CIVE 201
Introduction to GIS

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What is GIS?

Have you heard of it?

Have you used it?

Where and when and how?

Geographic Information System

- Most of you have consumed **SPATIAL DATA**
  - Google Maps
  - Google Earth
  - Bing Maps
  - GPS in car
  - Smart phone's GPS
  - Mapquest
  - CAD

- You have used basic GIS
  - Displayed informative layers on a **map**
  - Used the map to guide your decisions (e.g nearby restaurants or gas stations)
  - Interacted with the map to share your thoughts with other

Displaying Data: Patterns

Take a look at this chart

Earthquake Chart

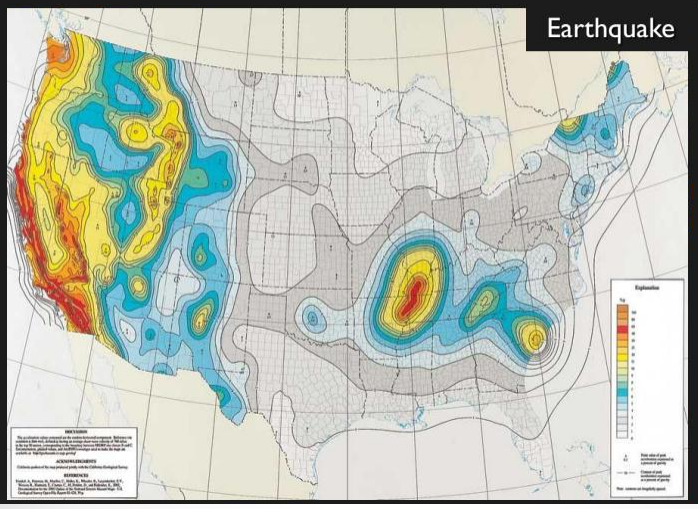
Magnitude	2000	2001	2002	2003	2004	2005					
8.0 to 9.9	1	1	0	1	2	1	2	4	0	1	1
7.0 to 7.9	14	15	13	14	14	10	9	14	12	16	17
6.0 to 6.9	146	121	127	140	141	140	142	178	168	142	124
5.0 to 5.9	1344	1224	1201	1203	1515	1693	1712	2074	1768	1855	1372
4.0 to 4.9	8008	7991	8541	8462	10888	13917	12838	12078	12291	6830	7023
3.0 to 3.9	4827	6266	7068	7624	7932	9191	9990	9889	11735	2903	3236
2.0 to 2.9	3765	4164	6419	7727	6316	4636	4027	3597	3860	3013	3080
1.0 to 1.9	1026	944	1137	2506	1344	26	18	42	21	26	22
0.1 to 0.9	5	1	10	134	103	0	2	2	0	1	0
No Magnitude	3120	2807	2938	3608	2939	864	828	1807	1922	18	22
Total	22256	23534	27454	31419	31194	30478	29568	29685	31777	14805	14897
Estimated Deaths	231	21357	1685	33819	228802	88003	6605	712	88011	1787	226215

looks mundane??

Where are the earthquakes? Are there any spatial patterns?
Are certain areas more prone? Where are these areas?
Can I use this information to update my building codes?

Source: ESRI

GIS can….. Find patterns and help you analyze these patterns



MAPS DO A MUCH BETTER JOB THAN PLAIN TEXT OR TABLES

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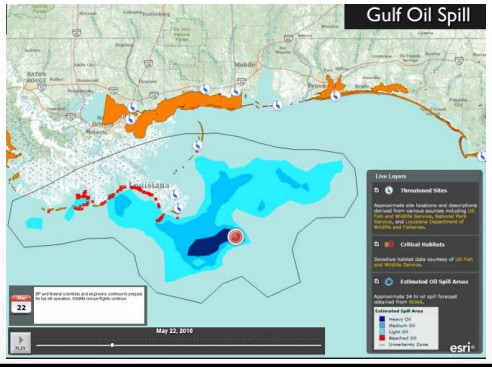
GIS in Emergency Planning

- I have an oil spill at an oil rig
  - Where is the oil located? At what concentrations?
  - Where are the affected areas? How far away?
  - What are my available resources? And how far off are they?



