2-week NHP training

nrsc

Introduction to GIS

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Credits

- GIS Basics by Shahab Fazal (New Age International publishers)
- IIT, DELHI @ NPTEL: Civil Engineering – GIS in Civil Engineering
- Many internet resources like Wikipedia

Outline

- Early form of GIS: Map to Overlay
- What is GIS?
- Why GIS?
- Components of GIS
- Functions of GIS
- GIS data Models
- GIS implementation

What is GIS?

- GIS stands for Geographical Information System.

- It is defined as an integrated tool, capable of mapping, analysing, manipulating and storing geographical data in order to provide solutions to **real world problems** and help in planning for the future.

- GIS deals with *what* and *where* components of occurrences.
  - *Ex:*

    to build fly-over (what component)

    traffic jams are common (where component)

HISTORICAL SETTING AND GIS EVOLUTION

Traditional Mapping

manually drafted map

Computer Mapping

automates the cartographic process (70s)

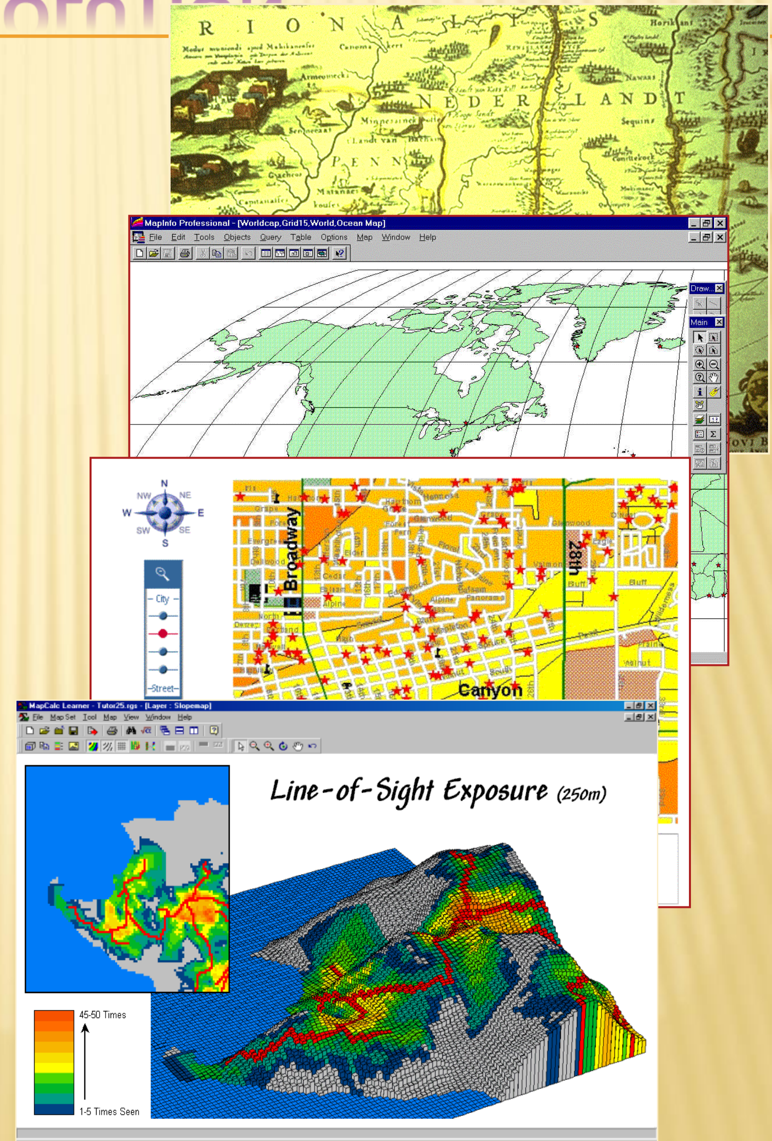
Spatial Database Management

links computer mapping techniques with traditional database capabilities (80s)

GIS Modeling

representation of relationships within and among mapped data (90s)

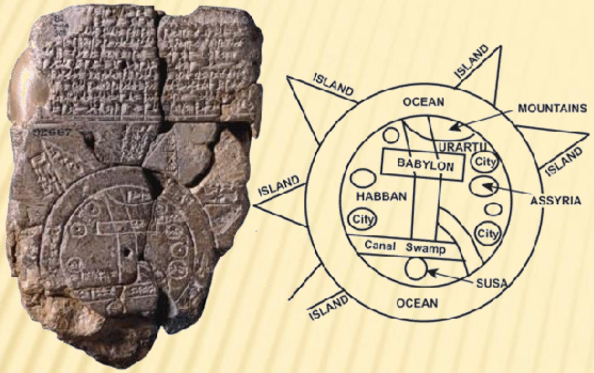
Distributed and Virtual GIS



Early days of Mapping / sketches

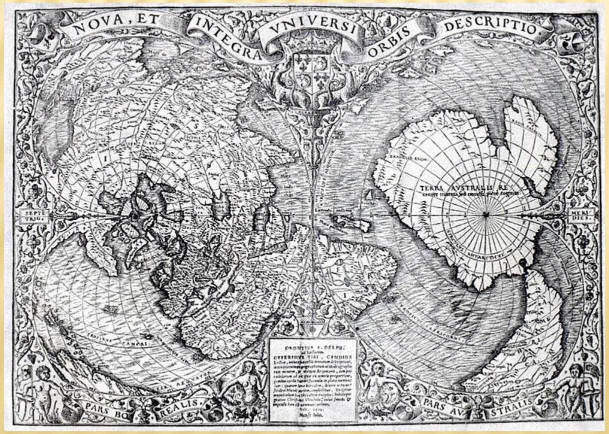
- Mapmaking is the representation of geographical information to be easily understood by common users.
- The early maps were hand drawn; in general, positions, shapes and scales for different places were not properly shown.
- Improvements in the fields of Geodesy, Surveying and Cartography helped in bringing the maps to their present form.
- The digital technology has altered the way of creating, presenting and distributing the geographic information
- The conventional cartography is replaced by computer aided designs and graphics, and the analogue maps (paper maps) by digital maps.

Early Maps



1000 BC - ** The **Babylonian Map

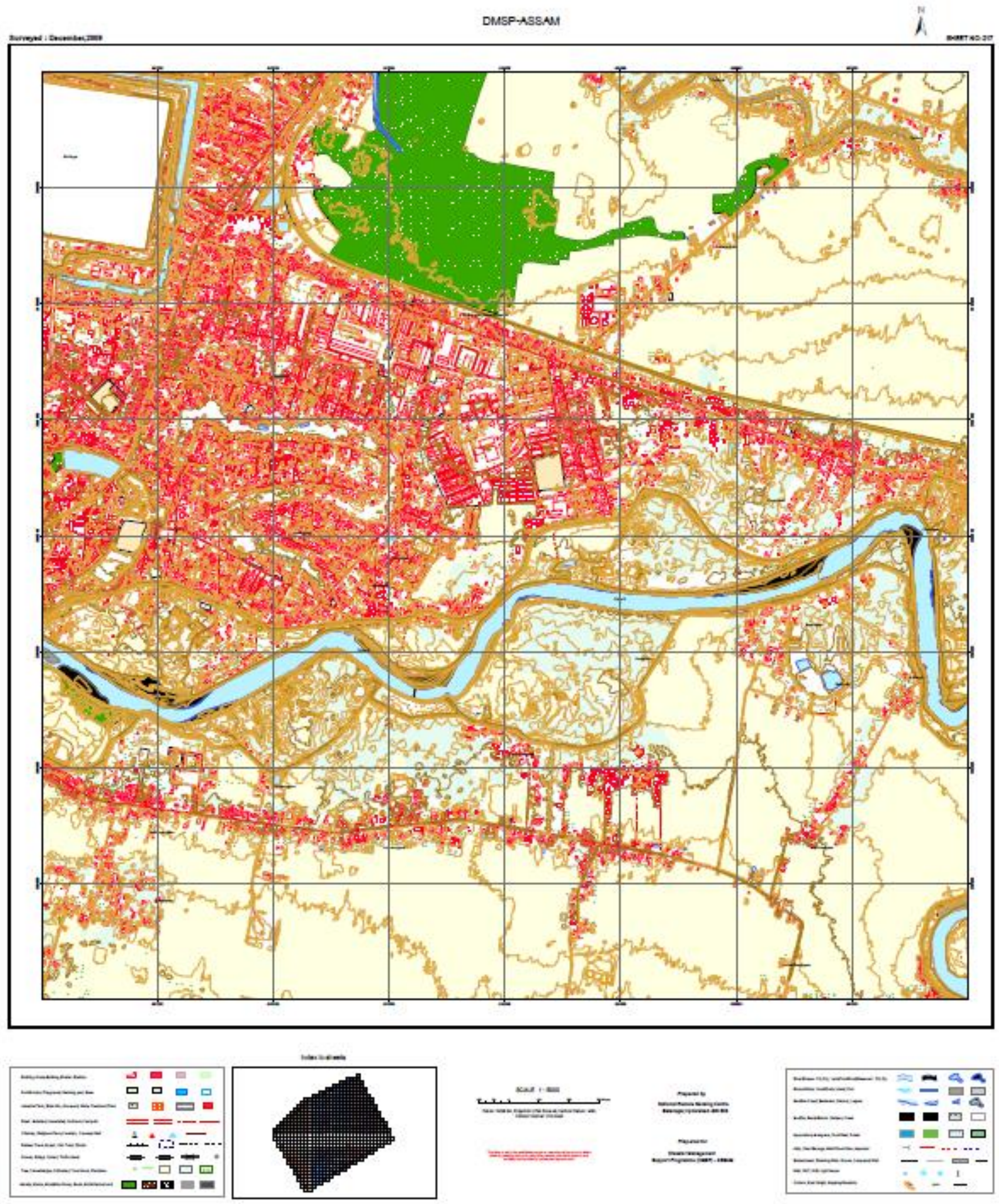
1100 AD TheTabula Rogeriana became the most **significant** source of information on the political, cultural, physical and social conditions of the territories under investigation



1500 AD - Mercator and Newton worked on projection and conformity

Maps

- Maps are models of the real world which is traditional method of storing and displaying geographic information.
- A map is a two dimensional representation of earth surface which uses graphics to convey geographical features on the landscape
- Different geographic features represented as either points, lines, and/or areas.
- Each feature is defined both by
  - Its location in space (with reference to a coordinate system), and
  - Its characteristics (attributes).
- A map portrays 3 kinds of information about geographic features.
  - Location and extent of the feature
  - Attributes (characteristics) of the feature
  - Relationship of the feature to other features.



1:5000 Scale Map of parts of Assam

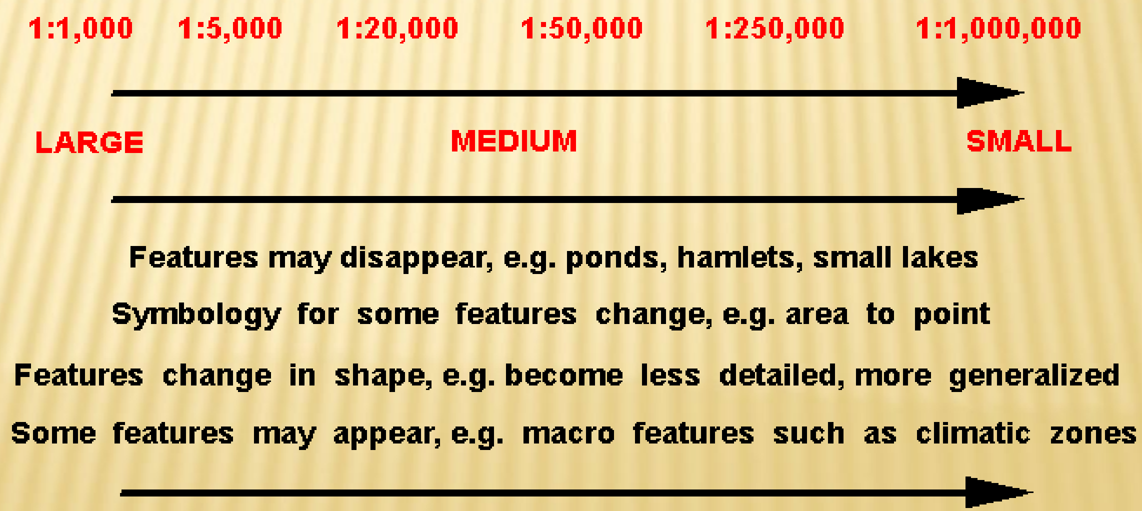
Scale of map

- Map represent snapshots of a particular day and time of the land at a specific map scale.

- Accordingly, the use of data from vastly different scales will result in many inconsistencies between the number of features and their type.

$$R.F = \frac{Distance\ between\ two\ points\ on\ the\ map}{Distance\ between\ the\ same\ two\ points\ on\ the\ ground}$$

- The use and comparison of geographic data from vastly different source scales is totally inappropriate and can lead to significant error in geographic data processing.



A portion of map showing the same area on different scales

1 : 25,000

1 : 10,000

1 : 5,000

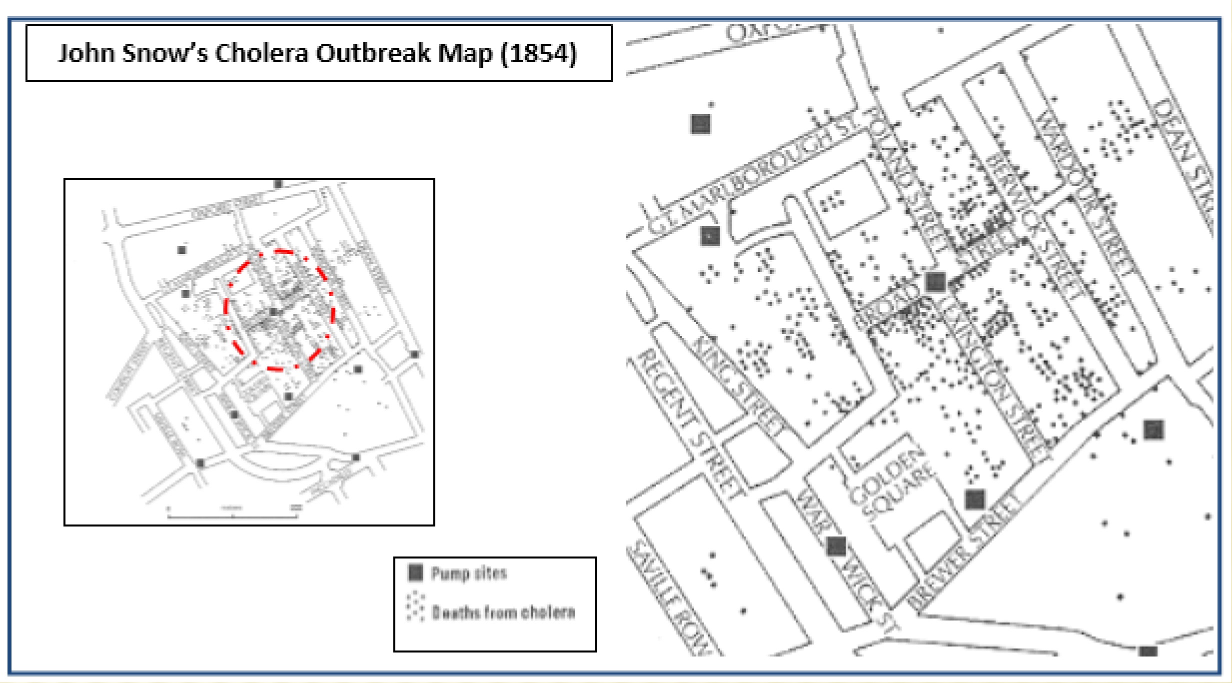
1 : 2,000

Dr.John Snow

Dr. John Snow is known as the ‘father of modern epidemiology’ and the ‘father of GIS’ because of the famous case of the 1854 Cholera outbreak in London’s Broad Street region.

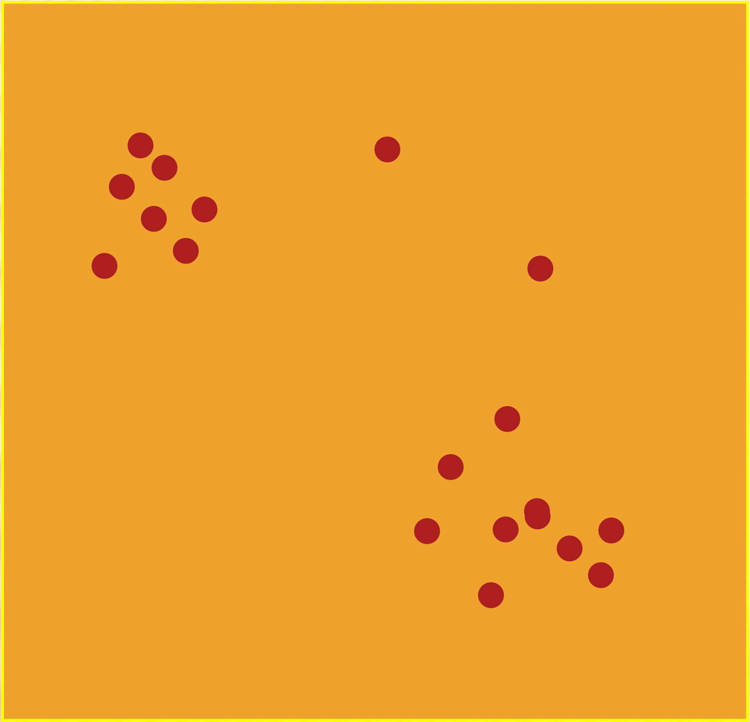
In the 1850s, cholera was very poorly understood and massive outbreaks were a common occurrence in major industrial cities. An outbreak in London in 1854 in the Soho district was typical of the time, and the deaths it caused are shown in the map.

