Introduction to Geographic Information System (GIS)

NR 506 – **GIS and Remote Sensing**

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Lesson Objectives

- Understand what a GIS is
- Understand how a GIS functions
- Understand how spatial data is represented in a GIS
- Look at some GIS applications

Data vs. Information

- Data, by itself, generally differs from information.
- Data is of little use unless it is transformed into information.
- Information is an answer to a question based on raw data.
- We transform data into information through the use of an Information System.

INFORMATION SYSTEM OVERVIEW

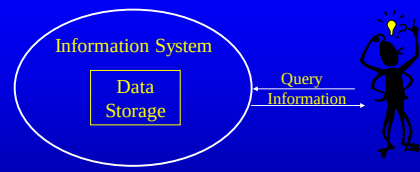
What is an Information System?

SYSTEM USED FOR:

capturing
storing
updating
manipulating
analyzing

DATA

What is an Information System?



Information systems can be very simple, such as a telephone directory.

What is a GIS?

Information System

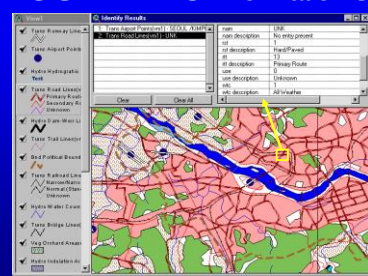
+

Geographic Position

A means of storing, retrieving, sorting, and comparing *spatial data* to support some analytic process.

What is a GIS?

GEOGRAPHIC Information System



GIS links graphical features (**entities**) to tabular data (**attributes**)

GIS Definition

- A GIS is a system (hardware + database engine) that is designed to efficiently, assemble, store, update, analyze, manipulate, and display **geographically referenced information** (data identified by their locations).
- A GIS also includes the **people** operating the system and the **data** that go into the system.

Defining Geographic Information Systems (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 computerised *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)

Key Functions of a GIS

Data can be:

1. Positioned by its known spatial coordinates.
2. Input and organized (generally in **layers**).
3. Stored and retrieved.
4. Analyzed
5. Modified and displayed

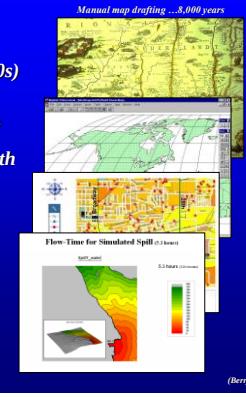
Historical Setting and GIS Evolution

Manual map drafting …8,000 years

Computer Mapping
automates the cartographic process (70s)

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

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



What do you think is the current (00s) frontier?
…but that's another story

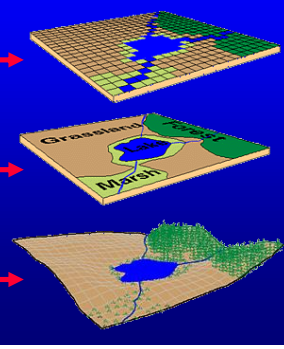
(Berry)

GIS DATA STRUCTURE

(How we represent features or spatial elements)

Representing Spatial Elements

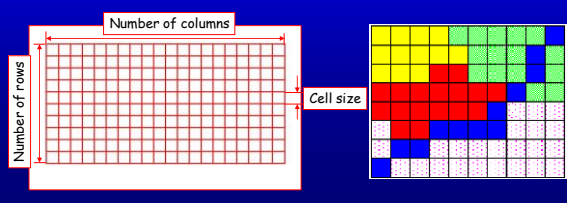
- RASTER
- VECTOR
- Real World



Representing Spatial Elements

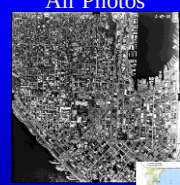
Raster

- Cellular-based data structure composed of *square cells of equal size* 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.



