Geographic Information Systems (GIS) and ITS
Outline

• Introduction
• What is GIS?
• What can we do with GIS?
• How does GIS work?
• Geography database & types of data
• Features and functionalities of GIS
• Applications of GIS
We Live in Two Worlds

Natural World

Self-Regulating

Managed

Constructed World

. . . These Are Increasingly In Conflict
Context and Content

Seeing the Whole

- Patterns
- Linkages
- Trends

Managing Places

- Watersheds
- Communities
- Neighborhoods
- Districts
Example
Example

THE GLOBAL TRANSPORTATION SYSTEM
What is GIS?
Geographic Information System (GIS) is a computer-based system including software, hardware, people, and geographic information.

A GIS can:
create, edit, query, analyze, and display map information on the computer.
Geographic Information System

- **Geographic** – Most of the data collected is associated with some location in space.

- **Information** – characteristics (data), can be used to provide meaningful information about a given location.

- **System** – running operation on the information and associated to the geography – which requires hardware, networks, software, data, and operational procedures.
Who uses GIS?

• International organizations
  – The World Bank, UNEP, FAO, WHO, etc.
• Private industry
  – Transport, Real Estate, etc.
• Government
  – Ministries of Environment, Housing, Agriculture, etc.
  – Local Authorities, Cities, Municipalities, etc.
  – Provincial Agencies for Planning, Parks, Transportation, etc.
• Non-profit organizations/NGO’s
• Academic and Research Institutions
What can you do with a GIS?

• The possibilities are unlimited...
  – Resource management
  – Land use planning
  – Water and Sanitation Mapping
  – Electricity network mapping
  – Transportation routing
  – Environmental impact assessment
How does a GIS work?

- GIS data has a spatial/geographic reference

  - Such as:
    - a latitude & longitude
    - a national coordinate system
    - an address
    - a district
    - a wetland identifier
    - a road name
Geography and Databases

- A GIS stores information about the world as a collection of thematic layers that can be linked together by geography.
GIS provides Data Integration

- Roads
- Land Parcels
- Population
- Utilities
- Land Mines
- Hospitals
- Refugee Camps
- Wells
- Sanitation
Two fundamental types of data

- **Vector**
  - A series of x,y coordinates
  - For discrete data represented as points, lines, polygons

- **Raster**
  - Grid and cells
  - For continuous data such as elevation, slope, surfaces

- A Desktop GIS should be able to handle both types of data effectively!
Data Representation

- Raster
- Vector
- Real World
Representing Spatial Elements

**Raster**
Stores images as rows and columns of numbers with a Digital Value/Number (DN) for each cell.

Units are usually represented as square grid cells that are uniform in size.

Data is classified as “continuous” (such as in an image), or “thematic” (where each cell denotes a feature type).

Numerous data formats (TIFF, GIF, ERDAS.img etc)
Representing Spatial Elements

- Matrix of cells or pixels
- Each cell contains a value

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<thead>
<tr>
<th>OID</th>
<th>VALUE</th>
<th>COUNT</th>
</tr>
</thead>
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<td>9</td>
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<tr>
<td>3</td>
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</tbody>
</table>

- **Forest land**: 8100 FL010
- **Wetland**: 4500 WL001
- **Crop land**: 8100 CL301
- **Urban**: 9900 UL040

NoData
The quality of the representation depends on the number of cells.
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.
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.
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.
**Raster vs. Vector**

**Raster Advantages**

The most common data format

Easy to perform mathematical and overlay operations

Satellite information is easily incorporated

Better represents “continuous”-type data

**Vector Advantages**

Accurate positional information that is best for storing discrete thematic features (e.g., roads, shorelines, sea-bed features).

Compact data storage requirements

Can associate unlimited numbers of attributes with specific features
Other features of a GIS

- Produce good cartographic products (translation = maps)
- Generate and maintain metadata
- Use and share geoprocessing models
- Managing data in a geodatabase using data models for each sector
GIS FUNCTIONALITY
GIS Functions

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

Data Assembly

Maps

Manual Digitizing
Scanning

Data Transfer

Intel Database

Direct Entry

Keyboard

Manual Digitizing
Scanning

RSI

Data Transfer

GPS
Data Input/Creation
GIS Functions

GIS Storage

1 (Universe polygon)

Spatial data
(ARC functions)

Attribute data
(INFO or TABLES functions)

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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
GIS Functions

Spatial Data Output

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

Citizens

The World

Inventory

Decision Support
APPLICATIONS
GIS Applications

• Site selection
  – Helicopter Landing Zones
  – Amphibious Assault (Water Depth)
  – Buffer Zones
  – Flight Planning
  – Battlefield Visualisation
Helicopter Landing Zones

HLZ sites
Amphibious Assault Planning
Spatial Analysis

Proximity Analysis (Buffers)

1000 Meter Buffer of Railroads
Flight Planning
Battlefield Visualization and/or Situation Awareness
Other GIS Applications

• Cross country movement
  – Route planning
  – Intervisibility study
• Facilities management
• Airfield assessment
• Road network analysis (convoys)
• Propagation coverages
• Observation post siting analysis
• Perspective views
CCM Analysis
Facilities Management
Network Analysis
Antenna Propagation Coverage
Trajectories Representation of Mobile Users