- Dr. John Snow showed the locations of death by cholera on a map to track the source of outbreak of cholera in Central London in September, 1854.
- This is the Broad Street Pump, made famous by Snow's discovery, a possible source of the outbreak.
- Thanks to Snow's investigation, when people were no longer able to access the contaminated pump, the cholera outbreak in came to an end.
- His research helped to improve sanitation and public health around the world.

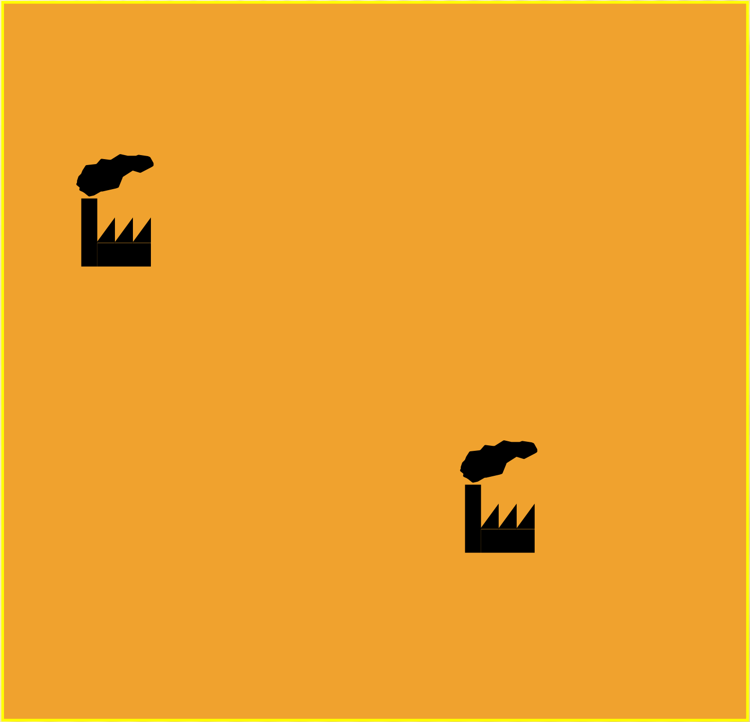


(Image source: http://healthcybermap.org/HGeo/pg1_1.htm)

COMBINING DATA SETS

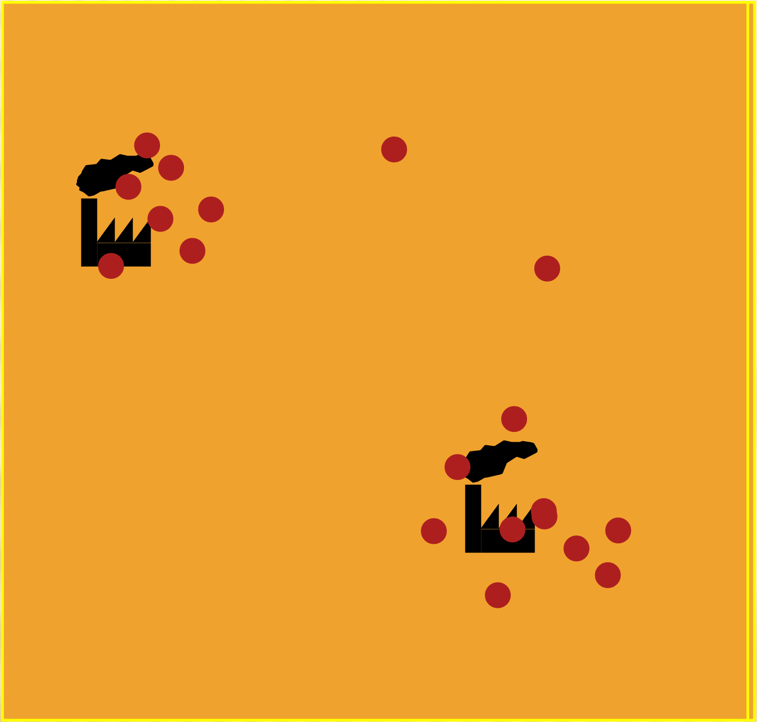


Leukemia Cases



Pollution Sources

COMBINING DATA SETS



Information about "where" allows us to combine heterogeneous data sets

Dr. *Roger Tomlinson*

- Dr. *Roger Tomlinson* (1933-2014) is generally recognized as the "father of GIS.
- *He* coined the term geographic information system (GIS) and developed the First True Operational Geographic Information System (GIS) in 1962.
- He created the first computerized geographic information system in the 1960s while working for the Canadian government—a geographic database still used today by municipalities across Canada for land planning.

Stages of GIS development

Stage	Period	Description	Characteristics
The Era of Beginning	1960 – 1975	Pioneering	• individual personalities important • mainframe-based systems dominant
The Era of Innovation	1975 – 1980	Experiment and practice	• local experimentation and action • GIS fostered by national agencies • much duplication of efforts
The Era of Commercialization	1980 – 2000	Commercial dominance	• increasing range of vendors • workstation and PC systems becoming common • emergence of GIS consultancies
The Era of Exploitation	2000 onwards	User dominance Vendor competition	• embryonic standardization • increasing use of PC and networked systems • systems available for all hardware platforms • internet mapping launched

Source: *Adopted from Heywood, Cornelius and Carver, 2004.*

What is GIS?

"Geographic Information System"

- **A Technological tool**
- **A Geospatial information handling strategy**

The objective is

"to improve overall decision making".

General questions with Geographical Data

Every day people pose questions

- Where is GURGAON ?
- What are the soil characteristics there ?
- What is the land use pattern in Gurgaon District ?
- Which is the main economic activity in Gurgaon District ?
- What are the trends in rural and urban employment pattern in Gurgaon District ?
- Where would be a better location for opening a restaurant in Gurgaon District ?
- Which is the shortest route to reach Gurgaon from New Delhi railway station?

Almost everything that happens or exists occurs 'somewhere'. Knowing 'where' it happened or existed is critically important.

All human activities require knowledge about the Earth, thus geographic location is very important.

GIS …

A *GIS* does not hold maps or pictures. Map is one of the inputs.

It holds a database

from which the data can be displayed in a variety of views.

Defining (GIS)

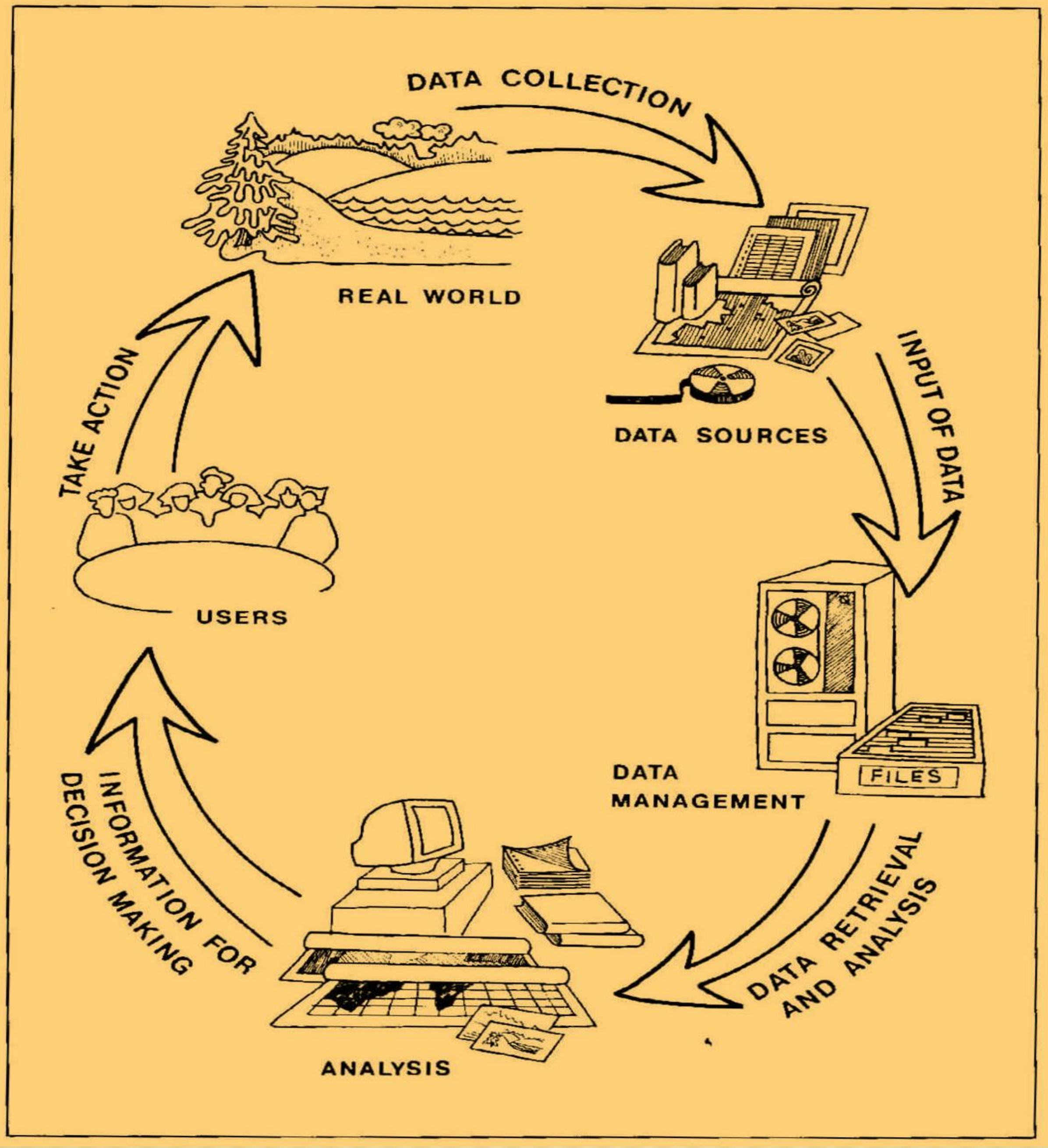
- **The *common ground* between information processing and the many fields using spatial analysis techniques. (Tomlinson, 1972)**

- **A powerful *set of tools* for collecting, storing, retrieving, transforming, and displaying spatial data from the real world. (Burroughs, 1986)**

- **A computerized *database management system* for the capture, storage, retrieval, analysis and display of spatial (locationally defined) data. (NCGIA, 1987)**

- **A *decision support system* involving the *integration* of spatially referenced data in a problem solving environment. (Cowen, 1988)**

The *National Center for Geographic Information and Analysis* (**NCGIA**) is an independent research consortium dedicated to basic research and education in geographic

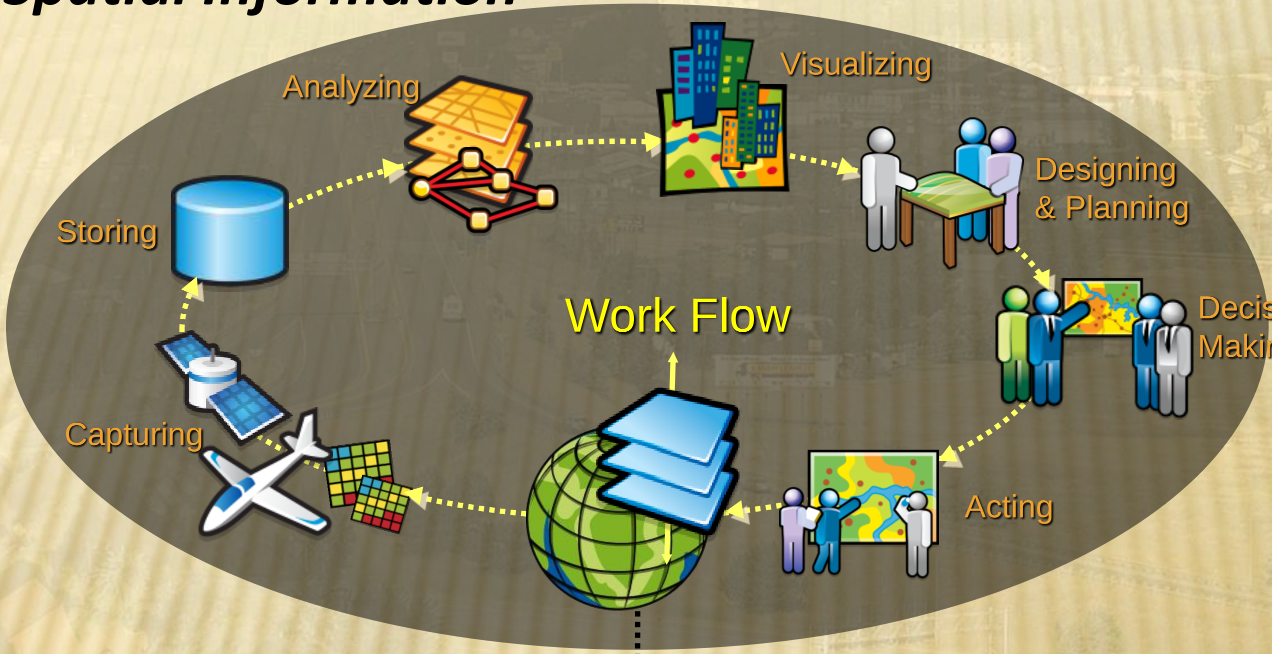


Adapted from Aronoff, 1995

GIS begins and ends with the real world.

GIS IS…

Software and Workflows that Enable Public Works to Benefit from Spatial Information



. . . ***Improving the Way You Do Things***

GIS IS…

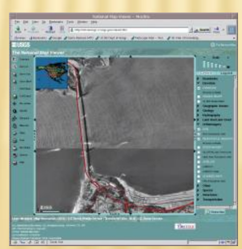
Geographic Information System (GIS) is a computer based information system designed to accept large volumes of spatial data derived from variety of sources and to efficiently store, retrieve, analyse, model and display (output) these data according to user defined specifications

GEOGRAPHIC PRIMITIVE

May or may not

Many objects related to time

$$G = F(x, y, z, f(t))$$



GIS …

Data → Information

Data – numbers, text, symbols

- Sea surface temperature, soil type, population density

Information – differentiated from data

- implying some degree of selection, organization, and preparation for particular purpose, or
- data given some degree of interpretation

Geographic Information

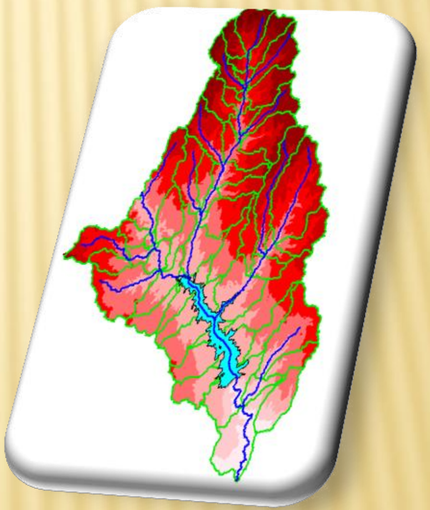
(map, digital form)

- Information about places on Earth's surface
  - *Geographic* versus *spatial*
    - *Geographic* refers to Earth's surface and near surface
    - *Spatial* refers to any space (more general)
- Knowledge about *where* something is
- Knowledge about *what* is at a given location

- Can be very detailed or very course
- Can be relatively static or change rapidly
- Can be very sparse or voluminous

An integrated view

Layers are integrated using explicit location on the earth's surface, *thus geographic location is the organizing principal*.

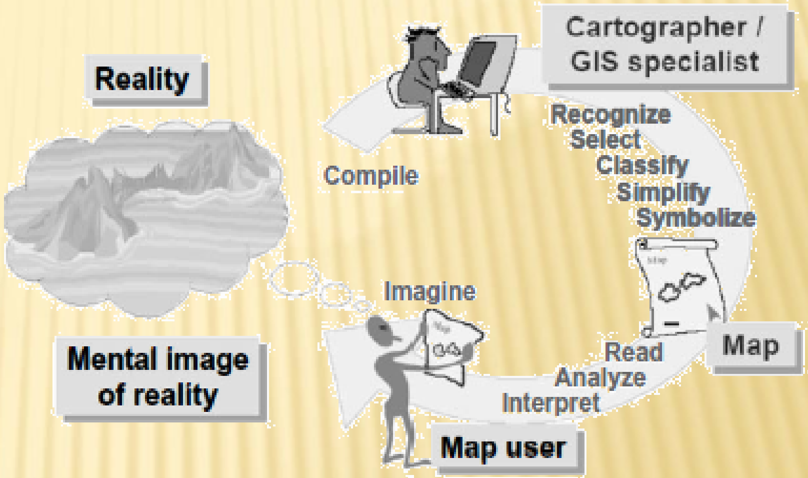


HOW GIS IS DIFFERENT ?

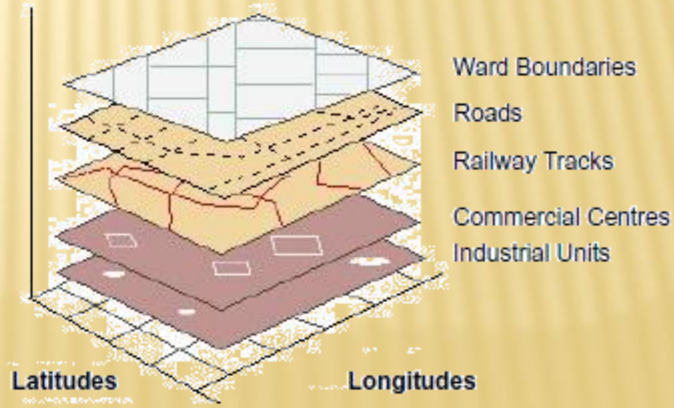
- All information in a GIS is linked to a spatial reference i.e. uses geo-references as the primary means of storing and accessing information.

- GIS comprehensively integrates technology where as other technologies might be used only to analyze, to create statistical models, or to draft maps etc.

- GIS, is a powerful tool or a process for making decisions rather than as merely software or hardware.



