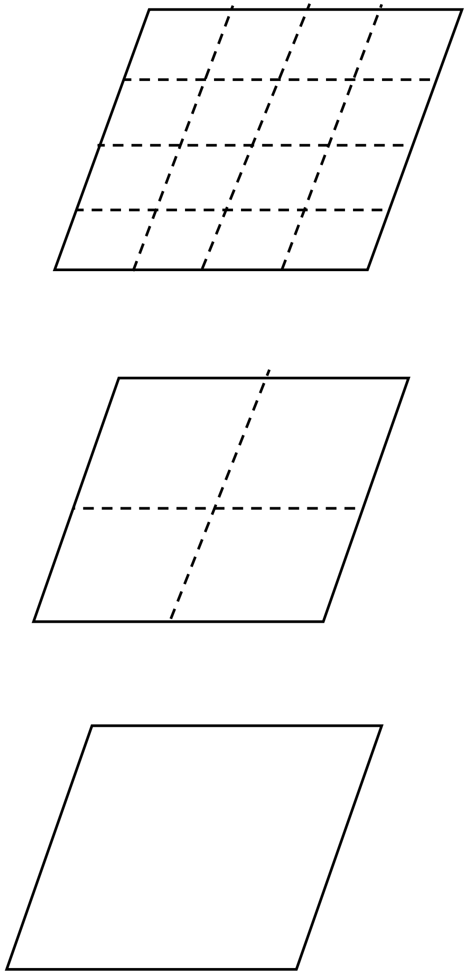
2	5	8	7
4	1	9	4
1	3	5	3
2	2	6	2

↓

3	7
2	4

↓

4



16 bytes

4 bytes

1 byte

ERROR DETECTION AND REMOVAL

WHY ??

Conserve Space

Conserve Time

Resampling

'average' the 4 values in a 2by2 neighborhood

use 1 value in a single cell occupying the location of 4 original cells

use mean [interval data]

not transitive!

ERROR DETECTION AND REMOVAL

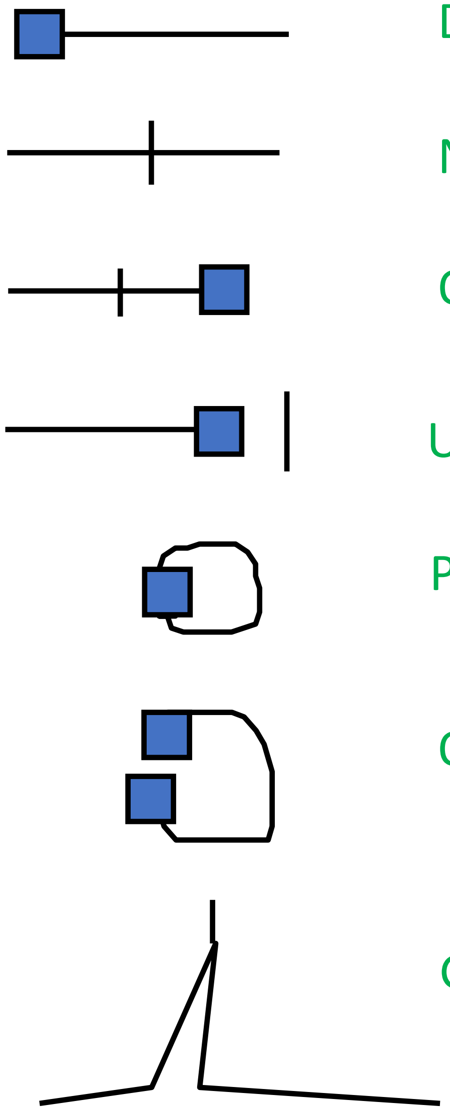
GIS packages commonly use topological structure checking to detect errors

Node Snapping used to correct errors

Snapping conducted based on tolerances – e.g. snap if within 1 foot

Care must always be taken to assure that topological “cleaning” does not itself introduce errors

ERROR DETECTION AND REMOVAL



Dangling Arc (node missing at one end)

No node at Arc Intersection (Overpass?)

Overshoot (or missing node)?

Undershoot?