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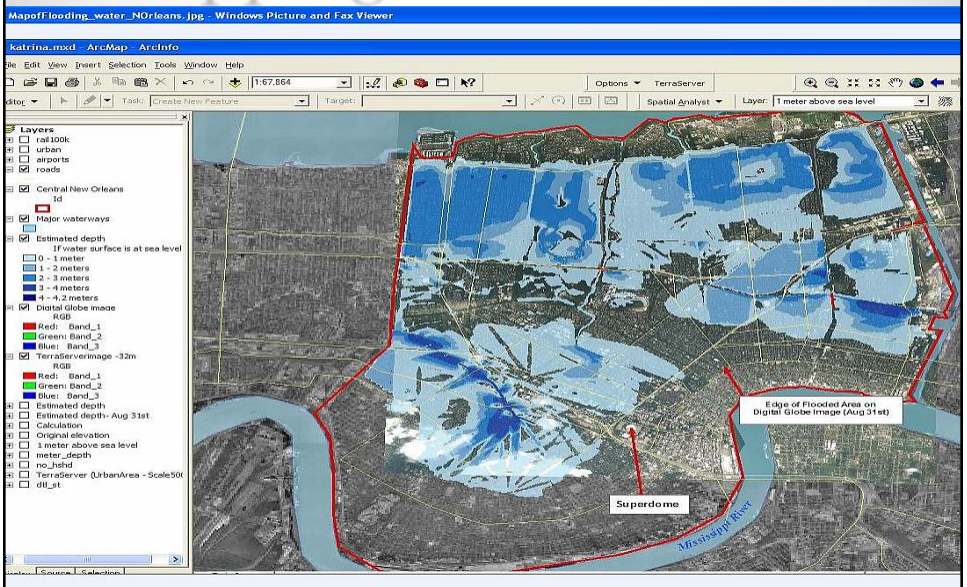
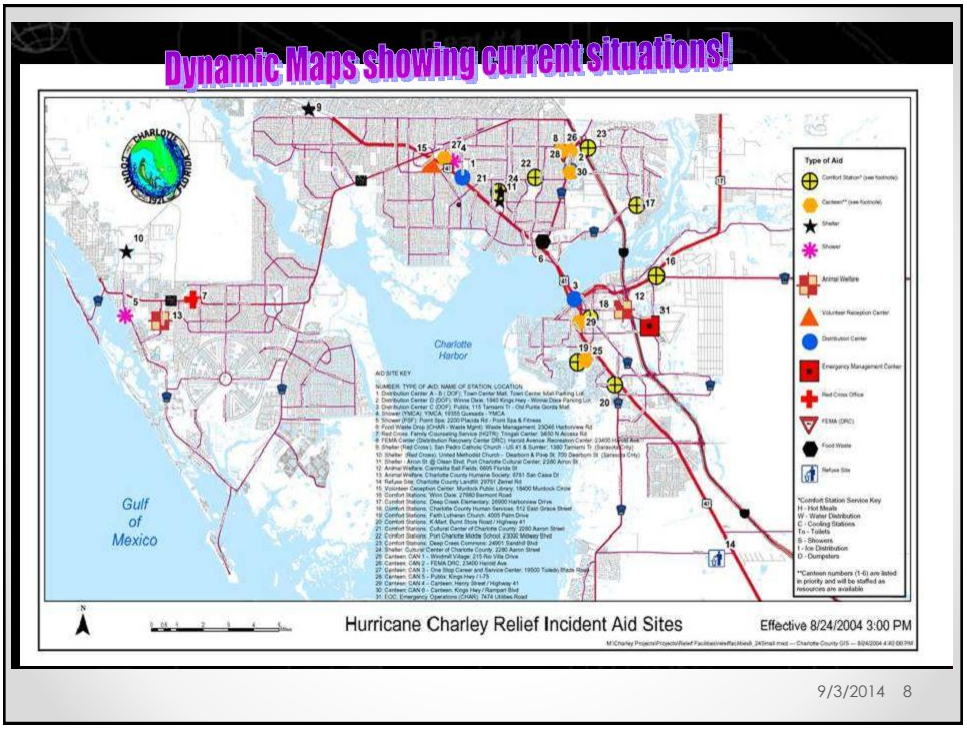
Mapping Flooded Areas