Raster Data Sources

Air Photos

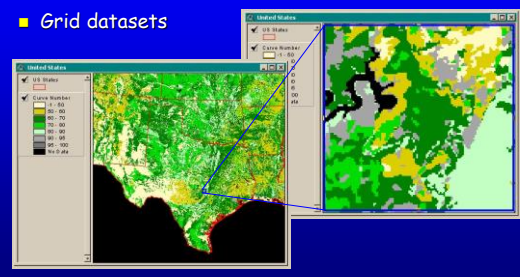


Satellite Imagery

Scanned Maps

Grid Datasets

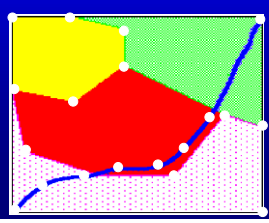
- Grid datasets



Representing Spatial Elements

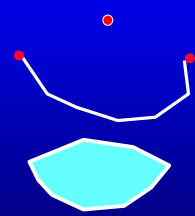
Vector

- Allows user to specify specific spatial locations and assumes that geographic space is continuous, not broken up into discrete grid squares.
- We store features as sets of X,Y coordinate pairs.



Entity Representations

We typically represent objects in space as three distinct spatial elements:



Points - simplest element

Lines (arcs) - set of connected points

Polygons - set of connected lines

We use these three spatial elements to represent real world features and attach locational information to them.

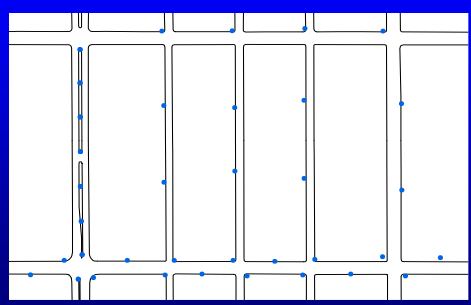
Points

Points are zero dimensional objects which have locations and attribute information but are too small to be represented as areas.

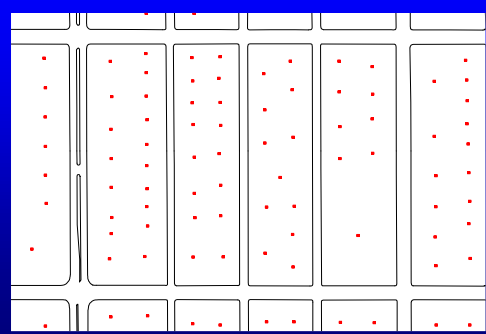
Points

- Soil Samples
  - Type
  - PH
  - Contaminants
- Utility Poles
  - Owner
  - Height
  - Attachments
- Spill Locations
  - Accident Number
  - Type of Spill
  - Extent
- Parcel Centroids
  - Section/Block/Lot No.
  - Address
  - Owner
  - Assessment Data

Light Poles



Parcel Centroids



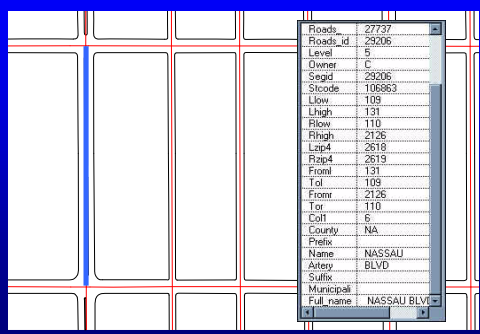
Lines or Arcs

Lines are one dimensional objects which have length but no area. Each line must begin and end at a node.

Lines or Arcs

- Street Centerline
  - Street Name
  - Address Ranges
- Water Main
  - Pipe size
  - Pipe Material
  - Date Installed
- Stream
  - Depth
  - Quality
  - Flow Rate

Street Centerlines



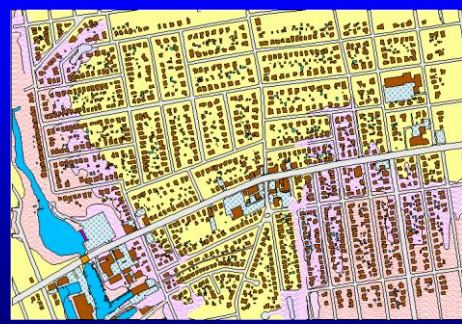
Polygons

Polygons are closed mathematical figures of any shape or size. They are formed by a series of connected lines.