Pseudo Arc (connects to itself)

Open Polygon

Gap

RECTIFICATION AND REGISTRATION

RECTIFICATION

Rearrangement of location of objects to correspond to specific reference system

REGISTRATION

Rearrangement of location of objects of one set so they correspond with those of another, without reference to a specific reference system

TWO METHODS

Homogeneous Transformation

Differential Transformation

HT: used for map projection and similar conversions

DT: used to correctly position distorted images or scanned maps

EDGE MATCHING

PROCESS

Required for Topo Map.

consistency even if features line-up visually

ISSUES

acceptable tolerance before 'further investigation' of mismatch

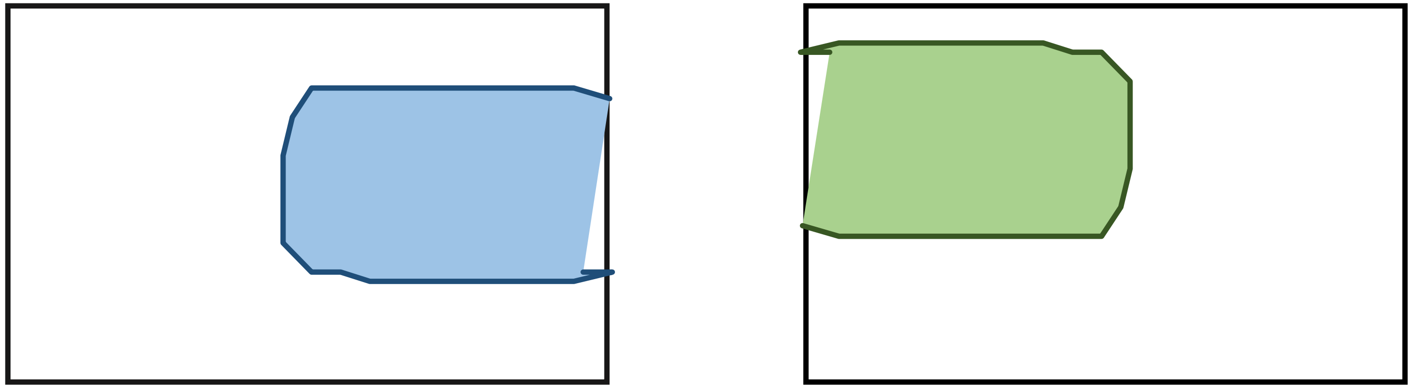
'how far back' to go on sheet(s) with adjustments for mismatch

CAUSES OF MISMATCH

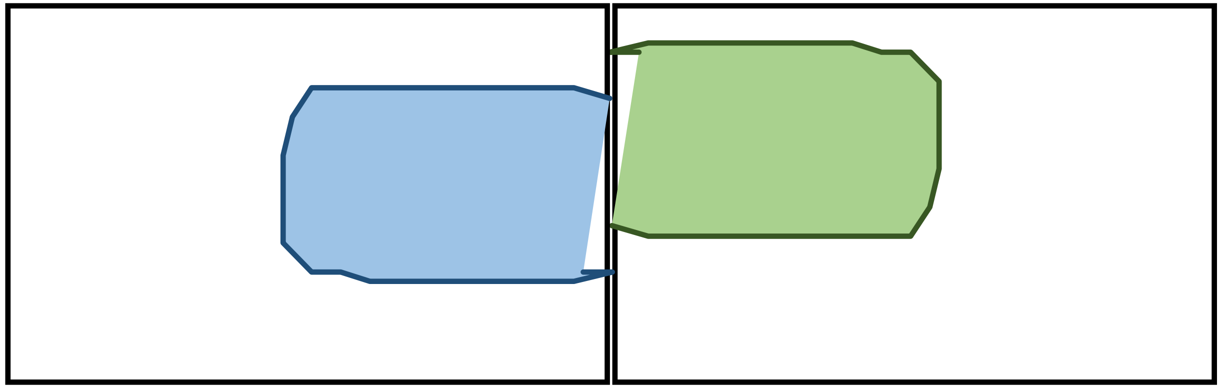
paper map shrinkage/expansion

errors from digitizing/scanning

EDGE MATCHING



Corresponding features fail to match on two sheets



Edge matching in this example would require ‘further research’

INTERPOLATION

estimating values for locations with no data based on:

known values

understanding of spatial behavior of phenomena

generally, should assign more importance to closer known values than those further away

Implemented in ArcGIS 9 via:

ArcToolbox>Spatial Analyst Tools>Interpolation

INTERPOLATION

create new master coverage from the best spatial <u>and</u> attribute qualities of two or more source coverages