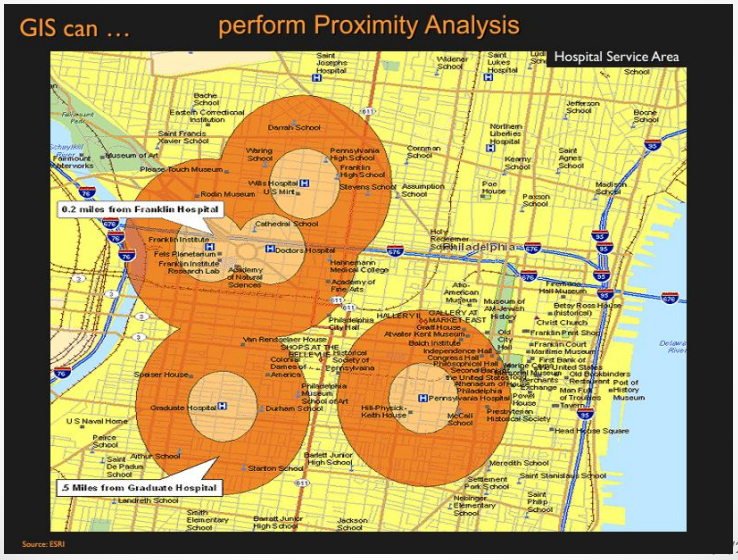




Infrastructure Planning

- You want to build a school or a hospital, where do you want to locate it?
- Several criteria need to go towards your final decision
  - One of them is proximity to people served
  - Distance to existing schools
  - Distance to major infrastructure
- Many of your criteria have a **spatial component** to them

Buffers



Determining Hotspots

- You are required to find roads that have a large number of accidents ➔ allocate funds to fix them
- You are measuring the water quality across a city or a river to find hotspots of pollution
- You are required to find areas with steep slopes, have clays, and are undrained ➔ risk of landslides
- You are required to find locations with highest wind potential + not affecting visual view + not affecting bird migration paths

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How Would You Do That?

- How do you collect your data?
- How do you store them?
- How do you display them?
- How do you analyze them?
- How do you inform people of your decision?

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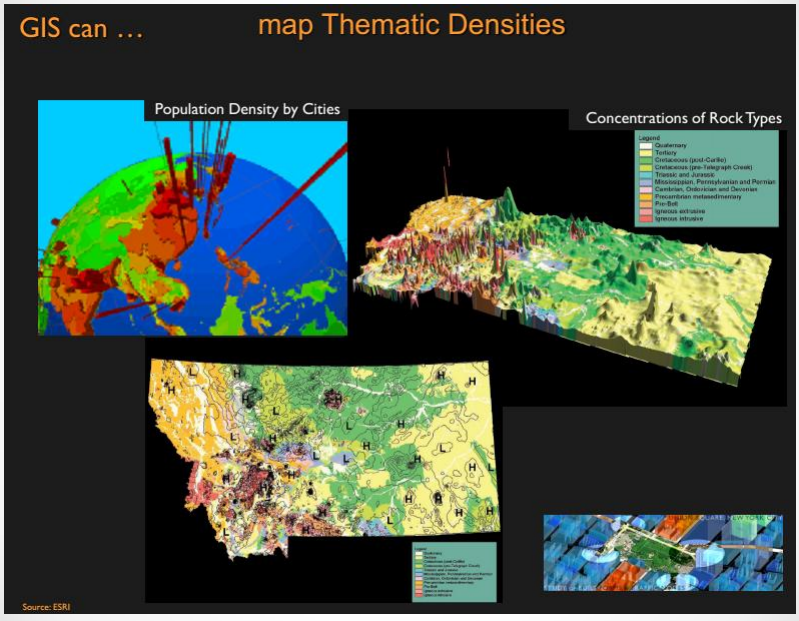

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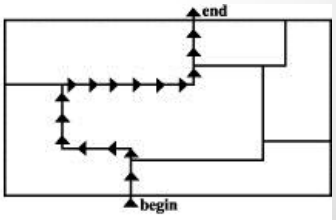
Transportation applications

- A city's **transportation department** needs to:
  - Store information on the state of pavement everywhere on the state highway network
  - Maintain an inventory of all highway signs
  - Analyze data on accidents, look for 'black spots'
- A driver needs to:
  - Find locations, routes
- A delivery company, e.g. Federal Express, UPS, needs to:
  - Keep track of shipments, know where they are
  - Plan efficient delivery routes
- A school bus operator needs to
  - Plan efficient collection routes
- A transit authority needs to
  - Know where transit vehicles are at all times



Studies have shown substantial savings when routes and schedules are managed using GIS