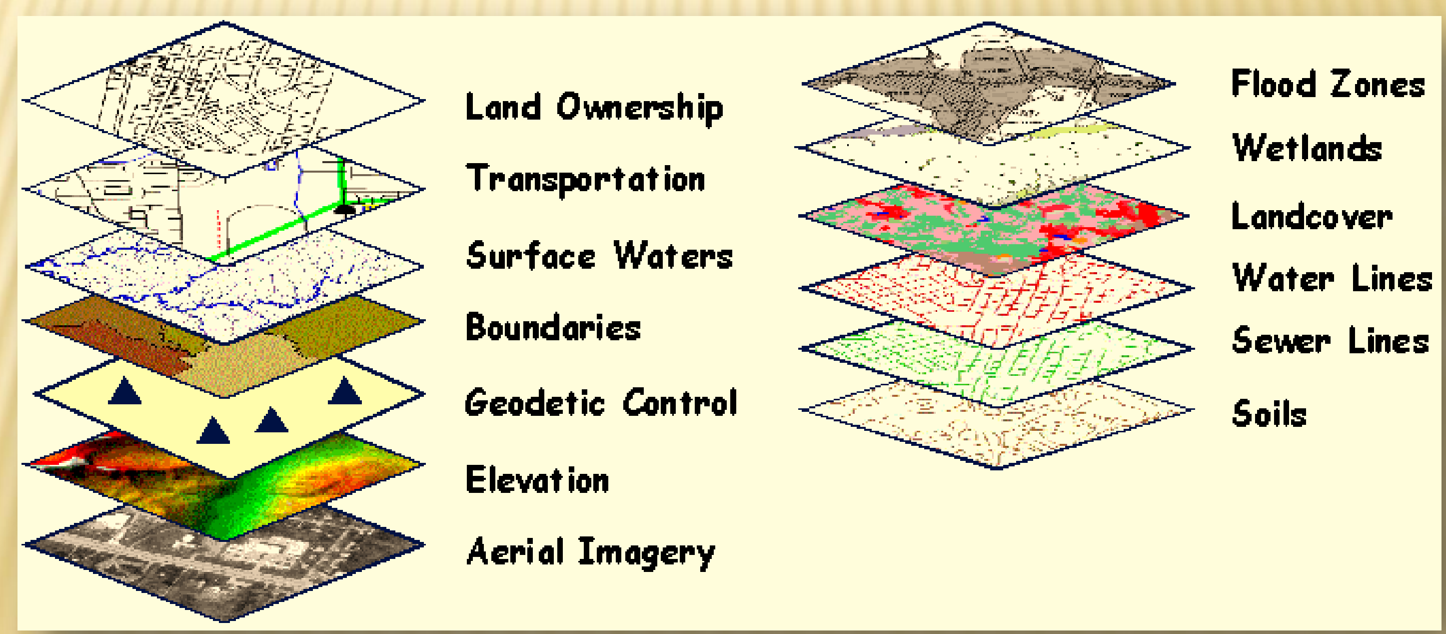
Different stages of information transfer in GIS



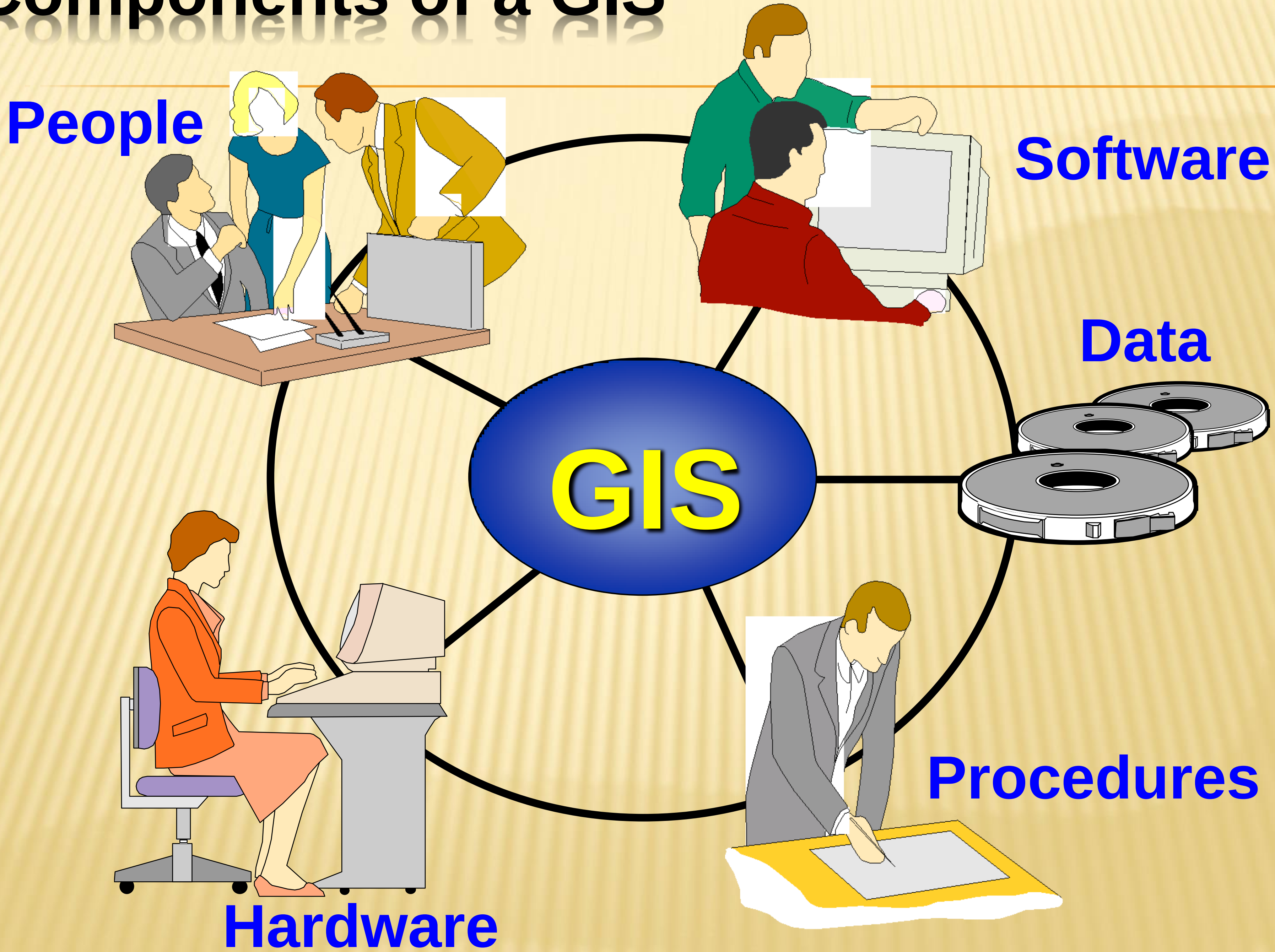
GIS - An integrating technology

GIS Design

- Geographic Information is organized
  - Thematic data layers
  - Contents of each Theme
  - Representation
  - Spatial Reference framework



Components of a GIS



Components of a GIS

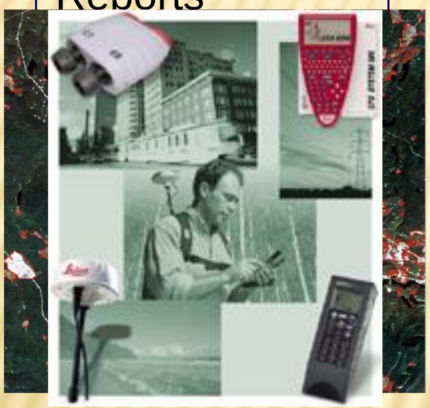
A working GIS integrates five key components:

Component	Function
Hardware	❑ Hardware is the computer system on which a GIS operates. ❑ Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.
Software	❑ GIS software provides the functions and tools needed to store, analyze, and display geographic information.
Data	❑ Most important component of a GIS is the data. ❑ GIS can integrate spatial data with other existing data resources, stored in DBMS. ❑ The integration of spatial data (often proprietary to the GIS software), and tabular data stored in a DBMS is a key functionality of GIS.
Procedures	❑ A successful GIS operates according to a well-designed implementation plan and business rules, which are the models and operating practices unique to each organization.
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. ❑ GIS specialists versus end users.

Functions of a GIS

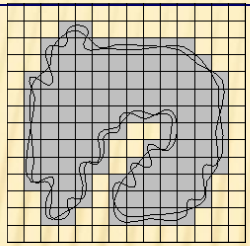
Data Collection

- Field data
- Satellite data
- Arial Photos
- Analog Maps
- Reports



Data Storage

Creation of database



Data Manipulation

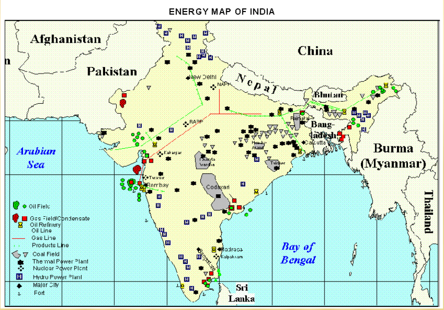
- Update/ Edit
- Reclassification
- Scale Change
- Registration
- Line Smoothening

Data Analysis

- **Querry**
- **Modeling**
- **Statistical Analysis**
- **Overlaying**
- **Buffer Analysis**

Data Display

- **Images**
- **Graphs**
- **Maps**
- **Tables**
- **ASCI Files**



FUNCTIONS OF GIS

Function	Service	Sub-functions
Data Acquisition and prepossessing	Capture, collect, and transform spatial and thematic data into digital form.	Digitizing, Editing , Topology Building, Projection Transformation, Format Conversion etc.
Database Management and Retrieval	Organizes the data, in a form which permits it to be quickly retrieved by the user for analysis, and permits rapid and updates of database.	Data Archival, Hierarchical Modeling , Network Modeling, Relational Modeling, Attribute Query, Object-oriented Database etc.
Spatial Measurement and Analysis	*Heart of a GIS* **which** allows the user to define and execute spatial and attribute procedures to generate derived information.	Measurement operations, Buffering, Overlay operations, connectivity Operations etc.
Graphic output and Visualization	Allows the user to generate graphic displays, normally maps, and tabular reports representing derived information products	Scale Transformation, Generalization, Topological Map, Statistical Map etc.

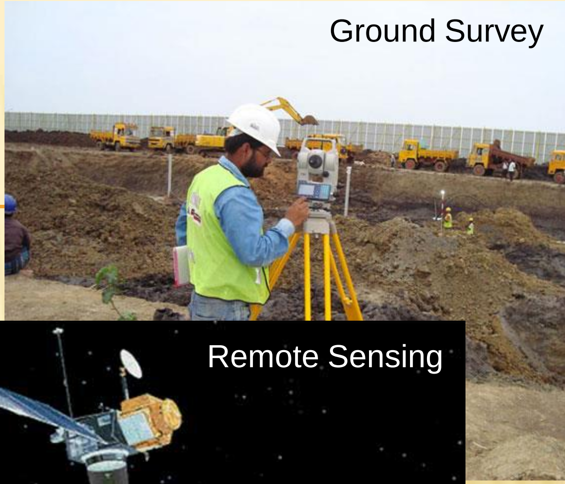
GIS VERSUS MANUAL WORKS

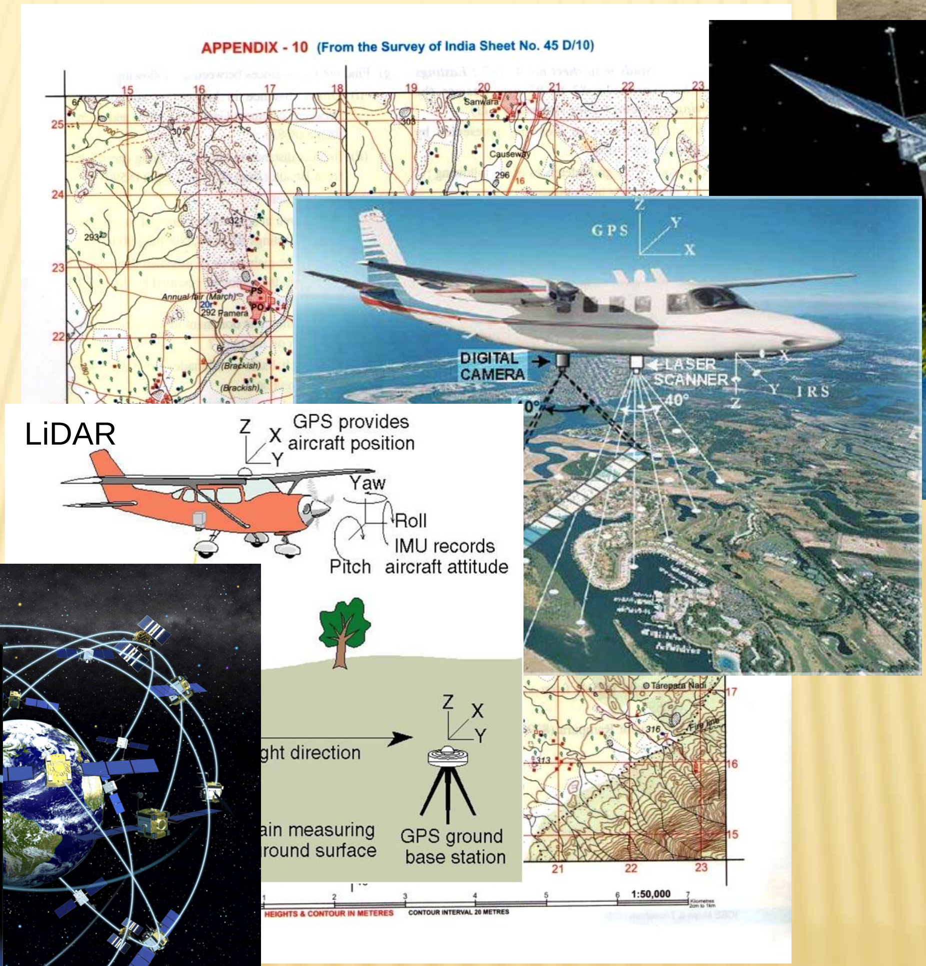
Maps	Manual works	GIS
Storage	Different scales on different standard	Standardized and integrated
Retrieval	Paper Maps, Census, Tables	Digital Database
Updating	Manual Check	Search by Computer
Overlay	Expensive & Time consuming	Very Fast
Spatial Analysis	Complicated	Easy
Display	Expensive	Cheap & Fast

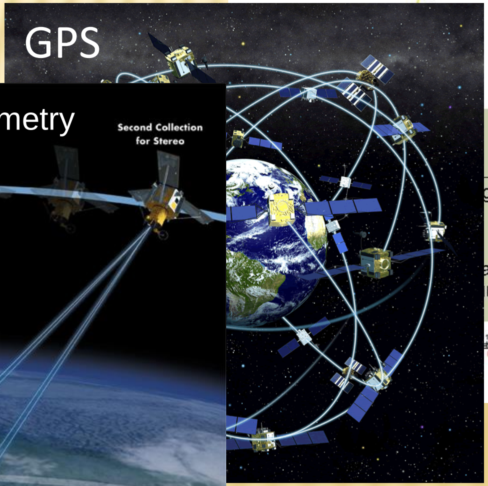
Users of GIS

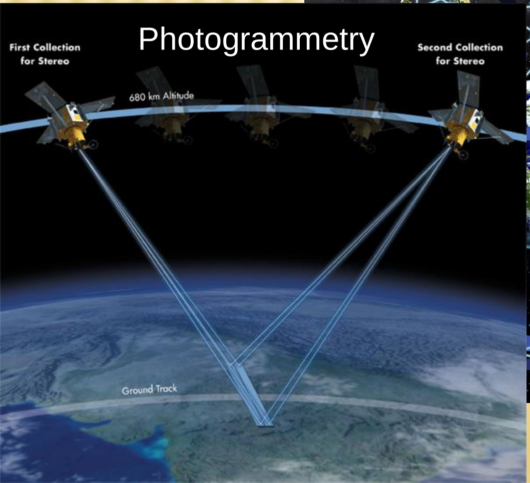
A container of maps in digital form	the general public
A computerized tool for solving geographic problems	decision makers, planners
A spatial decision support system	managers, operations researchers
A mechanized inventory of geographically distributed features	utility managers, resource managers
A tool for revealing what is otherwise invisible in geographic information	scientists, investigators
A tool for performing operations on geographic data that are too tedious if performed by manual methods	resource managers, planners, GIS experts

GIS Data sources









GIS Data conversion techniques

CHOICE OF ACQUISITION METHOD

Sources	Method	H/w & S/w	Accuracy	Cost	Remarks
Analog Map	Manual Digitizing	Digitizer	± 0.1 mm (on map)	High	One at a time
,,	Semi-Automatic	Conversion S/w	,,	High	
,,	Automatic	Conversion S/w	,,	High	Much Editing
Aerial Photos	Analytical	Analog Stereo Plotter	± 10 cm	High	
,,	Digital	Digital Workstation	± 10 cm	V High	Faster
Satellite Images	Visual	Image Zoom Scope	± 30 - 50 cm	Low	Conversion required
,,	DIP	IP S/w	± 10 - 30 cm	High	Faster
Ground Survey	Field measurement	Total Station, GPS	± 1 cm	V High	Much Time
Reports	Keyboard Entry	PC		Low	

GIS can be used to answer

- **Exploratory** *questions*: learn about a new issue

  Is there a spatial pattern?

- **Descriptive** *questions*: describe a phenomenon

  Has the pattern changed over time?

- **Explanatory** *questions*: explain a phenomenon

  What caused a pattern to change?

- **Predictive** *questions*: predicting future patterns

  What do we expect the pattern to look like in the future?