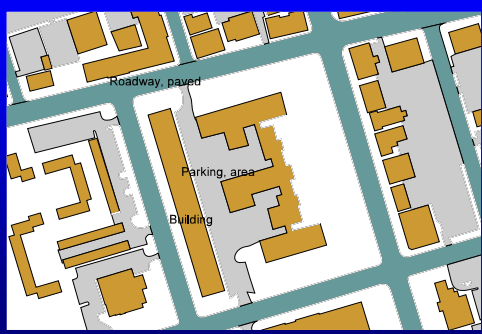
Polygons

- Parcel
  - Parcel ID Number
  - Dimensions and Area
- Soil Boundaries
  - Type
  - Permeability
- Flood Zones

Polygons



Polygons

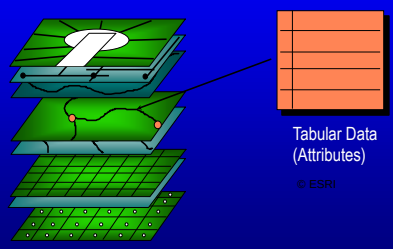


Attributes

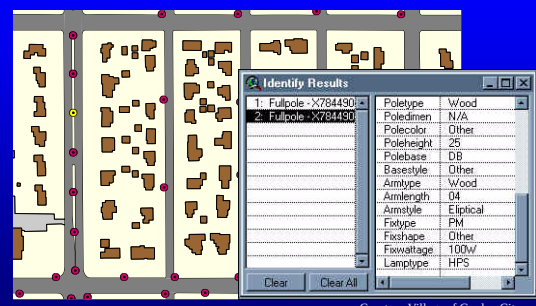
- In the raster data model, the cell value (Digital Number) is the attribute. Examples: brightness, landcover code, SST, etc.
- For vector data, attribute records are linked to point, line & polygon features. Can store *multiple* attributes per feature. Vector features are linked to attributes by a *unique feature number*.

"Linked" Attribute Data

Information which describes an entity represented by a graphic feature.

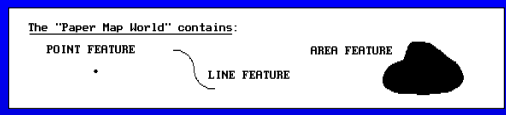


"Linked" Attributes



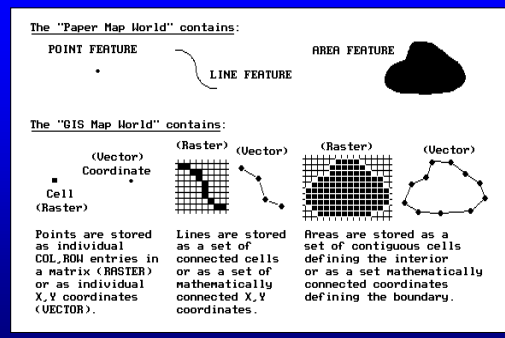
Courtesy Village of Garden City

Storing Points, Lines and Areas



(Berry)

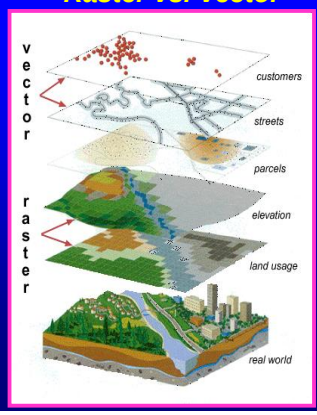
Storing Points, Lines and Areas



…how do you think Vector and Raster data structures store Surfaces, Volumes and Hyper Volumes?