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Los Angeles Metro Speeds, 2011-11-10
Indicatrix
Data from Los Angeles Metro and NextBus
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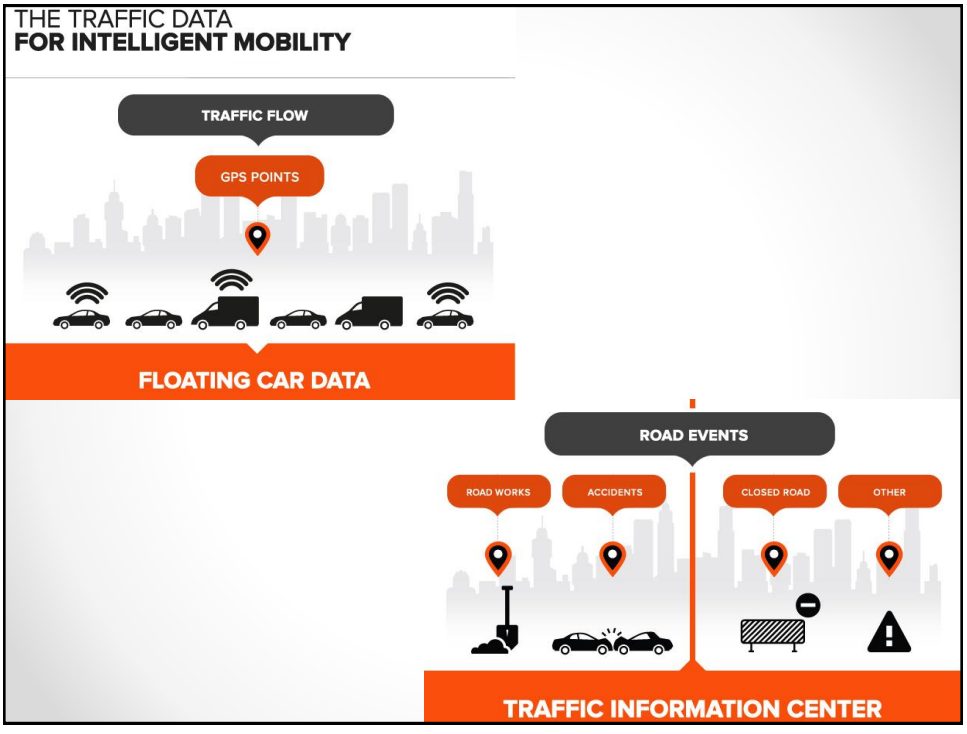
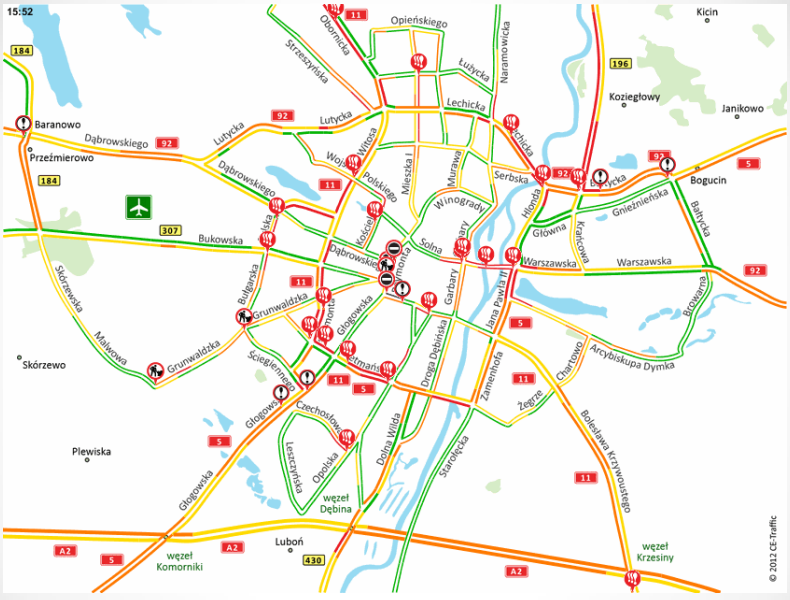
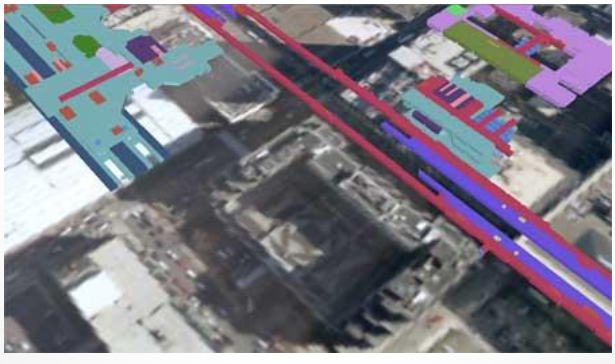