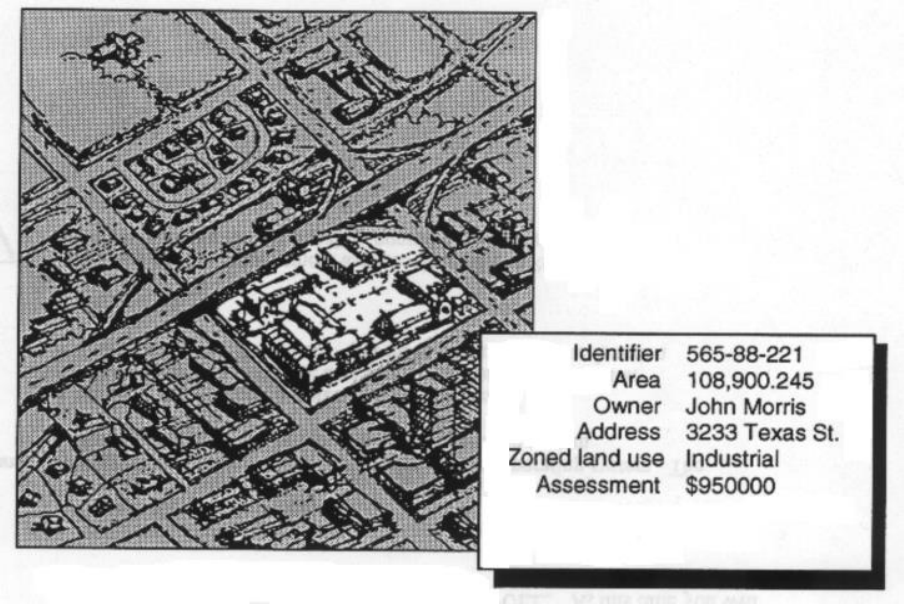
Questions a GIS can Answer

Spatial Query

A comprehensive GIS can answer all questions pertaining to ...

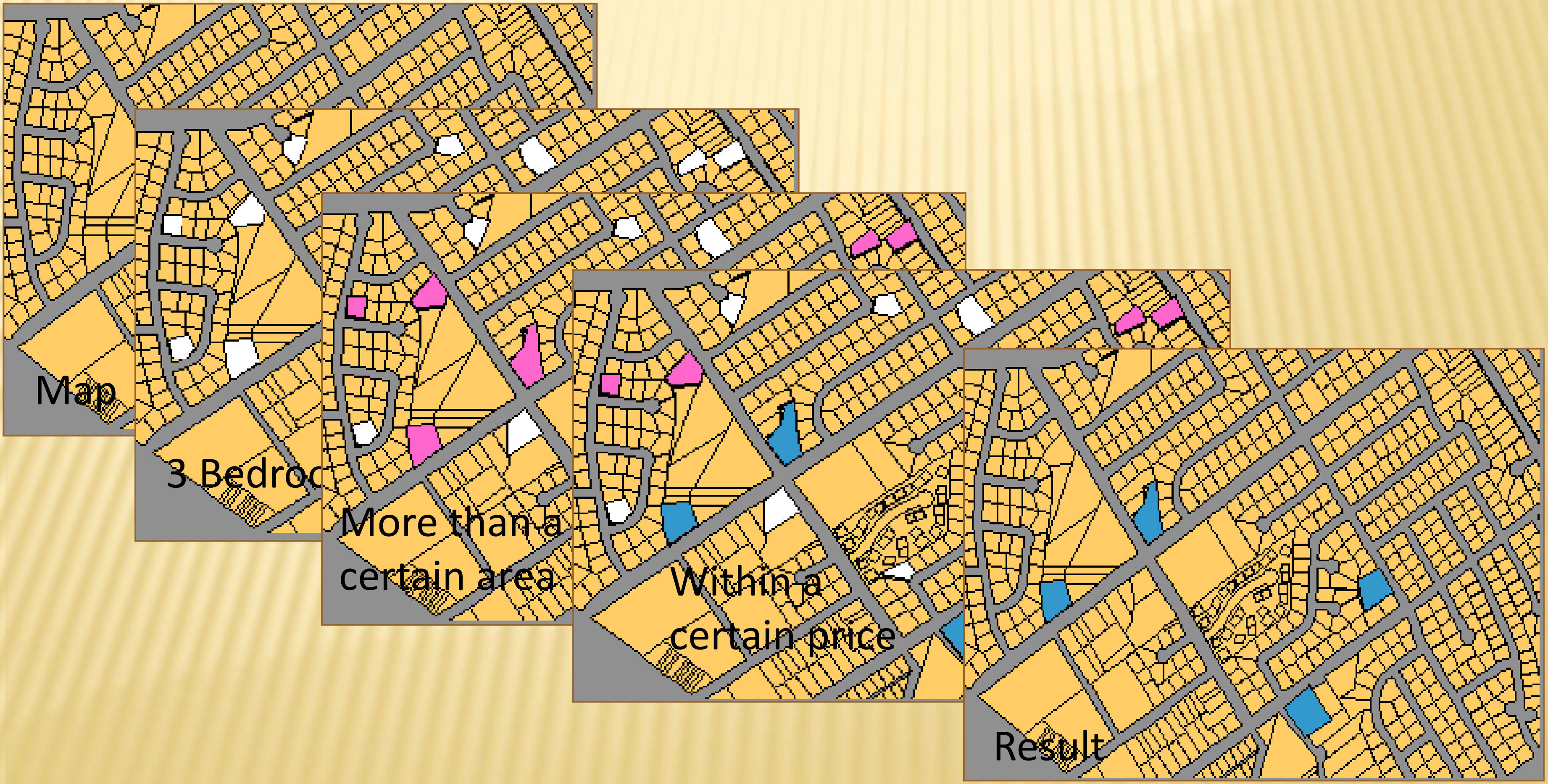
LOCATION: What is at…?

- *Here we are seeking to find out what exists at a particular location.*
- *A location can be described in many different ways using, for example, place name, or latitude and longitude coordinates*



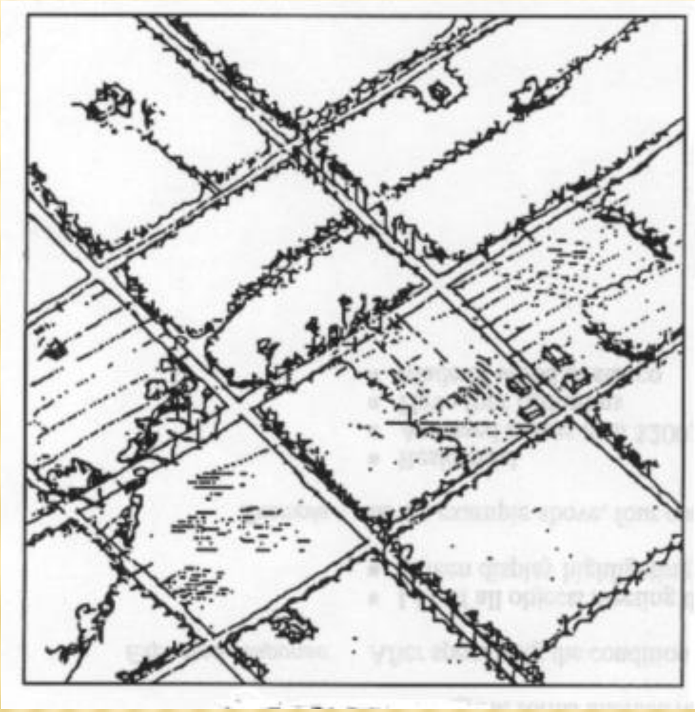
CONDITION: Where is it?

- *Instead of identifying what exists at a given location, you want to find a location where certain conditions are satisfied.*
- *For example, you wish to find a house assessed at less than Rs.60,00,000 with 3 bedrooms.*



TRENDS: What has changed since…?

- *This seeks to discover the differences between an area as the result of the passing of time.*

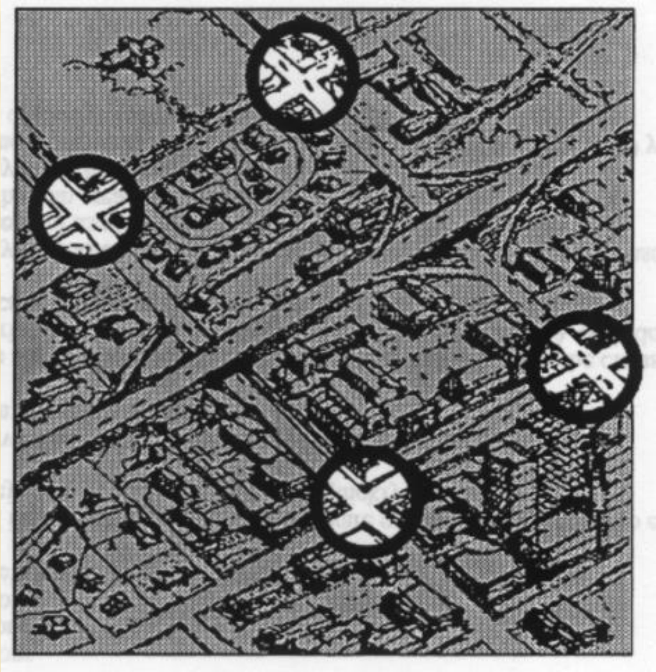


City in 1950

City in 2000

PATTERNS:
What spatial patterns exist?

- *This seeks to discover what types of patterns may exist in the newly created data file that were not visible before.*
- *For example you may wish to know where motor vehicle accidents occur and at what times.*

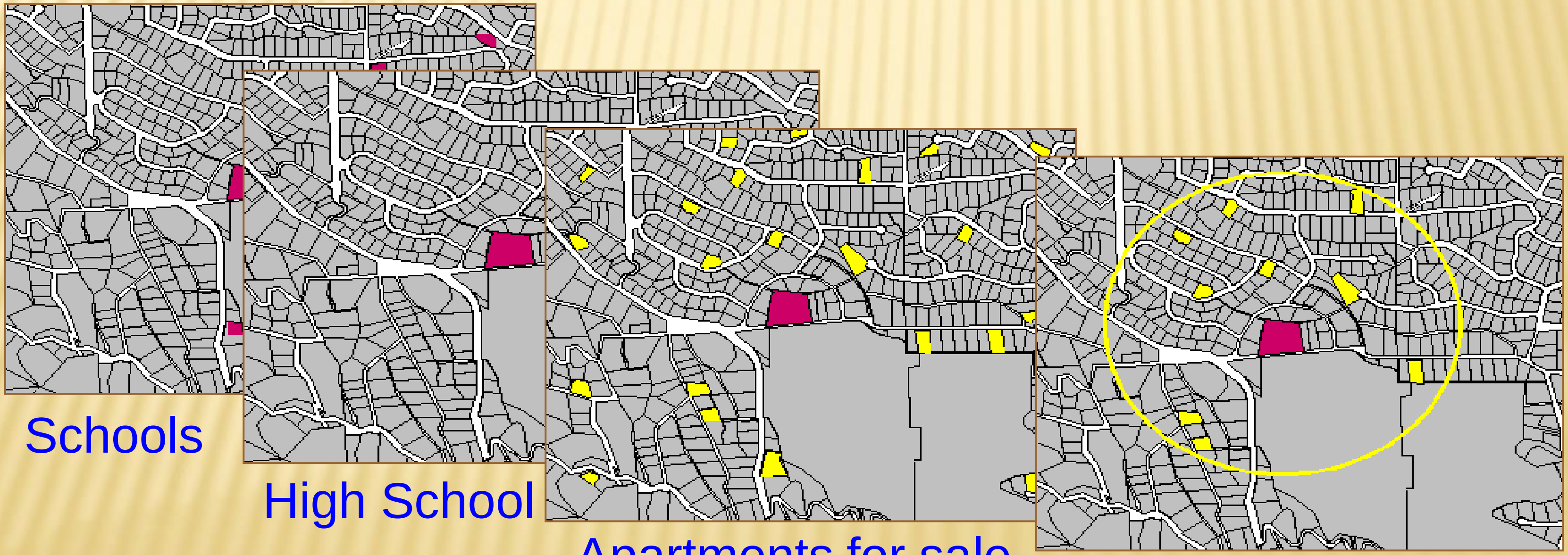


What kinds of patterns exist for motor vehicle accidents?

Where do they occur and at what times?

Spatial Query: What spatial link exist?

- GIS locates features with regards to their location to each other:
  - Features adjacent to…
  - Features within a certain distance
  - Features within a certain area