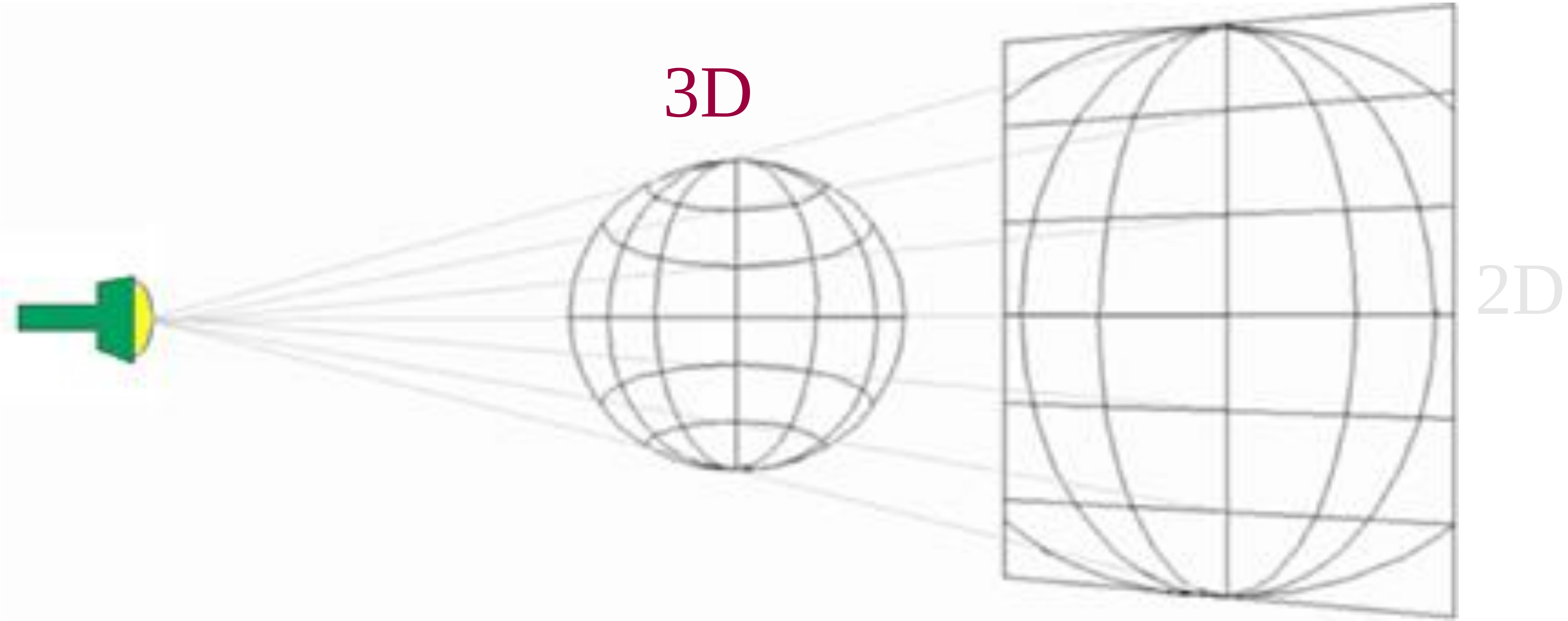
create new master coverage from quality spatial data in one source and quality attribute data in another

Depending on the situation, can require application of a variety of processing tools and can be labor intensive

ArcToolbox>Analysis Tools>Overlay>*Update*

MAP PROJECTION

This is the method by which we transform the earth's spheroid (real world) to a flat surface (abstraction), either on paper or digitally.



MAP PROJECTION

Every dataset has a coordinate system, which is used to integrate it with other geographic data layers within a common coordinate framework such as a map.

A map projection is defined by:

01 Name of Projection

02 Type of Projection

03 Description

04 Ellipsoid / Datum Parameters

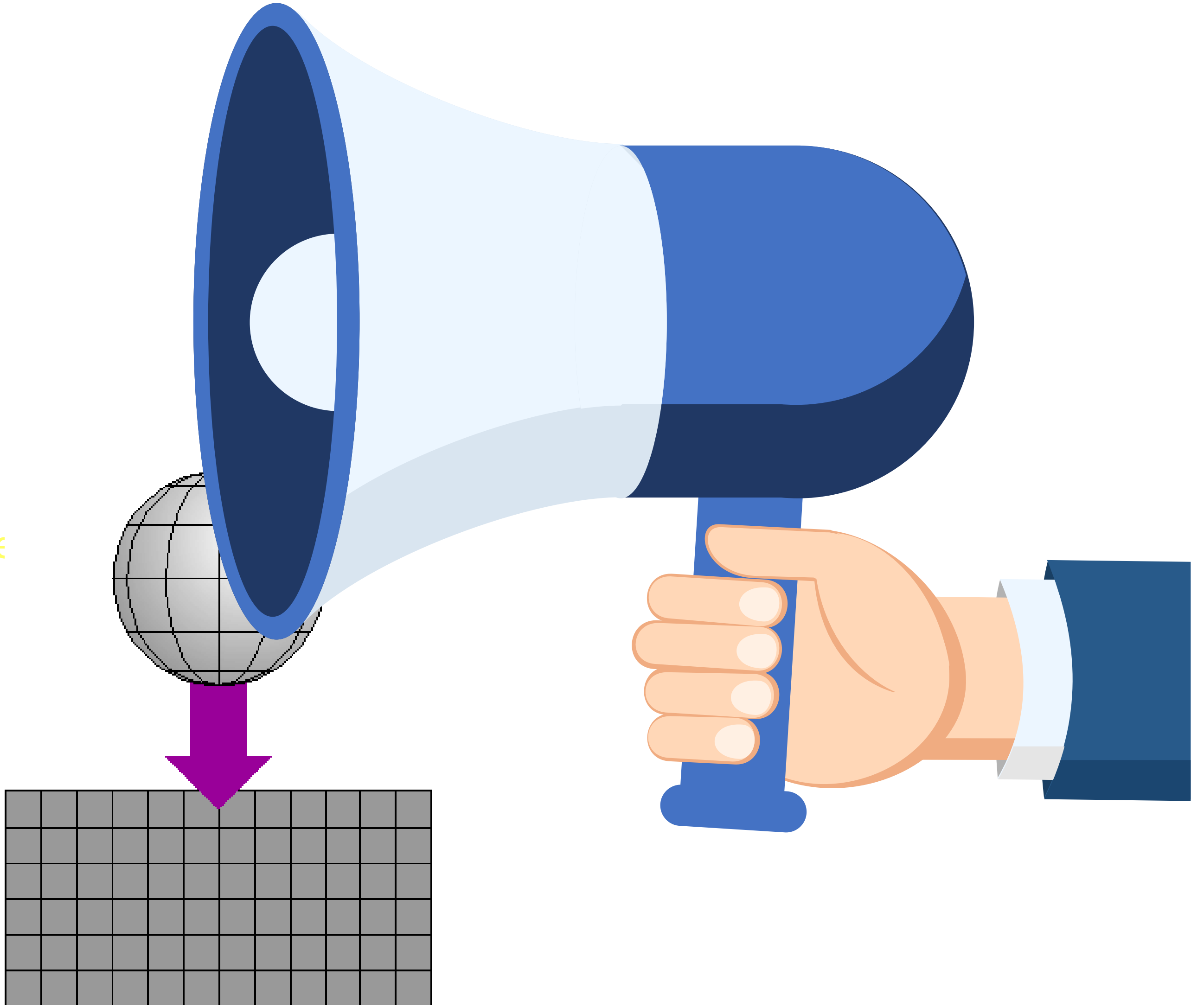
MAP PROJECTION

is a mathematical formula for representing the curved surface of the earth on a flat map.

Every projection has its own set of advantages & disadvantages.

There is no "best" projection.

Mapmakers and mathematicians have devised almost limitle ways to project the image of the globe onto a flat surface (paper).



MAP PROJECTION

Selection of a model for the shape of the Earth

usually choosing between a *sphere*, *ellipsoid*, *geoid*.