(Berry)

Raster vs. Vector

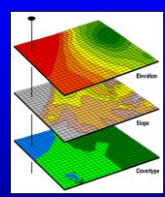


Vector – Advantages and Disadvantages

- Advantages
  - Good representation of reality
  - Compact data structure
  - Topology can be described in a network
  - Accurate graphics
- Disadvantages
  - Complex data structures
  - Simulation may be difficult
  - Some spatial analysis is difficult or impossible to perform

Raster – Advantages and Disadvantages

- Advantages
  - Simple data structure
  - Easy overlay
  - Various kinds of spatial analysis
  - Uniform size and shape
  - Cheaper technology
- Disadvantages
  - Large amount of data
  - Less "pretty"
  - Projection transformation is difficult
  - Different scales between layers can be a nightmare
  - May lose information due to generalization



GIS FUNCTIONALITY

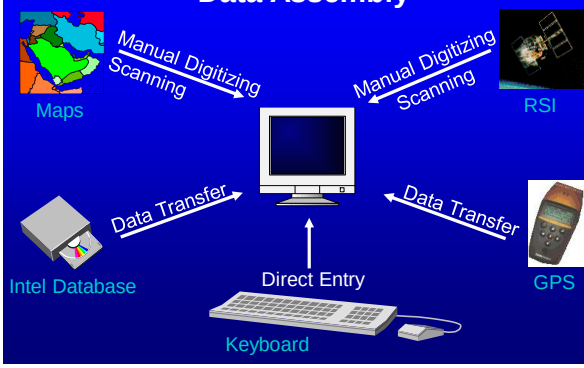
(What do they do?)

GIS Functions

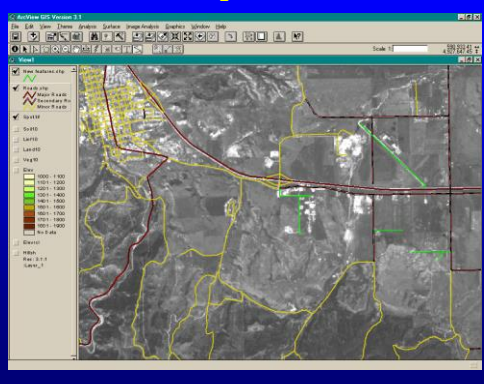
- Data Assembly
- Data Storage
- Spatial Data Analysis and Manipulation
- Spatial Data Output

GIS Functions

Data Assembly

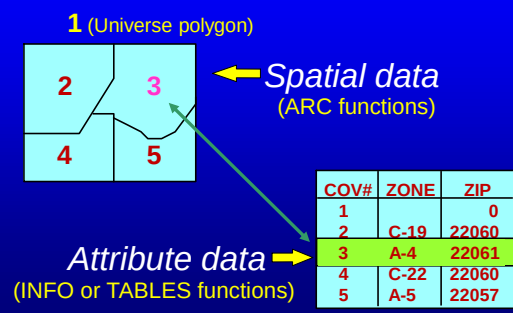


Data Input/Creation



GIS Functions

GIS Storage



COV#	ZONE	ZIP
1		0
2	C-19	22060
3	A-4	22061
4	C-22	22060
5	A-5	22057

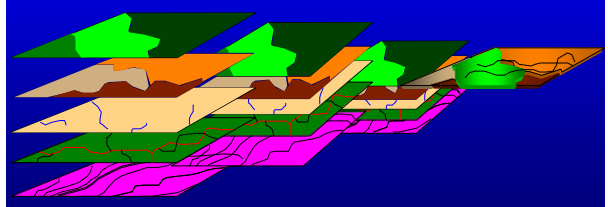
GIS Functions

Spatial Data Manipulation and Analysis

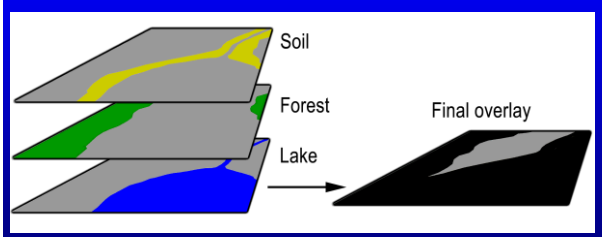
- Common Manipulation
  - Reclassification
  - Map Projection changes
- Common Analysis
  - Buffering
  - Overlay
  - Network