Schools

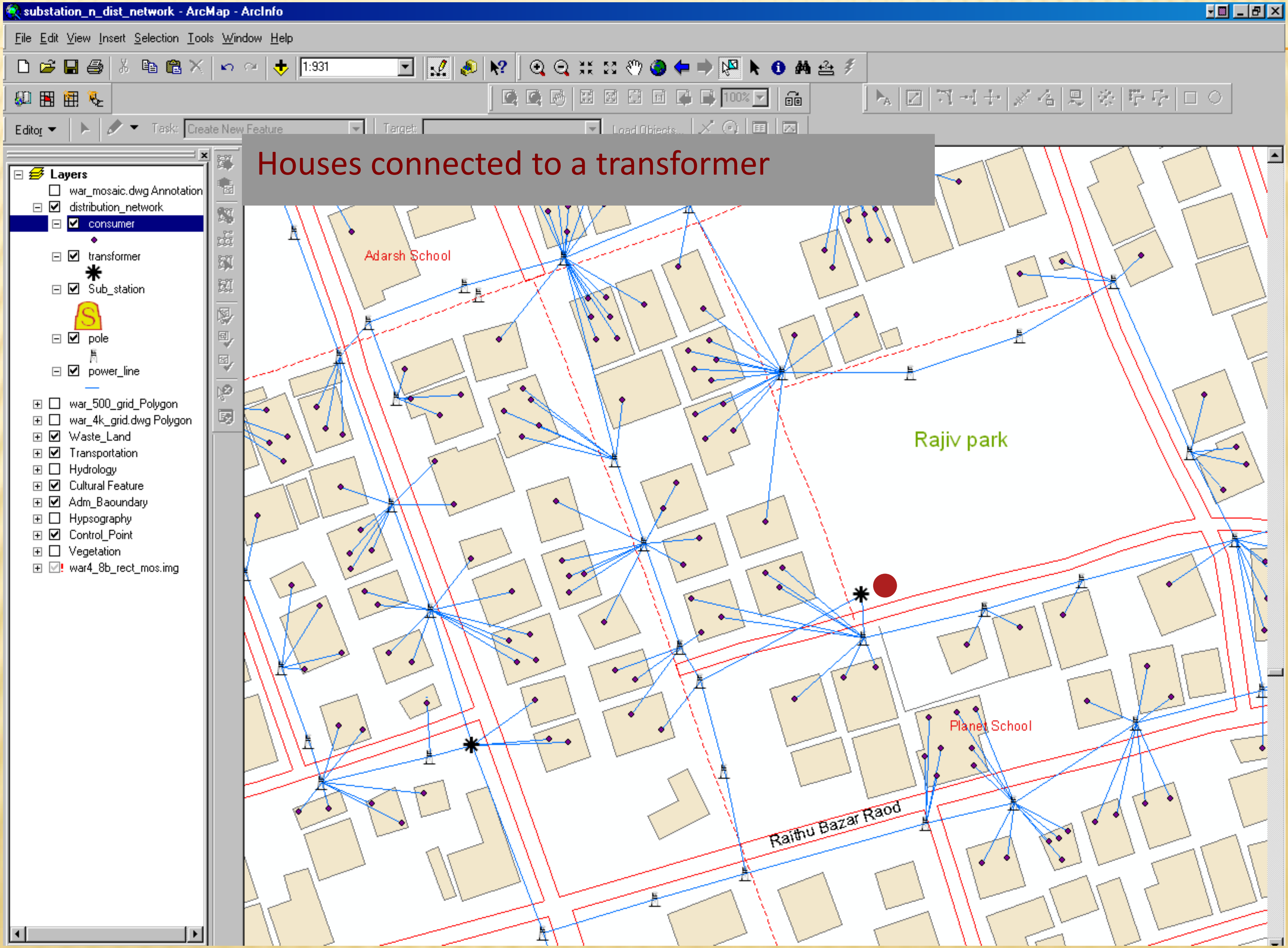
High School

Apartments for sale

Apartments for sale within 0.5 Km

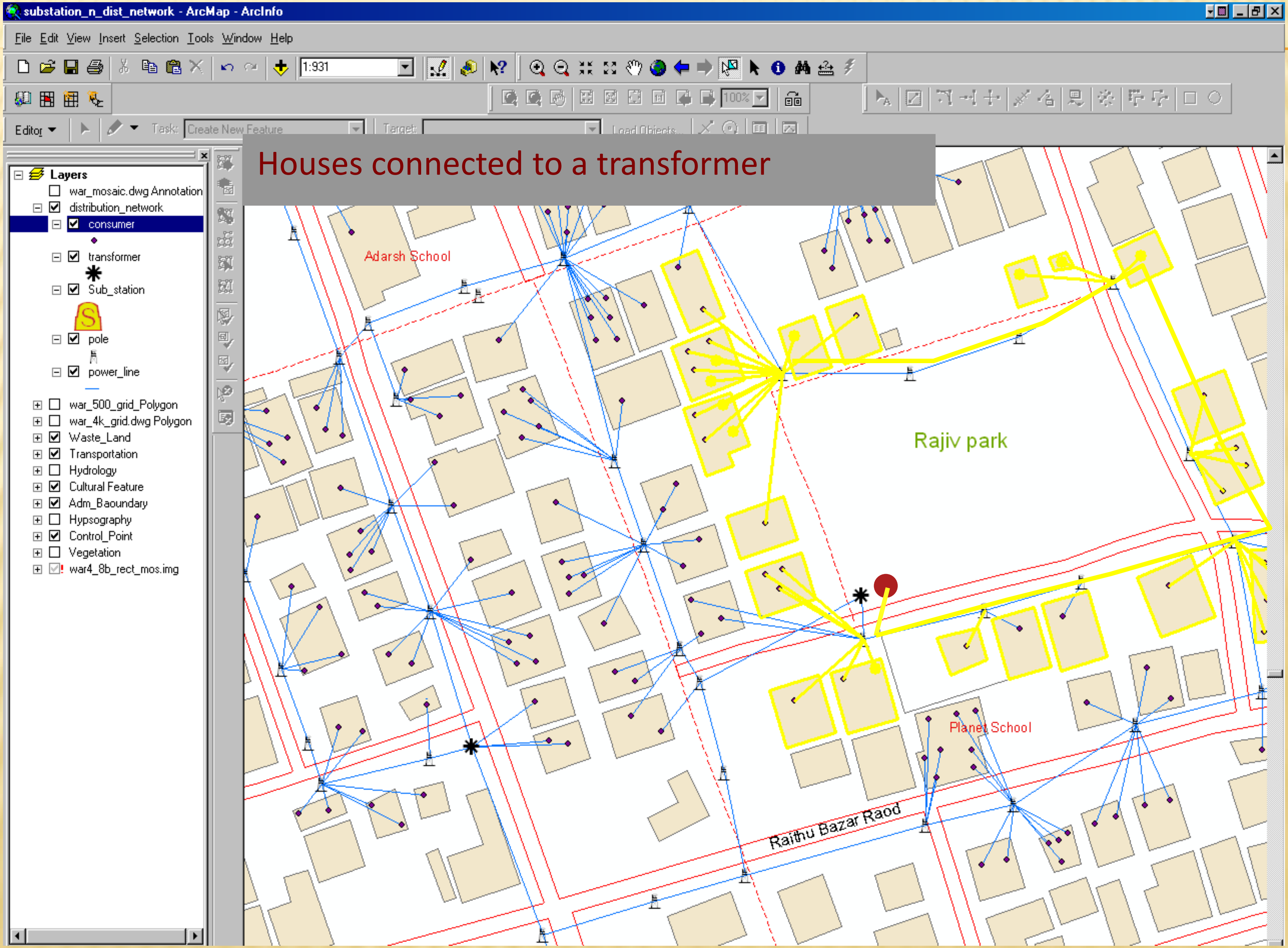
UTILITY MAPPING

Power GIS - Warangal



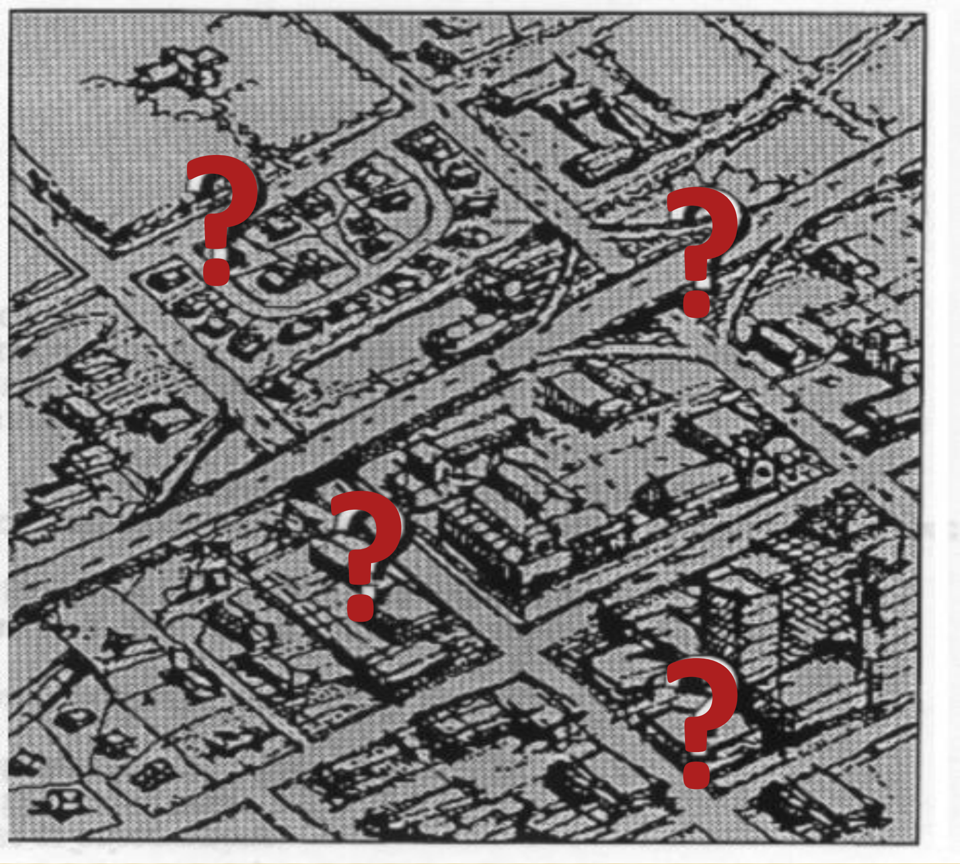
UTILITY MAPPING

Power GIS - Warangal



Modelling: What if

- *This seeks to determine what happens if something is changed within an area.*
- *For example a toxic substance seeps into the local ground water supply, or an earthquake of a given magnitude occurs at a given point, or you want to locate a new business.*



If you wanted to open a new facility, where would you locate it?

CONTRIBUTING DISCIPLINES

- GIS is a convergence of technological fields and traditional disciplines.
- GIS has been called an 'enabling technology' because of the potential it offers for the wide variety of disciplines which must deal with spatial data.
- GIS brings them together by emphasizing integration, modelling and analysis,

  - **Geography**
  - **Cartography**
  - **Remote Sensing**
  - **Photogrammetry**
  - **Surveying**
  - **Statistics**
  - **Computer Science**
  - **Mathematics**

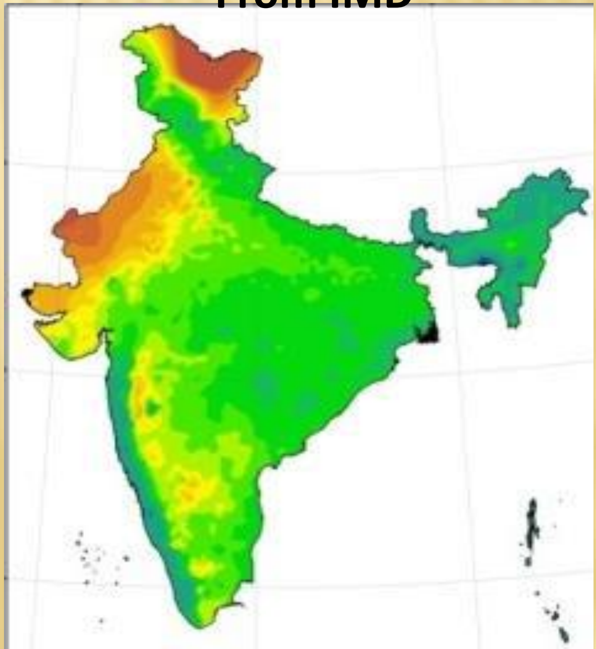
DATA TYPES

- GIS data represents real world objects. Real world objects can be divided into two abstractions:

- **Discrete**
    - Discrete data is geographic data that only occurs in specific locations having well defined boundaries (soil, land use, cities).
    - Maps made with discrete GIS data will have areas on the map that contain values from that dataset and areas on the map where that dataset is absent.
- **Continuous**
    - Continuous data has no clearly defined boundaries.
    - Every point on a map made with continuous GIS data will contain a value.
    - Elevation, slope, temperature, and precipitation are examples of datasets that are continuous.

- Traditionally, there are two broad methods used to store data in a GIS for both abstractions: **Raster** & **Vector**

Rainfall statistics of India 2015
From IMD



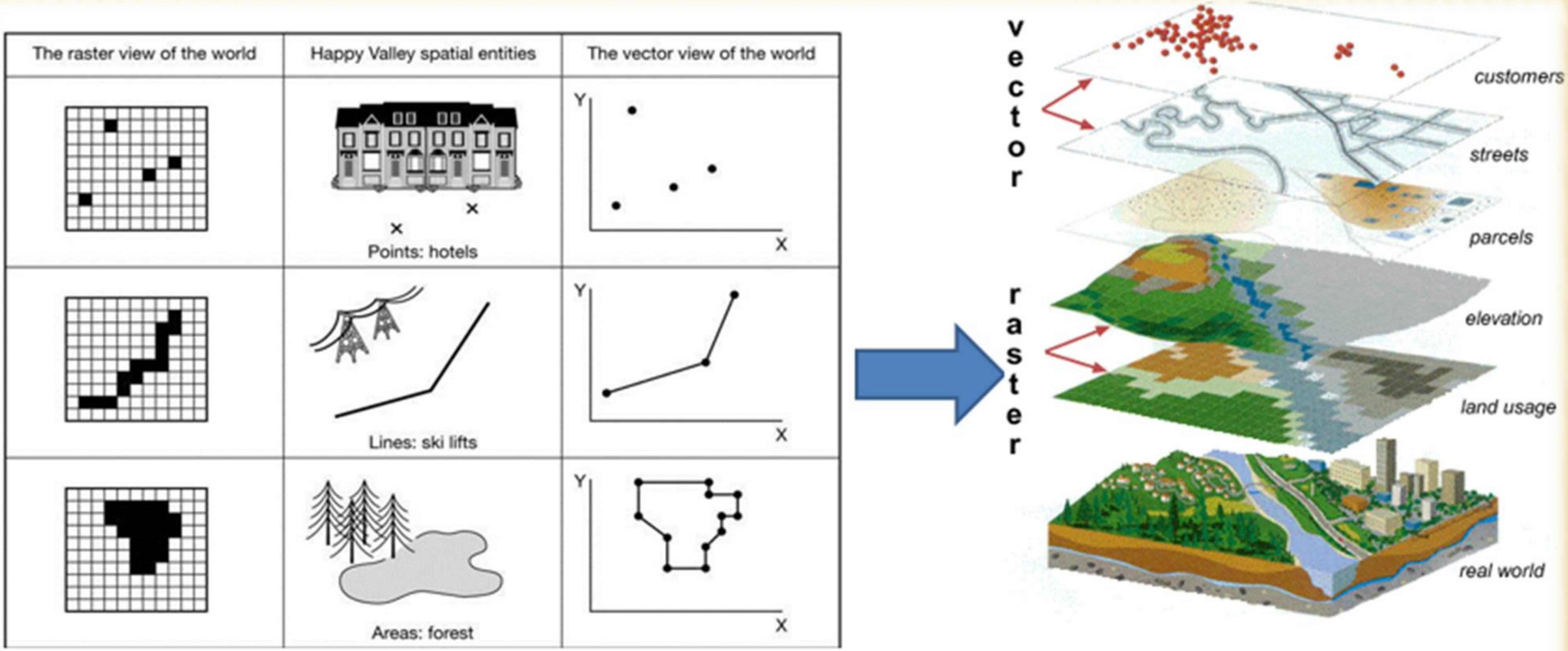
GIS DATA

- Spatial Data
  - Vector Model
  - Raster Model
  - 3D Data
- Attribute Data
- Metadata

It is Data about Data

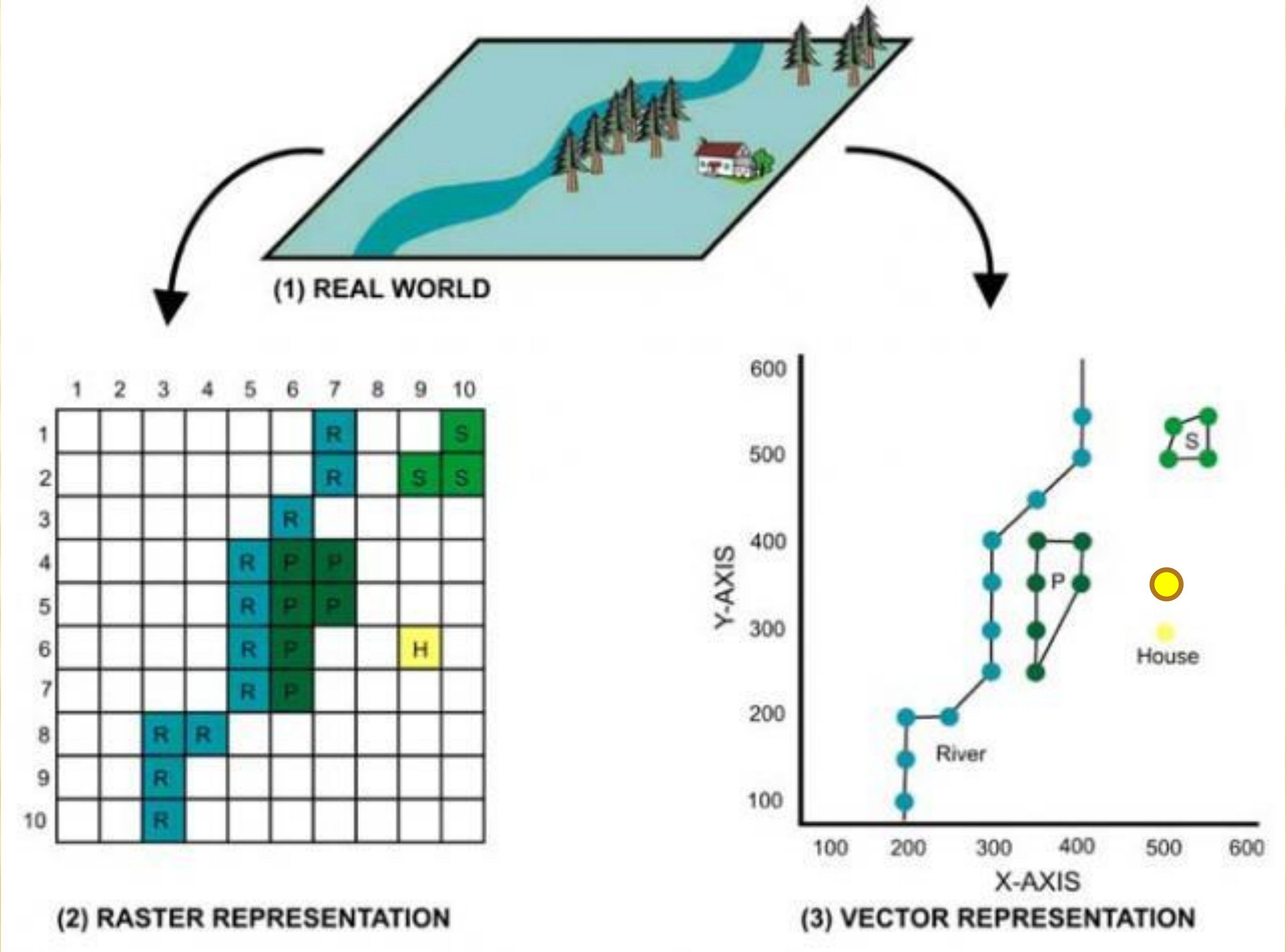
- Who created and maintains the data?
- Why were the data created?
- What is the content and structure of the data?
- When collected? When published?
- Which geographic area it covers?
- How were the data produced?
- What is the coordinate system?
- …
- …

Visualization of Spatial Data

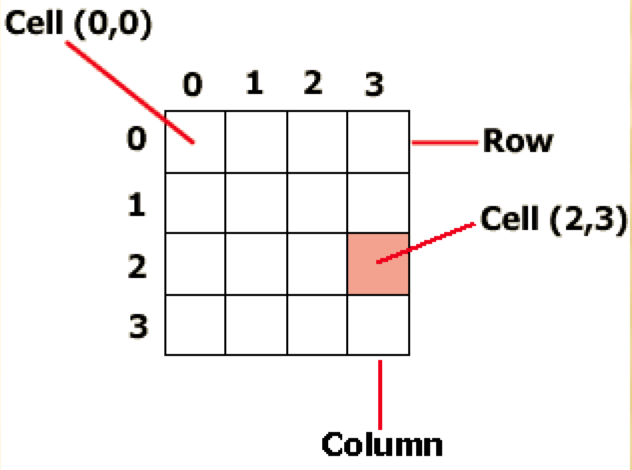


SPATIAL DATA MODELS

RASTER & VECTOR

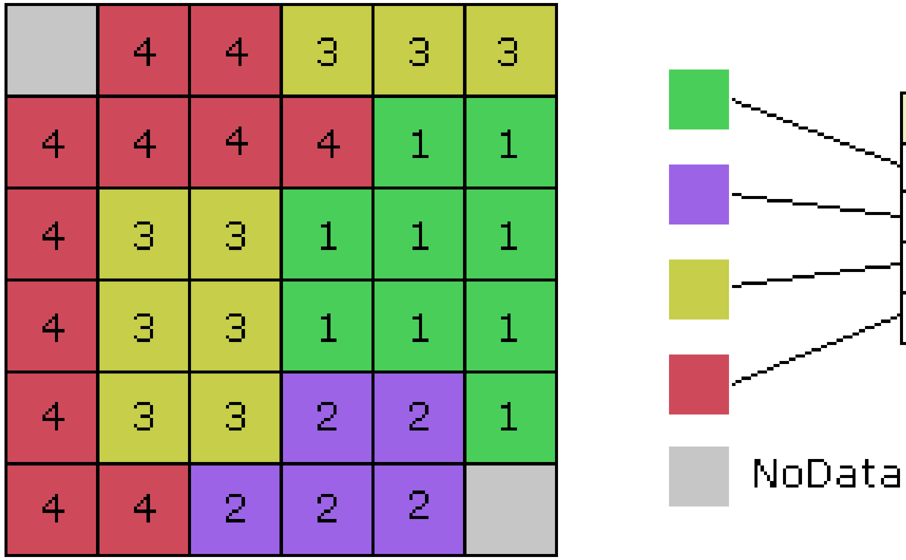


Raster Data Model



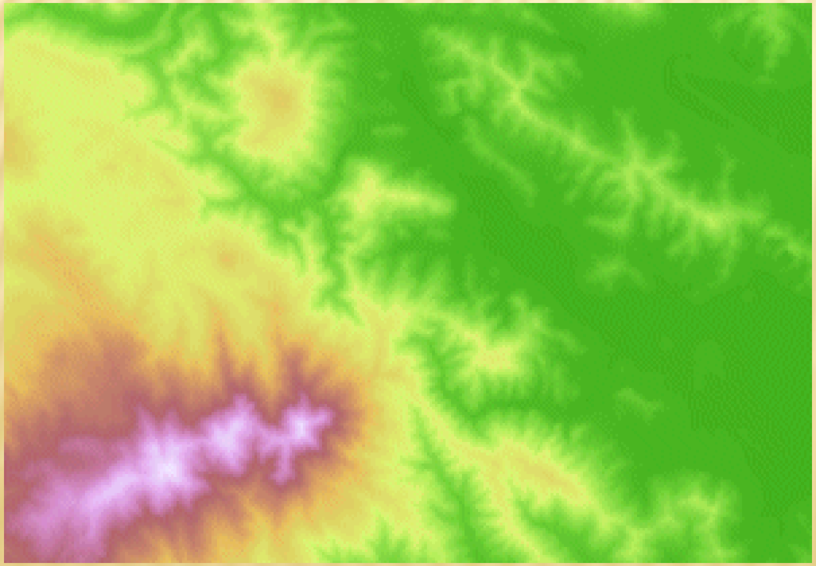
- **Cell or "pixel" is the basic spatial unit for a Raster / Grid data**
- Pixels are generally square in shape
- Pixels are organized into an array of **Rows** and **Columns** called a Grid/Raster
- Rows and columns are numbered from **0**
- Pixel locations are referenced by their row and column position
- Every pixel can be uniquely identified by its row and column position
- Pixels are assigned an integer, floating point, or NO DATA value
- Each pixel represent some kind of geographic phenomenon
- Number of rows and columns does not have to be the same