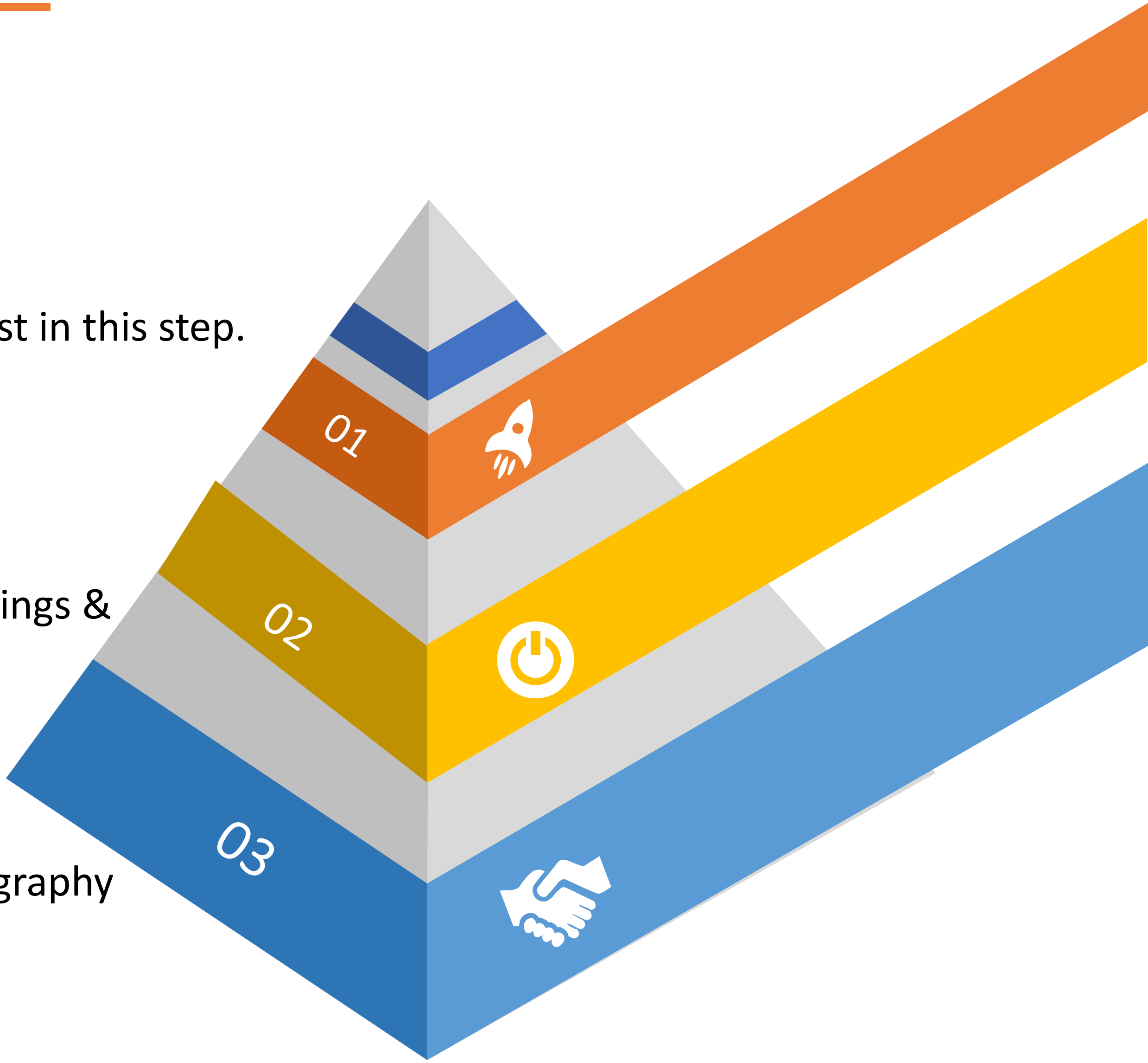
Because the Earth's actual shape is irregular, information is lost in this step.

Transformation of geographic coordinates

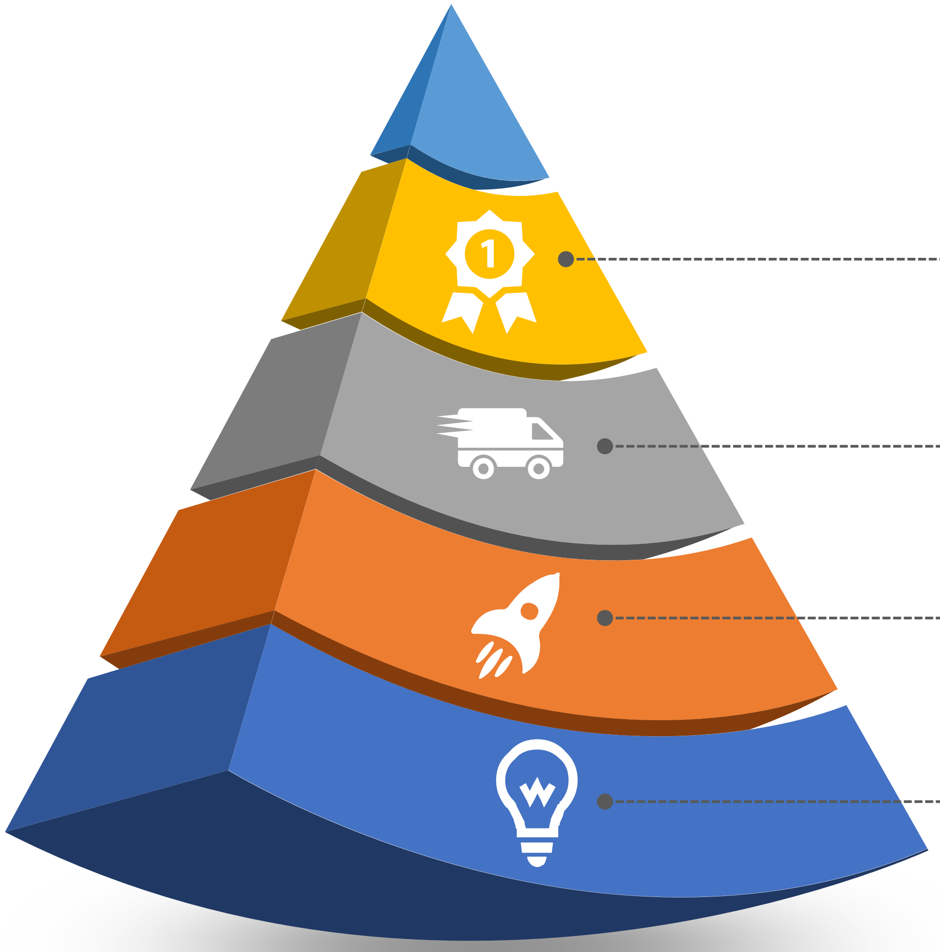
(long/lat) to Cartesian (x, y) or polar plane coordinates.
Cartesian coordinates normally have a simple relation to eastings & northings defined on a grid superimposed on the projection.