THE TRAFFIC DATA
FOR INTELLIGENT MOBILITY
TRAFFIC FLOW
GPS POINTS
FLOATING CAR DATA
ROAD EVENTS
ROAD WORKS
ACCIDENTS
CLOSED ROAD
OTHER
TRAFFIC INFORMATION CENTER



City Planning

- **In 2010 Philadelphia Center City**
  - Third most populous downtown district in the United States

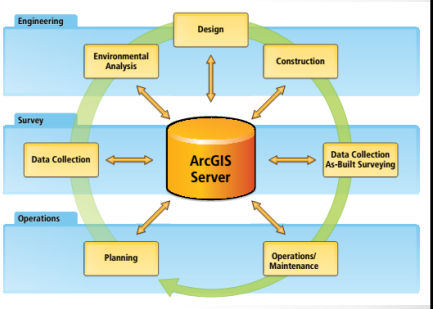
GIS + CAD + BIM = Full data management for facilities management



Interoperability is key

GIS and Civil Engineering

- GIS provides civil engineers with the **IT framework** for maintaining and deploying critical data and applications across every aspect of the infrastructure **project life cycle**:
  - Planning and design
  - Data collection and management
  - Spatial analysis
  - Construction, and operations management
  - Maintenance



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Why Study GIS?

- **80%** of government activities are geographically based
  - Zoning
  - **Public works** (streets, water supply, sewers)
  - Garbage collection
  - Land ownership and valuation
  - Public safety (fire and police)
  - Natural resource management
  - **Highways and transportation**
- **Businesses** use GIS for a very wide array of applications
  - Site selection & market analysis
  - Logistics: vehicle tracking & routing
  - **Natural resource exploration** (petroleum, etc.)
  - Precision agriculture
  - Civil engineering and construction
- **Military and defense**
  - Battlefield management
  - **Satellite imagery interpretation**
- **Scientific research (what my research group does)**

Examples of Applied GIS

- **Urban Planning, Management & Policy**
  - Zoning, subdivision planning
  - Land acquisition
  - Economic development
  - **Code enforcement**
  - Housing renovation programs
  - Emergency response
  - Crime analysis
  - Tax assessment
- **Environmental Engineering**
  - **Monitoring environmental risk**
  - Modeling stormwater 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 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

What Can You Do With GIS?

- With GIS, you can generate and analyze every possible map!
- Create and analyze data that is associated with a location!

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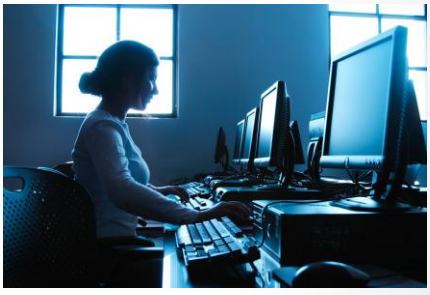
Learning by Doing



Some Basic Definition(s)

Defining GIS

Different definitions of a GIS have evolved in different areas and disciplines

- 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)

Defining GIS

- All GIS definitions recognize that spatial data are unique because they are linked to maps ➔ **Space matters!**
- A GIS should at least consist of a database, map information, and a link between them

➔ **It is a map with a database behind it**

GIS is a computer-based information system that enables capture, modeling, manipulation, retrieval, analysis and presentation of geographically referenced data (Worboys, 1997)

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The World and GIS

- The world we live in is a product of many properties
- Their complex interaction results in the heterogeneity we see
- We can slice the world into a set of properties
- Each one of these properties can be presented in a separate **layer**
- Overlying them regenerates the world

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The World and GIS

- Maps are graphic representations of the real world and a way of **communicating** spatially related information about the world we live in
- Maps are models of the world
  - **All models are wrong**
  - **Some are helpful**
- GIS organizes the world into **'layers'** of geographic objects that are alike