Raster dataset attribute table

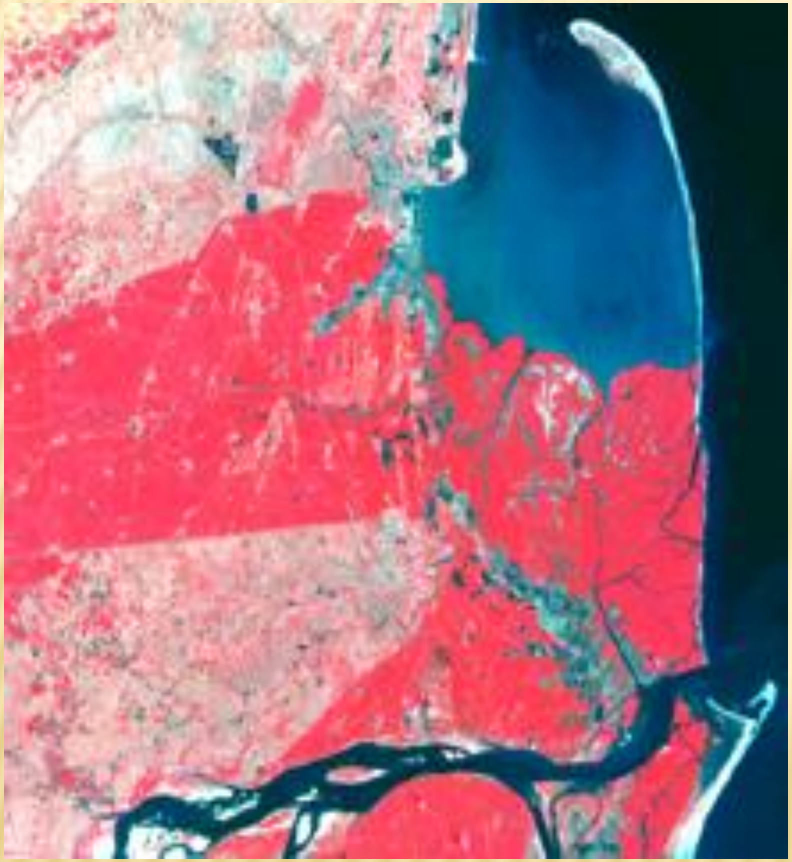


OID	VALUE	COUNT	TYPE	AREA	CODE
0	1	9	Forest land	8100	FL010
1	2	5	Wetland	4500	WL001
2	3	9	Crop land	8100	CL301
3	4	11	Urban	9900	UL040

Raster Data



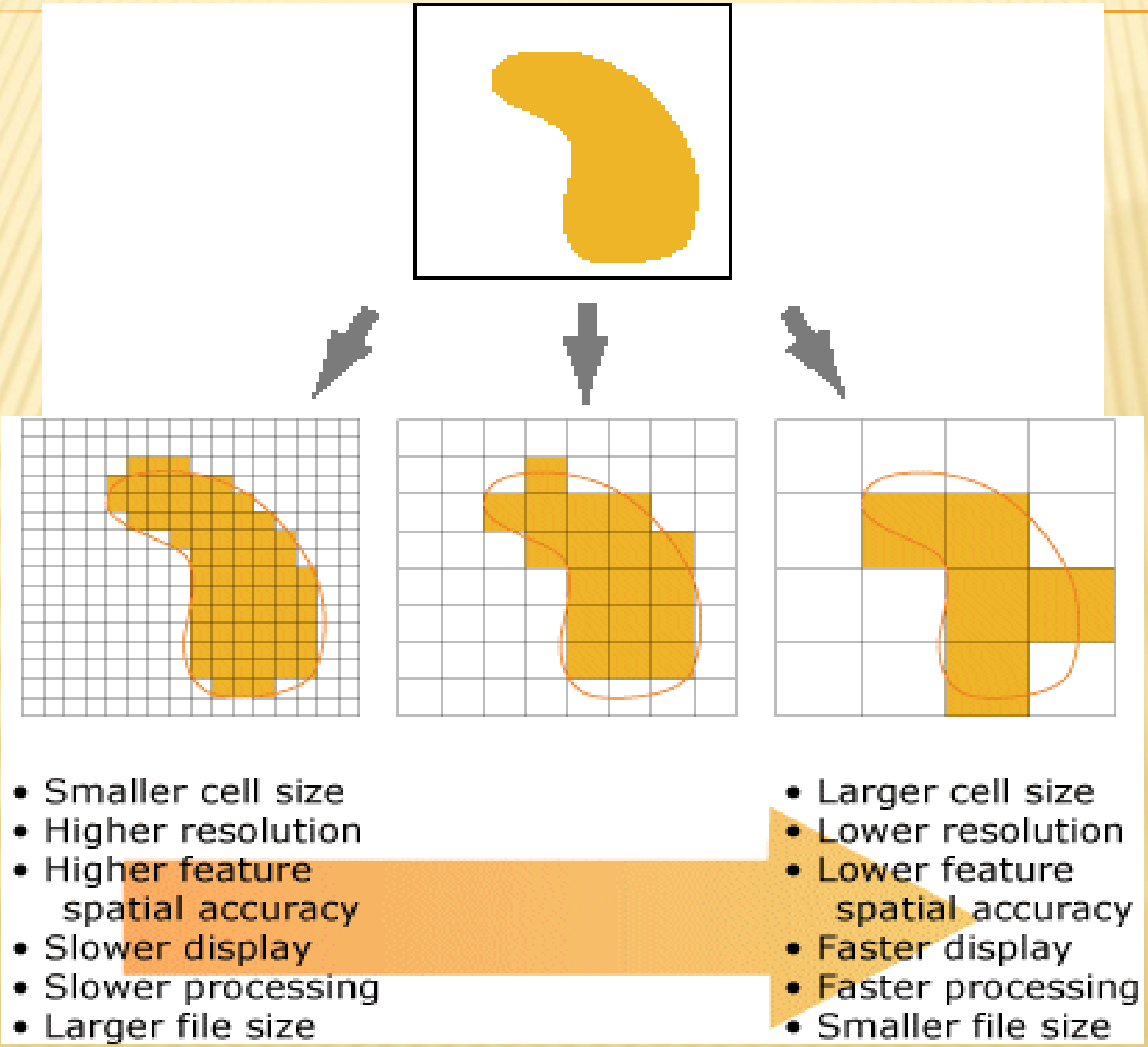
Raster Data Types



Continuous Raster

Thematic Raster

PIXEL SIZE

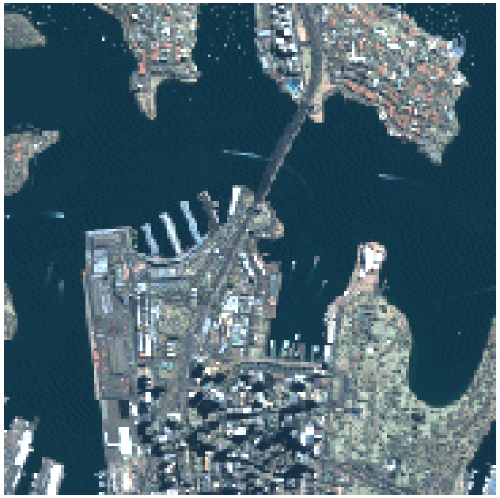


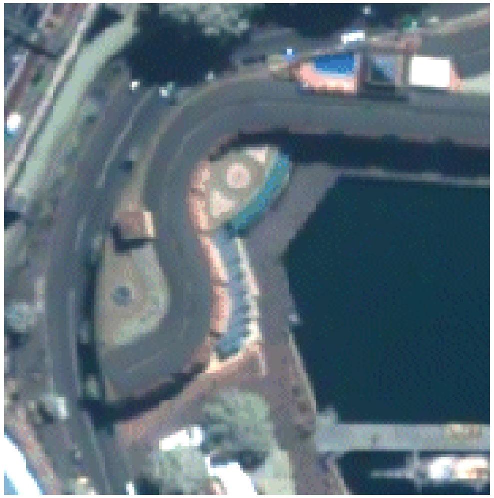
• Smaller cell size
• Higher resolution
• Higher feature spatial accuracy
• Slower display
• Slower processing
• Larger file size
• Larger cell size
• Lower resolution
• Lower feature spatial accuracy
• Faster display
• Faster processing
• Smaller file size

PIXEL SIZE vs SCALE


Scale 1:20,000
Cell size: 15 m


Scale 1:20,000
Cell size: 15.24 cm

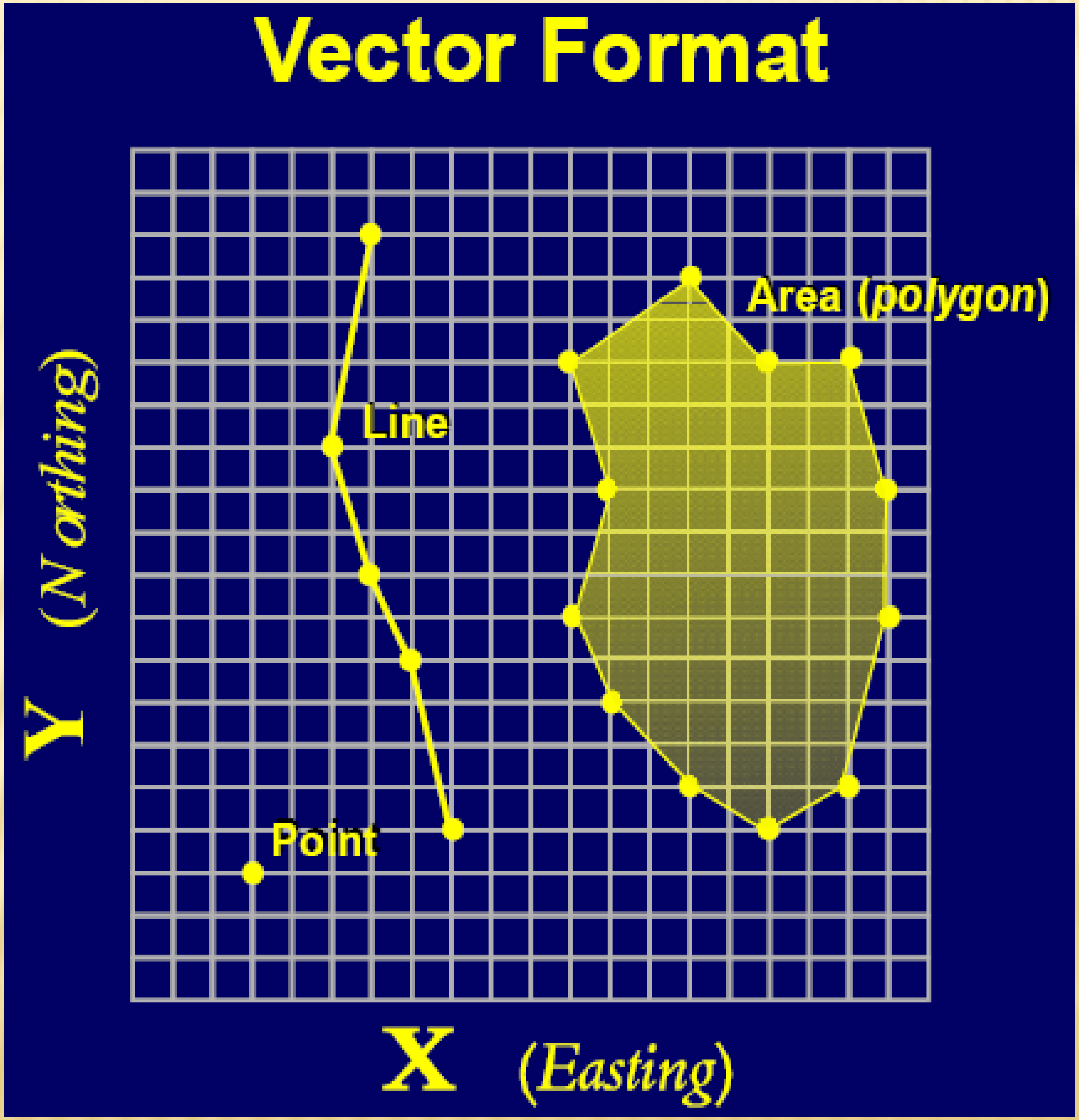

Scale 1:50,000
Cell size: 61 cm


Scale 1:2,500
Cell size: 61 cm

The higher the resolution of a raster, the smaller the cell size and, thus, the greater the detail.

This is the opposite of scale. The smaller the scale, the less detail shown.

Vector Model



Vector Model

Primitive Features

Attribute

Points

Lines / Arcs

Polygons

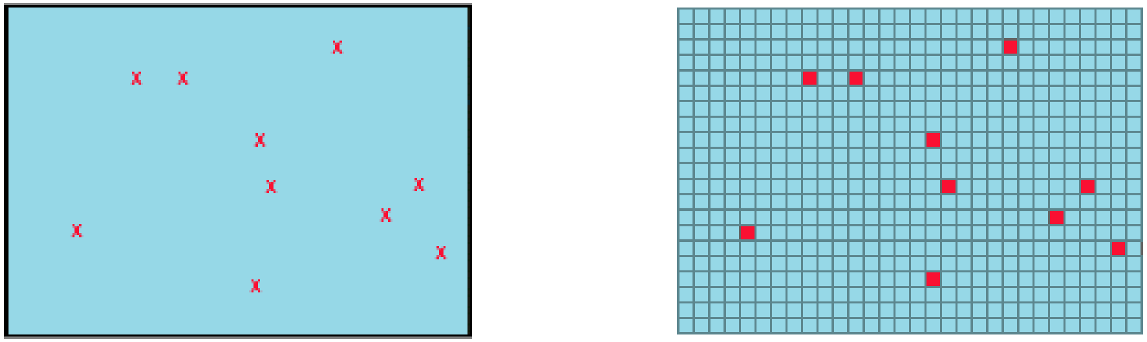
Selecting a **“primitive feature”** depends on **“Scale”** at which data is to be represented

VECTOR DATA MODEL

- ►Derived from the formulation of spatial concepts that emphasize on real world objects (roads, buildings, lakes etc).
- ►Geometry **primitives of vector** data model are

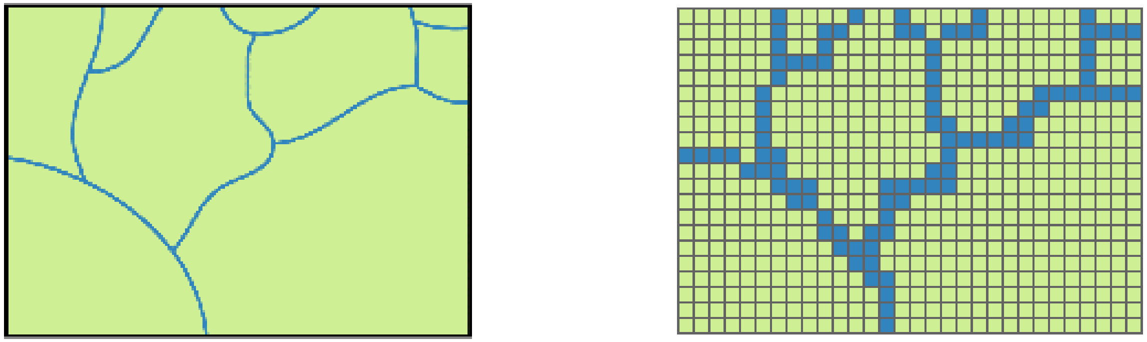
  Point, Line and Polygon
- ►Objects can be built from these primitives
- ►Object location determined by represented location point
- ►Accuracy of vector data does not change with the scale