Spatial Analysis

- Overlay function creates new "layers" to solve spatial problems



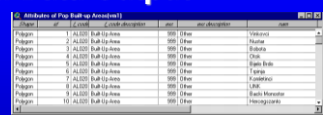
Map Overlay



GIS Functions

Spatial Data Output

- Tables
- Maps
- Interactive Displays
- 3-D Perspective View



SOME EXAMPLES AND GIS APPLICATIONS

Why Study GIS?

- 80% of **local government** activities estimated to be geographically based
  - plats, zoning, public works (streets, water supply, sewers), garbage collection, land ownership and valuation, public safety (fire and police)
- a significant portion of **state government** has a geographical component
  - natural resource management
  - highways and transportation
- **businesses** use GIS for a very wide array of applications
  - retail site selection & customer analysis
  - logistics: vehicle tracking & routing
  - natural resource exploration (petroleum, etc.)
  - precision agriculture
  - civil engineering and construction

Why Study GIS?

- **Military and defense**
  - Battlefield management
  - Satellite imagery interpretation
- **scientific research** employs GIS
  - geography, geology, botany
  - anthropology, sociology, economics, political science
  - Epidemiology, criminology

GIS Applications

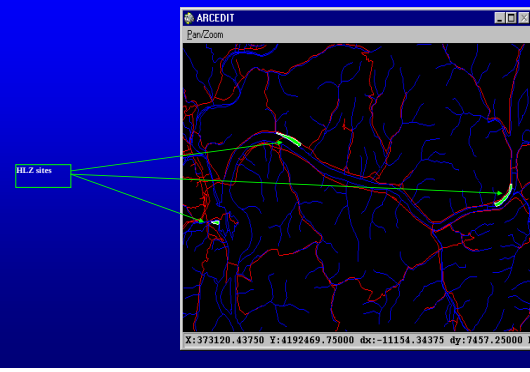
- Site selection
  - Helicopter Landing Zones
  - Amphibious Assault (Water Depth)
  - Buffer Zones
  - Flight Planning
  - Battlefield Visualization