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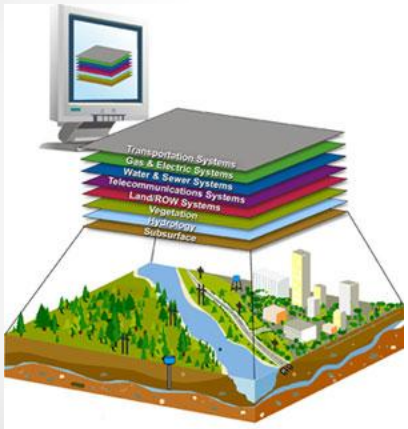
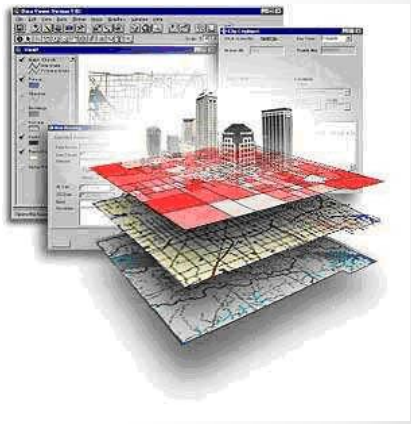
A City in GIS





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The World According to GIS

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

YZ

Attributes

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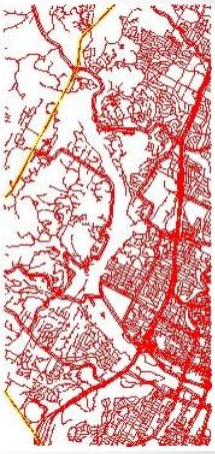
Spatial Data + Attributes

Attributes of central arteries

Length	Centerart_	Street_nam	Street_typ	Sut_dir	Alts	Type
1987.841	1379	CAPITAL OF TEXAS	HWY	N	0	MAJOR
530.507	2028	BEE CAVES	RD		0	MAJOR
609.973	926	F M 2222	RD		0	MAJOR
155.524	3851	MO-PAC	EXPY	N	0	MAJOR
6065.322	946	CAPITAL OF TEXAS	HWY	N	0	MAJOR
1022.476	960	CAPITAL OF TEXAS	HWY	N	0	MAJOR
2459.327	965	F M 2222	RD		0	MAJOR
228.862	2118	BEE CAVES	RD		0	MAJOR
779.617	2148	BEE CAVES	RD		0	MAJOR
210.440	2060	BEE CAVES	RD		0	MAJOR
2916.411	3852	MO-PAC	EXPY	N	0	MAJOR



⌘ Every Feature (e.g. road) has several *Attributes* (e.g. name, length) in an *Attribute Table.*

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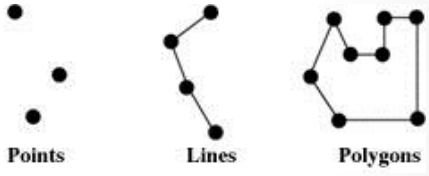
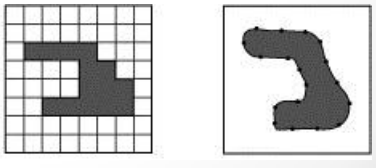
But How Can I Represent the World in Layers?

- 2 models:
  - **Vector**



  - **Raster (grids)**



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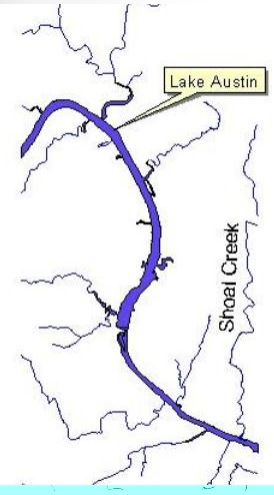
Vectors



- Features are geographic objects represented by a point, line or polygon
  - Polygons (filled or unfilled) for things large enough to have boundaries
  - Lines for things too narrow to be polygons
  - Points for things too small to be poly

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Vector Data

- **Points** represent a specific latitude and longitude
  - Points do not have any length nor do they have area
  - When displayed in ArcMap, they can be displayed at any size but in actuality, they are just a point
- **Lines** have length but no width, and represent things such as transects or roads
  - When a road is represented as a line, it has no area so it does not accurately represent the area on the ground covered by the actual road
- **Polygons** are anything with an area – buildings, municipal boundaries, or water bodies

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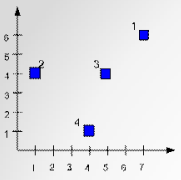
Connecting features to attributes