Point representation



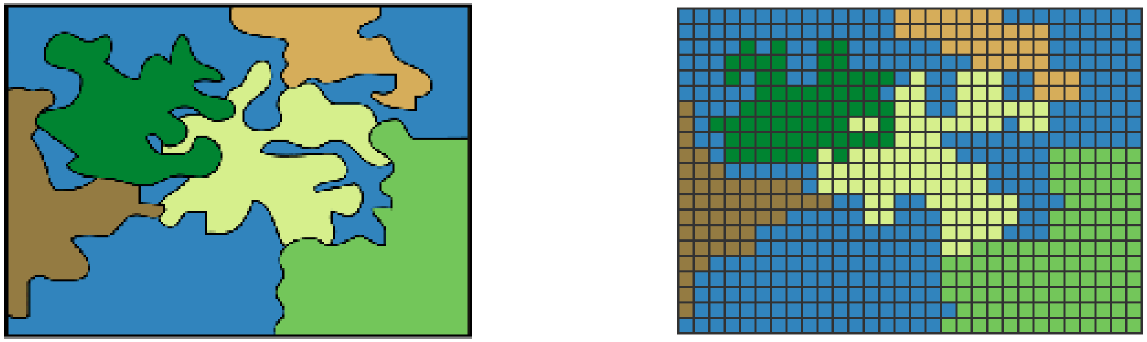
Point features   Raster point features

Line / Arc representation



Line features   Raster line features

Polygon / Area representation



Polygon features   Raster polygon features

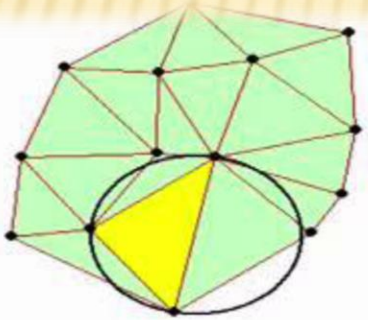
Raster vs. Vector Data Model

Continuous data (Raster)	Discrete (Vector)
Simple data structure	Complex data structure
Large data volumes	Compact Data File
Easy overlay	Overlay is more difficult
Rapid data collection	Slow data collection
Poor network analysis	Possibility of Network analysis
No topology stored (no relationships shown)	Efficient Topology
High spatial variability	Low spatial variability
Suitable for highly variable data	Good for homogeneous data
Lower positional accuracy	Potentially excellent positional accuracy
Determined by cell size	Given by (X,Y) coordinates
Low geometric accuracy	High geometric accuracy
Better suited for imagery	Better suited for graphics

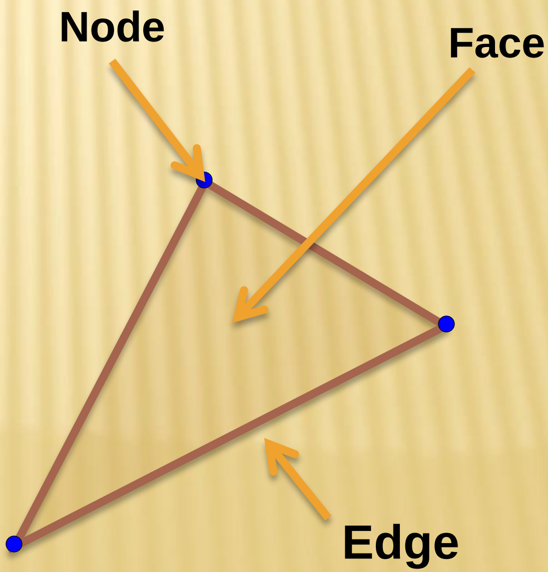
3-D Data Representation

Triangulated Irregular Network (TIN)

- TIN is a vector data structure that partitions geographic space into contiguous, non-overlapping triangles.
- The vertices of each triangle are sample data points with x, y and z values.
- These points are connected by lines to form Delaunay triangles.

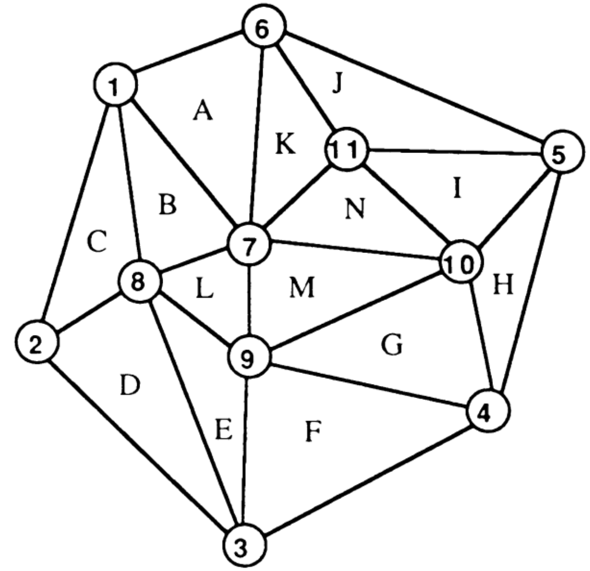


Delaunay triangulation is a proximal method that satisfies the requirement that a circle drawn through the three nodes of a triangle will contain no other node



Triangulated Irregular Network (TIN)

- TIN is a vector topological data model for representing surfaces
- TIN represents a surface as a set of interconnected triangular facets derived from sample points
- Associated Data tables:
  - Node table - lists each triangle and its defining nodes
  - Edge table - lists 3 adjacent triangles for each facet
  - XY coordinate table - stores nodes coordinates



X–Y COORDINATES

node	coordinates
1	x1, y1
2	x2, y2
3	x3, y3
:	
11	x11, y11

Z COORDINATES

node	coordinate
1	z1
2	z2
3	z3
:	
11	z11

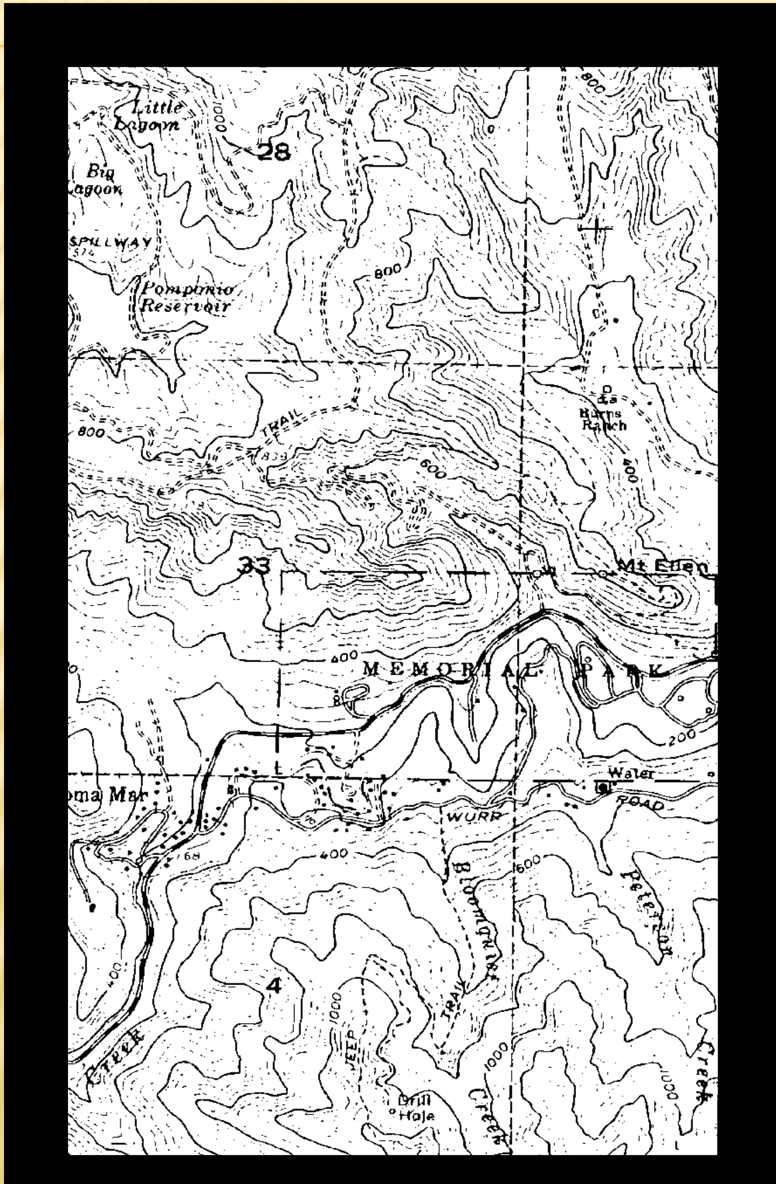
EDGES

Δ	adjacent Δ
A	B,K
B	A,C,L
C	B,D
D	C,E
E	D,F,L
F	E,G
G	F,H,M
H	G,I
I	H,J,N
J	I,K
K	A,J,N
L	B,E,M
M	G,L,N
N	I,K,M

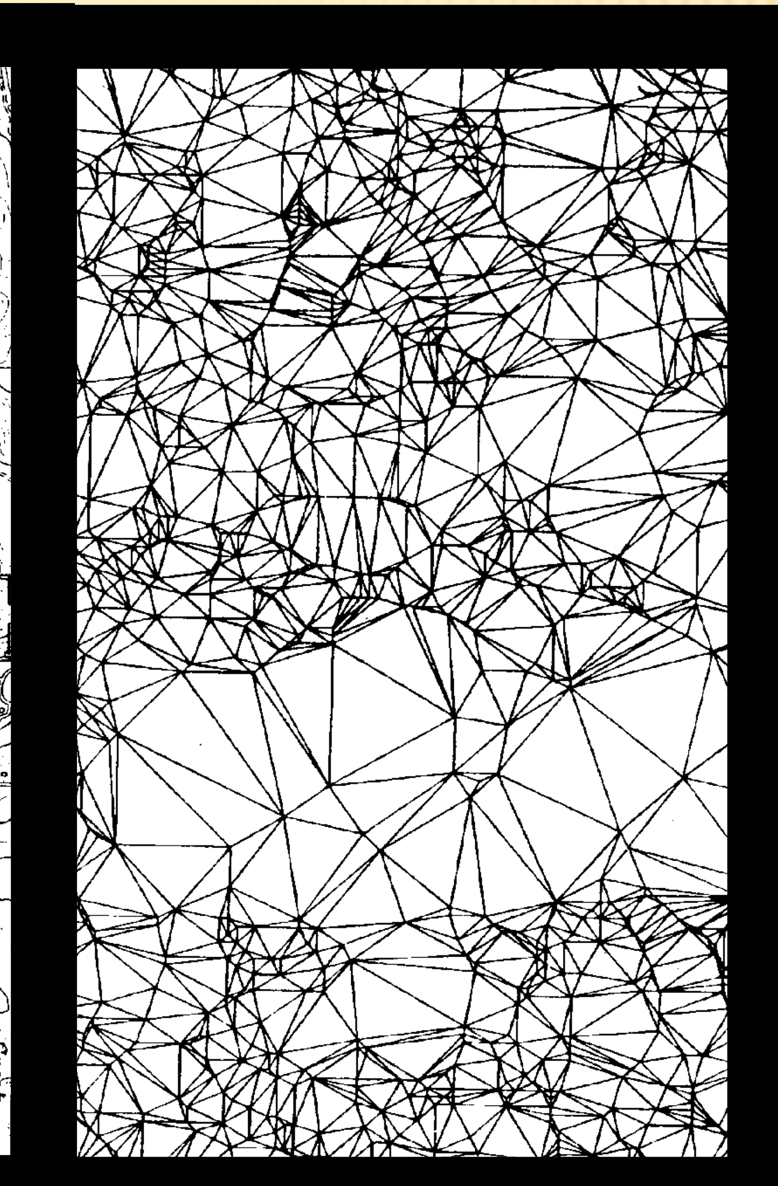
NODES

Δ	node
A	1,6,7
B	1,7,8
C	1,2,8
D	2,3,8
E	3,8,9
F	3,4,9
G	4,9,10
H	4,5,10
I	5,10,11
J	5,6,11
K	6,7,11
L	7,8,9
M	7,9,10
N	7,10,11

Contours



TIN



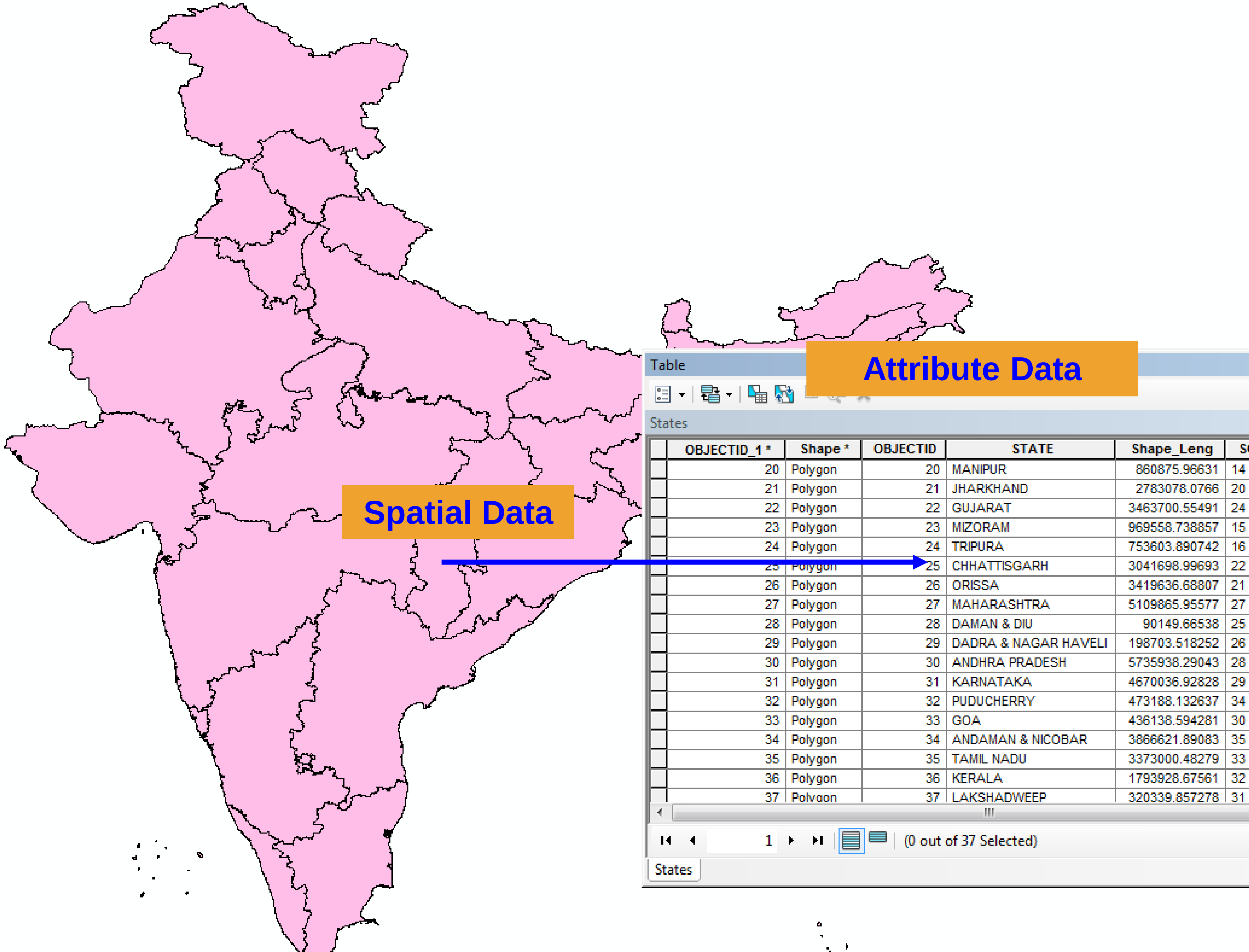
Triangulated Irregular Network (TIN)

Advantages

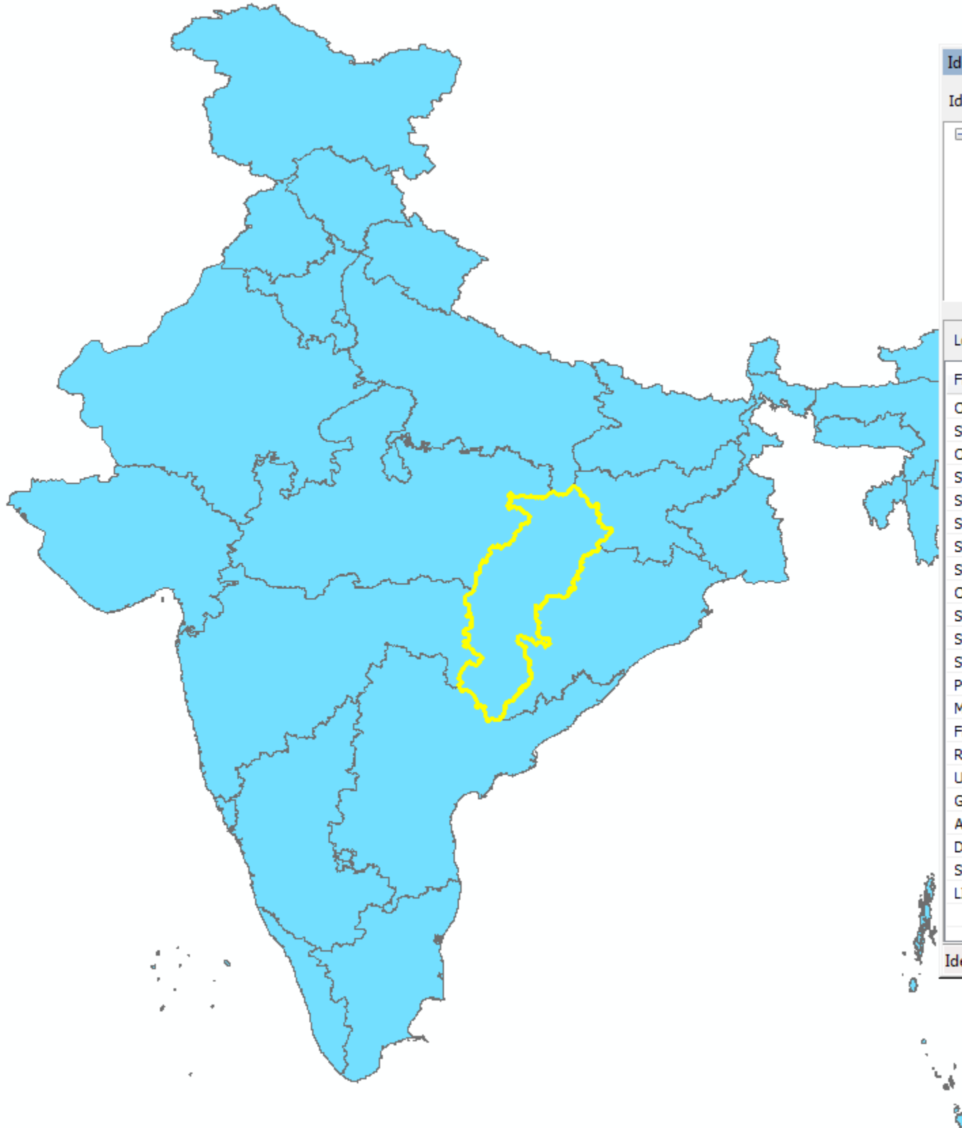
- Slope and Aspect calculated for each triangle and stored as attributes of the *facet*
- For areas of complex relief, TIN works better than raster
- More detailed representation for higher density of data points