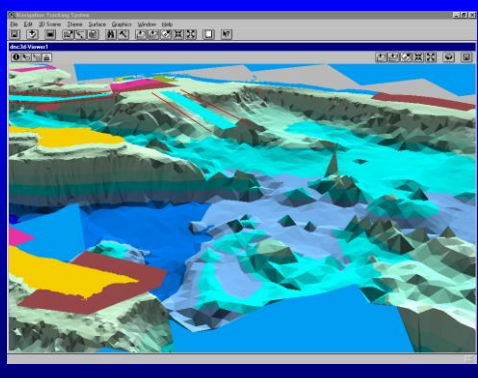


Overlay based on Common Geographic Location

Helicopter Landing Zones

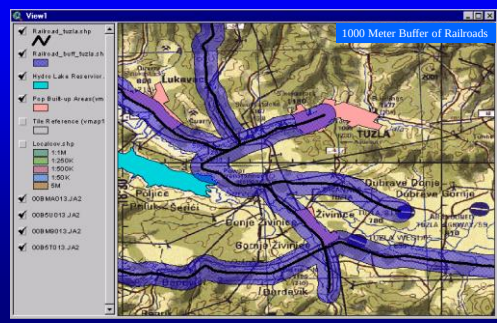


Amphibious Assault Planning

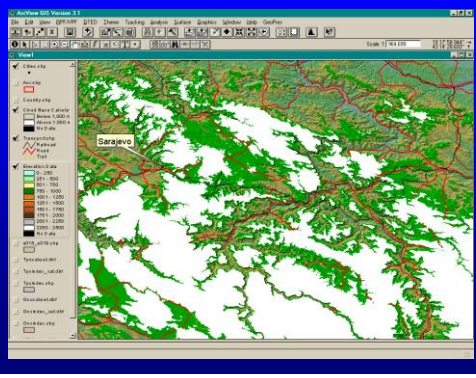


Spatial Analysis

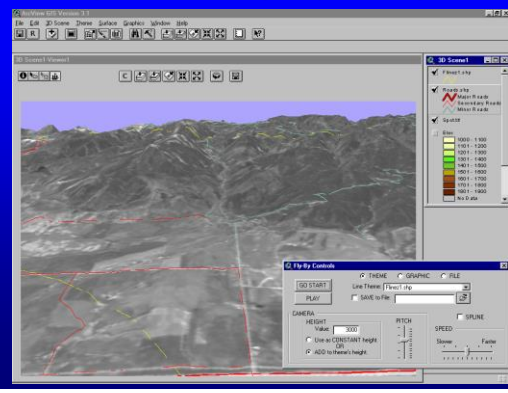
Proximity Analysis (Buffers)



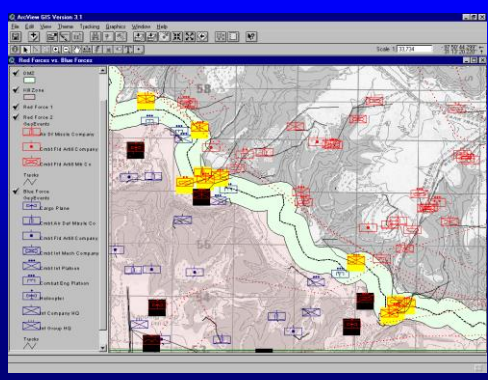
Flight Planning



Flight Planning/Flythroughs



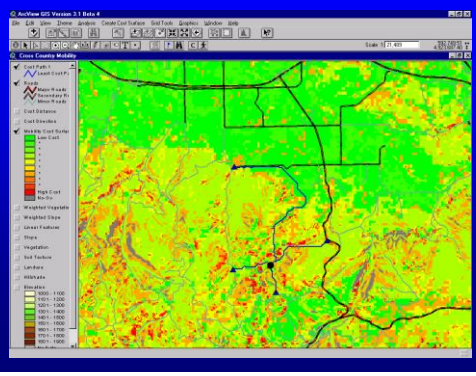
Battlefield Visualization and/or Situation Awareness



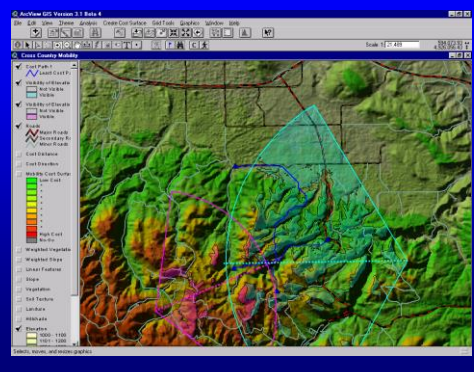
Other GIS Applications

- Cross country movement
  - Route planning
  - Indivisibility study
- Facilities management
- Airfield assessment
- Road network analysis (convoys)
- Propagation coverages
- Observation post siting analysis
- Perspective views

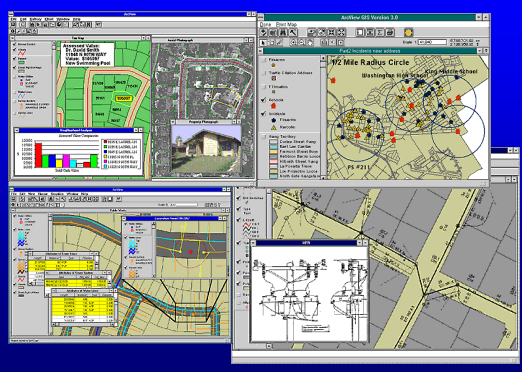
CCM Analysis
(Cross Country Movement)