Reduce the scale

in manual cartography this step came second, in digital cartography it comes last



MAP PROJECTION: TYPES



Planisphere

whole earth is “unwrapped“ onto a plane one way or another

Azimutal

part of earth‘s surface is projected onto a plane

Conical

part of earth‘s surface is projected onto a conical shape and then flattened

Cylindrical

same thing with a cylindrical shape

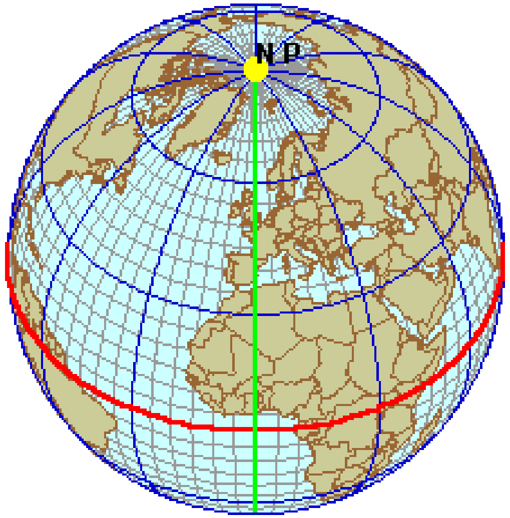
Map Projections Parameters

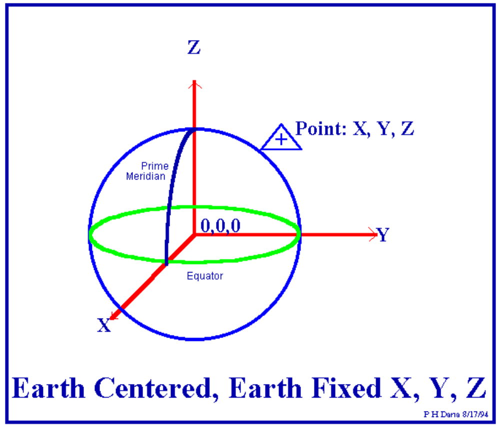
- Standard Line – line of tangency - where the projection surface meets the globe
  - ✓ No distortion at this point – increase distortion moving away
  - ✓ Standard Parallel
  - ✓ Standard Meridian
  - ✓ More than one standard line possible
- Central Line
  - ✓ Defines the center of the map projection
  - ✓ Central parallel - latitude of origin
  - ✓ Central meridian
  - ✓ Can be different from standard line

- False Easting – x- coordinate value
- False Northing – y- coordinate value

Spatial Reference

- Every spatial feature needs to be referenced to a location for GIS use.
- Spatial reference systems provide a framework to define positions on the Earth‘s surface.
- We are used to working with coordinate systems, but due to the Earth‘s irregular, spherical shape this can become intricate.





Spatial Reference Systems

- Clear definition scheme required for geodata exchange and interoperability
- This description needs to be coupled to geodata by sets of metadata
  - ✓ to permit flexible georeferenced visualization
  - ✓ to permit correct measurements
  - ✓ to permit operations between datasets based on different reference systems

Local vs global referencing

- Local coordinate systems used to be sufficient for some maps and plans:
  - ✓ local origin with no given global reference
  - ✓ mostly cartesian systems, no projection info
- Universal interoperability is only feasible within globally unequivocal reference systems
- DO NOT USE LOCAL SYSTEMS!