Disadvantages

- Significantly more processing required to generate the TIN file to start (but then more efficient representation)
- Errors along edges often need correction



OBJECTID_1 *	Shape *	OBJECTID	STATE	Shape_Leng	SC
20	Polygon	20	MANIPUR	860875.96631	14
21	Polygon	21	JHARKHAND	2783078.0766	20
22	Polygon	22	GUJARAT	3463700.55491	24
23	Polygon	23	MIZORAM	969558.738857	15
24	Polygon	24	TRIPURA	753603.890742	16
25	Polygon	25	CHHATTISGARH	3041698.99693	22
26	Polygon	26	ORISSA	3419636.68807	21
27	Polygon	27	MAHARASHTRA	5109865.95577	27
28	Polygon	28	DAMAN & DIU	90149.66538	25
29	Polygon	29	DADRA & NAGAR HAVELI	198703.518252	26
30	Polygon	30	ANDHRA PRADESH	5735938.29043	28
31	Polygon	31	KARNATAKA	4670036.92828	29
32	Polygon	32	PUDUCHERRY	473188.132637	34
33	Polygon	33	GOA	436138.594281	30
34	Polygon	34	ANDAMAN & NICOBAR	3866621.89083	35
35	Polygon	35	TAMIL NADU	3373000.48279	33
36	Polygon	36	KERALA	1793928.67561	32
37	Polygon	37	LAKSHADWEEP	320339.857278	31



Identify

Identify from: <Top-most layer>

States
CHHATTISGARH

Location: 82.011068 21.773091 Decimal Degrees

Field	Value
OBJECTID_1	25
Shape	Polygon
OBJECTID	25
STATE	CHHATTISGARH
Shape_Leng	3041698.99693
SCODE	22
Shape_Length	28.865502
Shape_Area	11.772526
OBJECTID	17
SNO	16
SCODE	22
STATE	Chhattisgarh
POP_2011	25540196
MALES	12827915
FEMALES	12712281
RURAL	19603658
URBAN	5936538
GROWTHR...	23
AREA_SQKM	135192
DENSITY	189
SEX_RATIO	991
LITERACY	70

Identified 1 feature

What is Metadata:

- Data about data
- Identifies and describes datasets, coverage, images, etc

Simple Metadata for Geospatial Data

Originator:	NRSC Hyderabad
Title:	Roads in Hyderabad
Date Created:	10/01/2018
Filename:	rds197.shp
Filesize:	1MB
Fileformat:	ArcView Shapefile
Source Scale:	1:24K

Projection/Coordinate Info: UTM Zone 44/WGS84

Objectives for Metadata

- **Identification** - inventory data holdings; facilitate browsing/searching for relevant information
- **Evaluation** - determining “fitness for use” based on application requirements
- **Interpretation** - extracting and utilizing data correctly in terms of schema, accuracy/ precision, reference

TOPOLOGY

- **The Intelligent way of representation based on spatial relationships between objects**

Where is it? (**location**)

What is next to (**adjacency**)

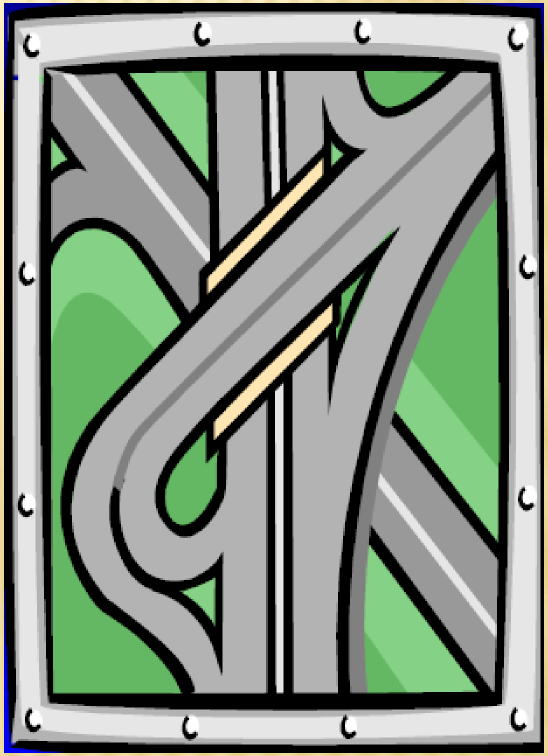
Is it inside or outside (**containment**)

How far is it (**connectivity**)

“Mathematical property that makes spatial relationships explicit and establishes connectivity between the features on a map”.

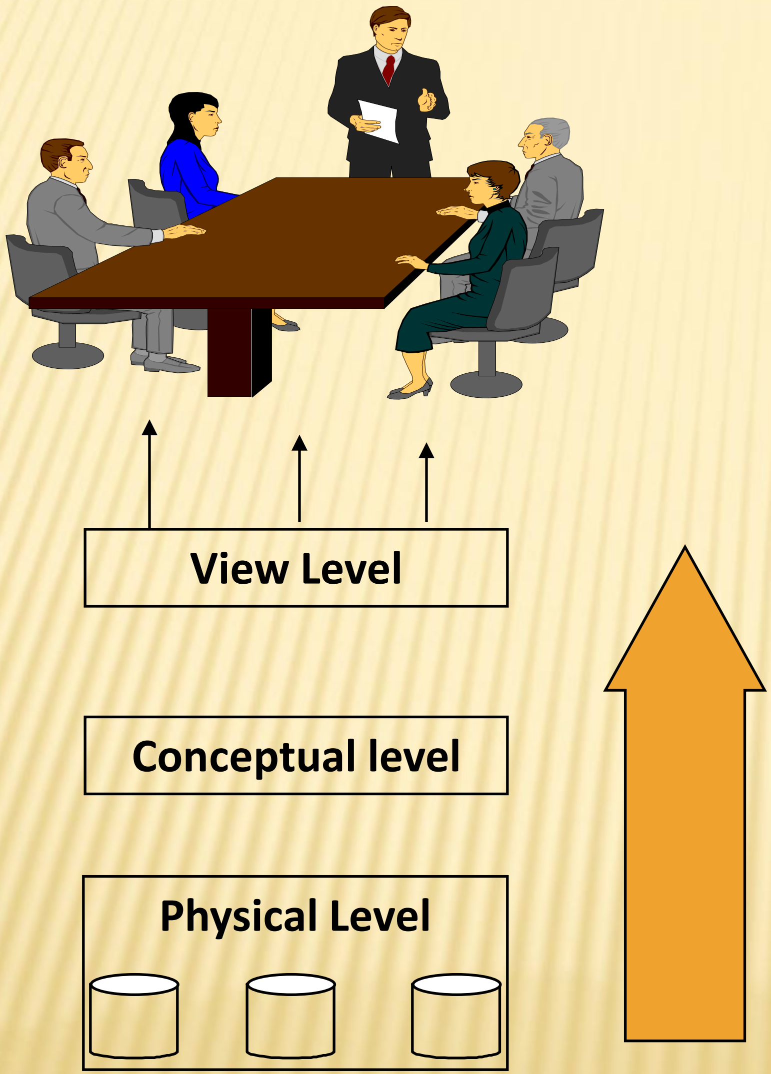
Object Oriented Data Model

- While the behaviour of streams, roads, and other real-world objects are different, they are represented only by a line
- When two road cross, an intersection is formed even if there is an overpass or underpass
- Spatial / Object oriented data models takes care of these aspects.



Data Abstraction

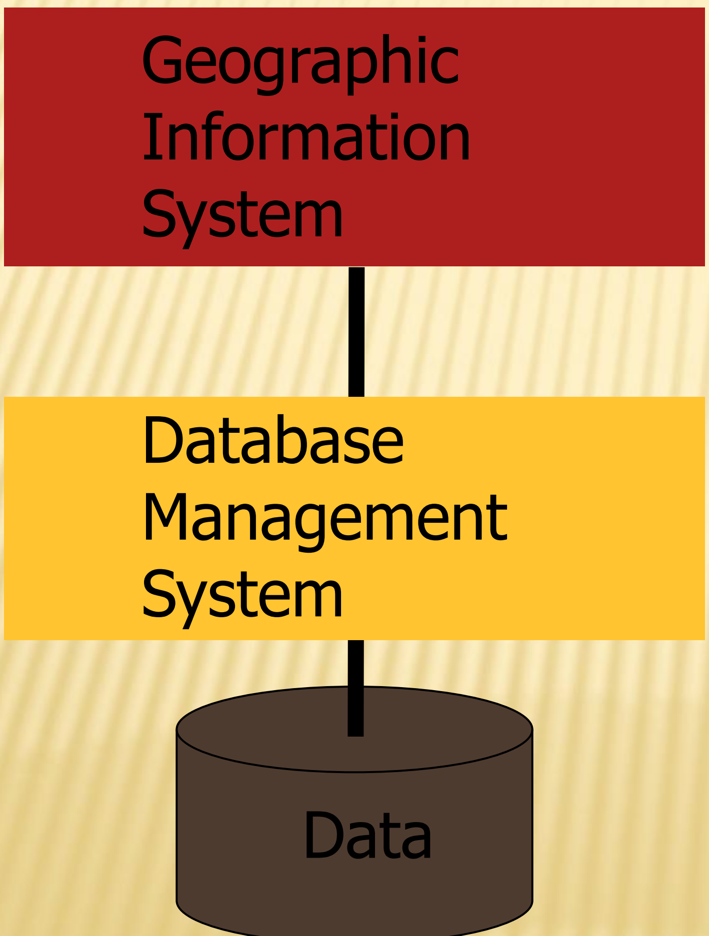
Different users for the same data



- View level:
  - Describe only a part of the entire database.
  - Many users of the database may be concerned with a subset of information.
  - The system may provide many views for the same database
- Conceptual level:
  - Describe what structure data are actually stored in the database.
  - It gives Schematic representation of total data.
- Physical level:
  - Describe how the data are actually stored

ROLE OF DBMS

- Without database GIS is cartography (electronic map)
- No database - No spatial analysis



Task of DBMS

- Data loading
- Editing
- Visualization
- Mapping
- Analysis

- Storage
- Indexing
- Security
- Query

GIS process: project implementation

1. Understanding basic geographic concepts
   - Projections, datums, coordinate systems
   - Reading maps
2. Formulating a game plan
   - Planning the process
3. Acquiring data
   - Data storage formats
   - Data sources
   - Data challenges
4. Database manipulation
   - Attribute data
   - Database management
   - Computer database types
5. Analysis techniques
   - Spatial analysis
   - Models and modeling
     - Cartographic
     - Interpolation
     - Dynamic modelling
6. Presenting the results
   - Map creation and design

Benefits of GIS implementation

- **Expands with time.**
- **Geospatial data are better maintained in a standard format, Hence, better Visualization of data and faster Information Access.**
- **Revision and updating are easier hence better data management**
- **Geospatial data and spatial information are easier to search, analysis and represent hence better decision making**
- **More value added product**
- **Geospatial data can be shared and exchanged freely**
- **Due to Automation, Time and money are saved hence better Operational Efficiencies**
- **Newer Applications by integration of technologies**

Cost benefit ratio

- Various studies showed that considerable benefits may be achieved, provided that the strategy used to implement GIS is suitably chosen.

- Studies also showed that benefits are often related to objectives and that the following benefit/cost ratios may be attained by introducing GIS.

Objective	GIS Operation	Production of Data	Use of Data
Task	• Storage • Update • Manipulation • Maintenance • Retrieval	• Analysis of Data • Map Production • Planning • Project Management	• Map Production • Coordination of Tasks • Information Updating • Information Sharing • Management & Planning • Execution of Task
Benefit / Cost Ratio	**1:1**	**2:1**	**4:1**

GIS – Based on the deployment

- Desktop Application / Full Package
- Web Mapping / Feature Server / Server GIS (server)
- Web Browser with GIS Tools / Thick Client
- Apps, Mashups, APIs – Distributed GIS

Web GIS

- **Web GIS** is a **GIS** system that uses **web** technologies.
- The simplest architecture of a **Web GIS** must have at least one client and one server .
- Client is a desktop application or **web** browser application that allows users to communicate with server, and the server is a **web** server application.

What GIS is <u>not</u>

- GIS is not simply the technology: it also has a (growing and important) conceptual base
- GIS can not produce good results from bad data or poor conceptual frameworks
- GIS is not simply a program to produce maps
- GIS is not a substitute for thinking!
- GIS is not the universal answer to all problems!

Applications of GIS

- **Urban Planning, Management & Policy**
  - Zoning, subdivision planning
  - Land acquisition
  - Economic development
  - Code enforcement
  - Housing renovation programs
  - Emergency response
  - Crime analysis
  - Tax assessment
- **Environmental Sciences**
  - Monitoring environmental risk
  - Modeling storm water runoff
  - Management of watersheds, floodplains, wetlands, forests, aquifers
  - Environmental Impact Analysis
  - Hazardous or toxic facility siting
  - Groundwater modeling and contamination tracking
- **Political Science**
  - Redistricting
  - Analysis of election results
  - Predictive modeling

Civil Engineering/Utility

Locating underground facilities
Designing alignment for freeways, transit
Coordination of infrastructure maintenance

Business

Demographic Analysis
Market Penetration/ Share Analysis
Site Selection

Education Administration

Attendance Area Maintenance
Enrollment Projections
School Bus Routing

Real Estate

Neighborhood land prices
Traffic Impact Analysis
Determination of Highest and Best Use

Health Care

Epidemiology
Needs Analysis
Service Inventory

GIS Software Tools

- GIS started at universities as research tools

Primary flavors

ESRI (ArcGIS) **Intergraph** **QGIS** **Bentley Map**

Microimages **Autocad** **MapInfo**

ERDAS **Manifold** **Smallworld**

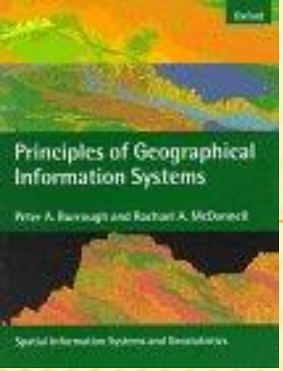
GeoMedia **AUTOCAD MAP 3D** **Maptitude**

The Future

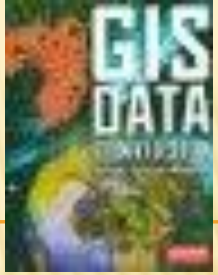
- *FUTURE DATA*
  - Easy access to digital data
  - Remote Sensing and GIS
  - GPS as data source for GIS
  - Image Maps and GIS
  - Data Exchange and GIS
  - Location-Based Services and GIS
- *FUTURE HARDWARE*
  - Workstation Revolution
  - Network Revolution
  - Microcomputer Revolution
  - Mobility Revolution
- *FUTURE SOFTWARE*
  - Software Trends
  - The User Interface and GUII
  - The Raster versus Vector Debate
  - Object – Oriented GIS
  - Distributed Databases
  - GIS User Needs
  - GIS Interoperability
- *FUTURE ISSUES AND PROBLEMS*
  - Privacy
  - Data Ownership
  - Scientific Visualization
  - New Focus

“The application of GIS is limited only by the imagination of those who use it”

Jack Dangermond
Co-founder of ESRI Inc.



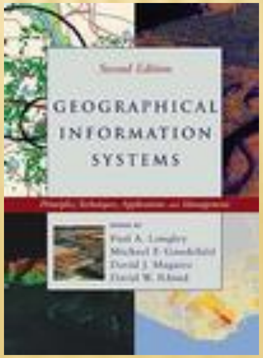
Suggested reading

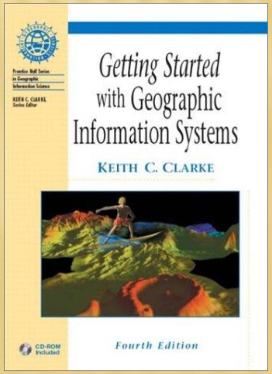


- Burrough, P.A. (1990), *Principles of Geographical Information Systems*. Clarendon Press. Oxford.
- Antenucci, J.C., Brown, K., Croswell, P.L., Kevany, M. and Archer, H. (1991), *Geographic Information Systems: a guide to the technology*. Chapman and Hall. New York.
- Star, J. and Estes, J. (1990), *Geographic Information Systems: an Introduction*. Prentice Hall. Englewood Cliffs
- Arnoff, (1989), Introduction to GIS
- David J. Maguire (Editor), Michael F. Goodchild (Editor), David Rhind (Editor) : Geographical Information Systems: Principles and Applications, 2 Vol.
- Keith C. Clarke: Getting Started with GIS (4th Edition)

SUGGESTED WEBSITES

- http://gisgeography.com/free-gis-software/





Thank You