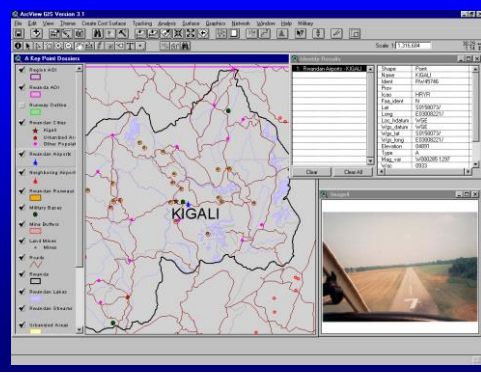
CCM & Viewshed



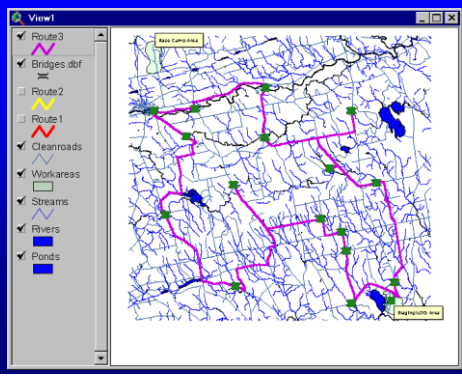
Facilities Management



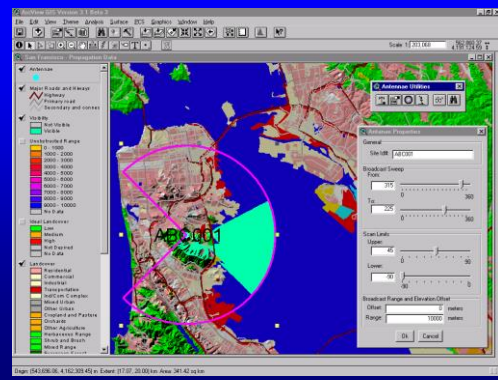
Airfields



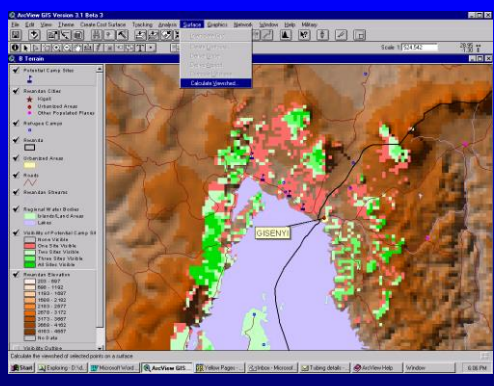
Network Analysis



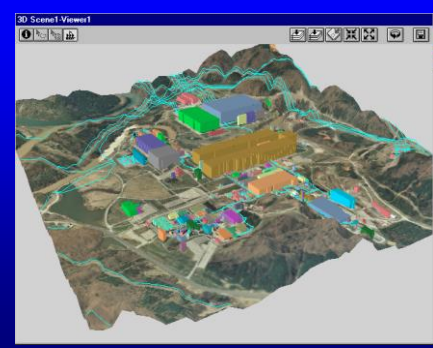
Antenna Propagation Coverages



Observation Post Siting Analysis



Perspective Views



SUMMARY

- ✓ Key Concepts
- ✓ Data representation
- ✓ Applications

Software: ArcGIS

In the case your school does not have a copy of ArcGIS, you will need to obtain an evaluation copy of ArcGIS (60 day trial only) in order to do the exercises at home

We advise you to order the evaluation copy BEFORE you start the course, as it may take some time before the software gets to you.

Follow this link http://www.esri.com/software/arcgis/arcview/eval/evaluate.html

Which will take you to this page:

You will then click on the Request a Trial button as pointed in the image on the right. This will take you to a page containing an electronic form which needs to be completed and sent online.

Alternatively, you can go straight into the following link: http://www.esri.com/apps/products/offers/av93dvd/index.cfm