Coordinate systems

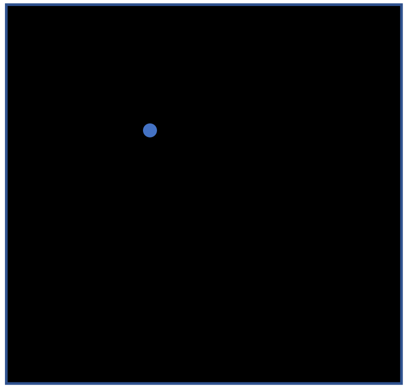
- Rules for identifying the position of each point in space by an ordered set of numbers:
- Systems:
  - ✓Cartesian: coordinate values locate a point in relation to mutually perpendicular axes
  - ✓Polar: coordinates locate a point by angular direction(s) and distance from center.
  - ✓Spherical: point on surface located by angular measurements from center (latitude, longitude)

Coordinate system

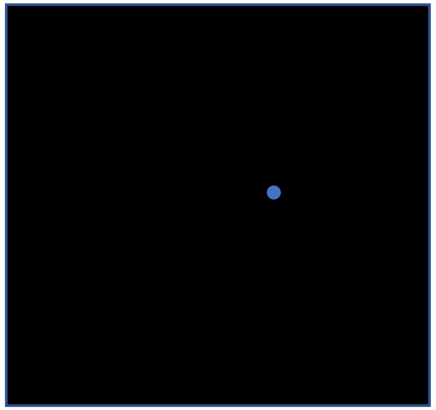
- Coordinate systems are defined by:
  - ✓number of dimensions (1, 2 or 3)
  - ✓sequence/name of coordinate values (x, y, z)
  - ✓unit scaling factor and system (meters)
  - ✓origin of axes
  - ✓direction of axes
- Coordinate systems can be based on a geodetic reference (datum) and a map projection

Direct vs. Indirect Positioning

- Two methods to position points relative to the surface of the Earth:
  - <u>direct position</u>:
    - ✓ position based on coordinates



  - <u>indirect position</u>:
    - ✓ position not using coordinates (e.g. street address)

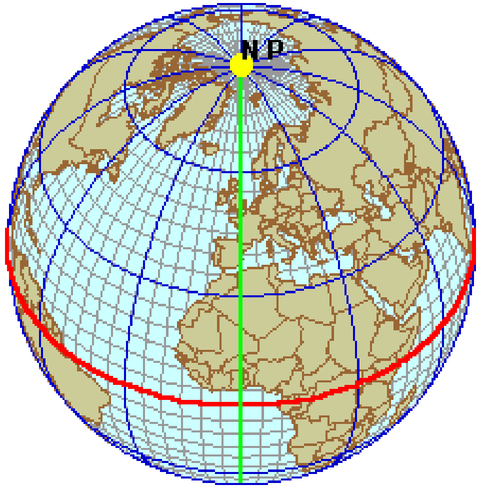


2D vs. 3D systems

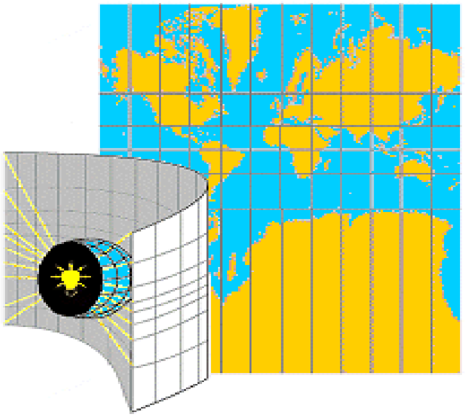
- Most GIS are 2D or 2.5D
- Many GIS operations are not defined in 3d space
- Increasingly, we need to handle 3D data, even if we don‘t fully use them
- Visualisation of 3D data sets is currently more important than analysis

Geographic vs. Projected Coordinate System

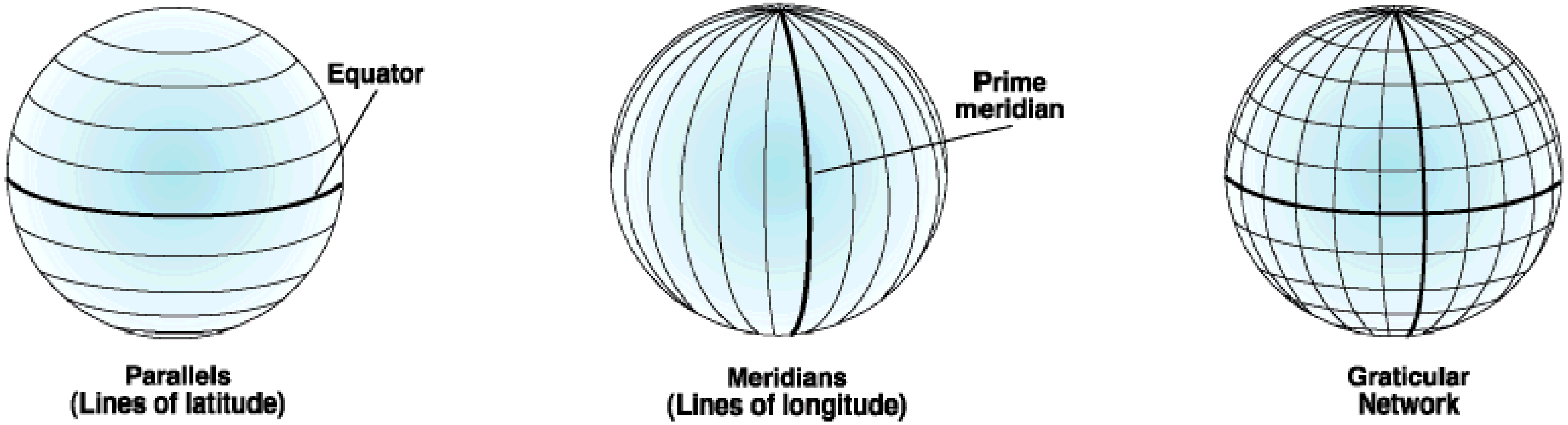
- GCS:
  - Location measured from curved surface of the earth
  - Measurement units: Lat/Lon
    - Degrees-minutes-seconds (DMS)
    - Decimal degrees (DD) or radians (rad)