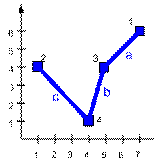


Point No	X	Y
1	7	6
2	1	4
3	5	4
4	4	1

Point No	deep	amount
1	12.35	63.45
2	25.79	79.83
3	3.50	24.34
4	17.52	69.23

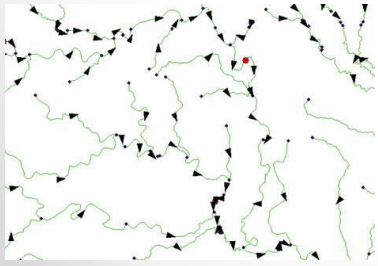
node

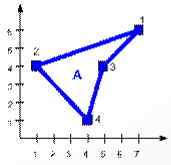
Node No	X	Y
1	7	6
2	1	4
3	5	4
4	4	1



Line	First Node	Last Node
a	1	3
b	3	4
c	4	2

Line	Flow	Capacity
a	960	2200
b	1250	2000
c	1100	2000



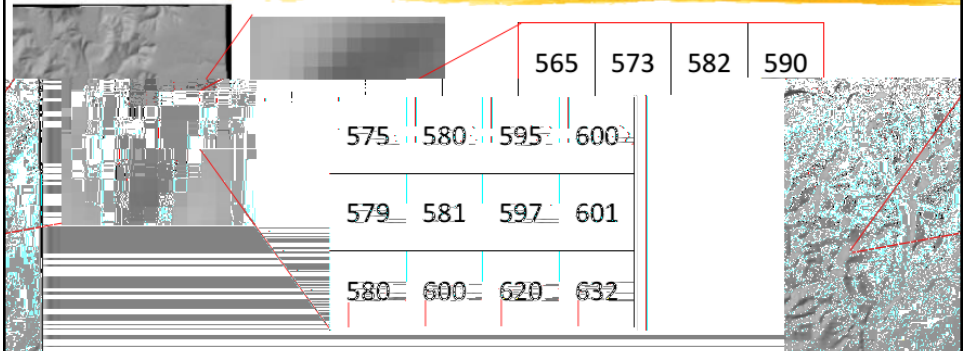


Node No	X	Y
1	7	6
2	1	4
3	5	4
4	4	1

Polygon	Node sequence
A	1,3,4,2,1

Polygon	Area	Population
A	15.23	12.35

Rasters



- Surface composed of matrix of square cells, each containing a value for its location, e.g. elevation.

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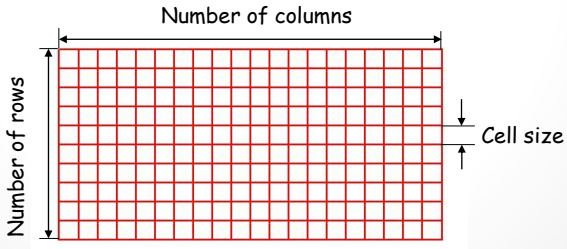
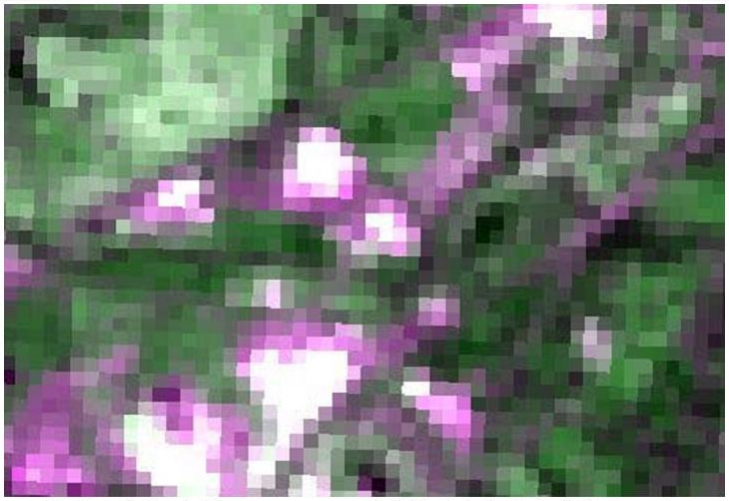
Grid Datasets

- Cellular-based data structure composed of **square cells of equal size** (most of the time) arranged in rows and columns
- The grid cell size and extension (number of rows and columns), as well as the value at each cell have to be stored as part of the grid definition



Landsat Image



Portion of a Landsat image - you can see individual pixels. Each pixel represents an area 30 meters by 30 meters on the surface of the earth

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