- PCS:
  - Flat surface
  - Units can be in meters/feet/inches
  - Distortions will occur, except for very fine scale maps



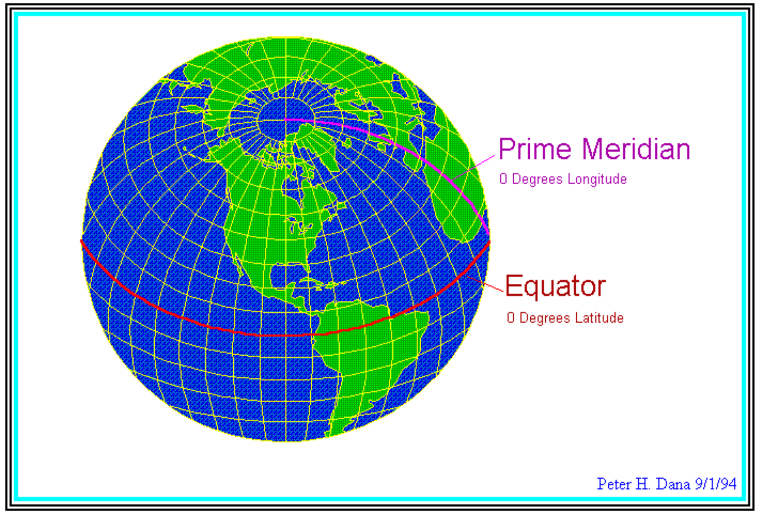
Geographic Coordinate System



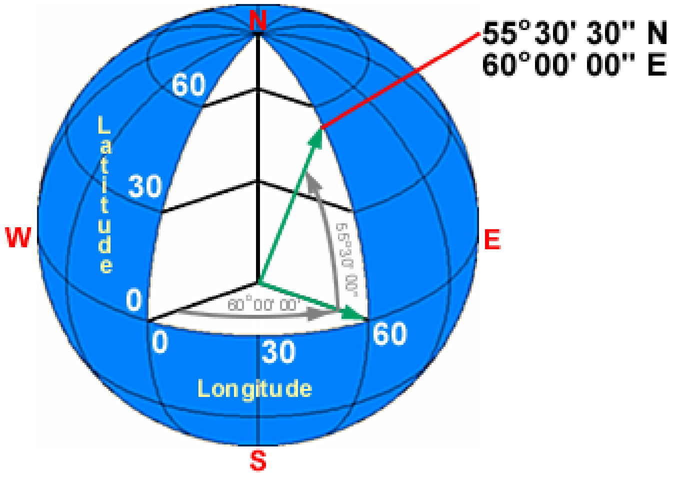
- **Parallels**: east to west – 0° at the Equator (0 °-90 °)
- **Meridians**: north to south – 0° at the Prime Meridian (0 °-180 °)
- Latitude and longitude are angular measurements made from the center of the earth to a point on the surface of the earth

Globe

- Spherical Earth's surface
  - ✓Radius 6371 km
- Meridians (lines of longitude)
  - ✓Passing through Greenwich, England as prime meridian or 0º longitude.
- Parallels (lines of latitude)
  - ✓Using equator as 0º latitude.
  - ✓Degrees-minutes-seconds (DMS),
  - ✓Decimal degrees (DD)



True direction, shape, distance, and area



Earth Surface: Ellipsoid, Geoid, Topo

- The *reference ellipsoid* surface (a map of average sea level).
- The *reference geoid* surface (a mean sea level surface).
- The real surface of the Earth (the ground) also called the topographic surface.