Spatial Data Concepts

Q.1 What is GIS?

(A) A geographic Information system (GIS) is a computer system for capturing, storing, querying, analyzing, and displaying geospatial data. Also called geographically referenced data, geospatial data are data that describe both the locations and the characteristics of spatial features such as roads, land parcels, and vegetation stands on the Earth's surface. The ability of a GIS to handle and process geospatial data distinguishes GIS from other information systems. It also establishes GIS as a technology important to such occupations as market research analysts, environmental engineers, and urban and regional planners, which are also listed at the U.S. Department of Labor's website.

Q.2 Explain applications of GIS.

(A) From its beginnings, GIS has been important in natural resource management, including land-use planning, natural hazard assessment, wildlife habitat analysis, riparian zone monitoring, and timber management. Here are some examples on the Internet:

- The U.S. Geological Survey has the National Map program that provides nationwide geospatial data for applications in natural hazards, risk assessment, homeland security, and many other areas (http://nationalmap.usgs.gov).
- The U.S. Census Bureau maintains an On-Line Mapping Resources website, where Internet users can map public geographic data of anywhere in the United States (http://www.census.gov/geo/www/maps/).
- The U.S. Department of Housing and Urban Development has a mapping program that combines housing development information with environmental data (http://www.hud.gov/offices/cio/emaps/index.cfm).
- The U.S. Department of Health and Human Services warehouse provides access to information about health resources, including community health centers (http:// datawarehouse.hrsa.gov/).

In more recent years GIS has been used for crime analysis, emergency planning, land records management, market analysis, and transportation applications. Here are some examples on the Internet:

- The Department of Homeland Security's National Incident Management System (NIMS) identifies GIS as a supporting technology for managing domestic incidents (http:// www.dhs.gov/).
- The National Institute of Justice uses GIS to map crime records and to analyze their spatial patterns by location and time (http://www.ojp.usdoj.gov/nij/maps/).
- The Federal Emergency Management Agency links a flood insurance rate map database to physical features in a GIS database (http://www.fema.gov/plan/ prevent/fhm/mm_main.shtml).

Integration of GIS with the global positioning system (GPS), wireless technology, and the Internet has also introduced new and exciting applications (e.g.. Tsou 2004). Here are some examples:

- Location-based services (LBS) technology allows mobile phone users to be located and to receive location information, such as nearby ATMs and restaurants.
- Interactive-mapping websites let users select map layers for display and make their own maps.
- In-car navigation systems find the shortest route between an origin and destination and provide tum-by-tum directions to drivers.
- Mobile mapping allows field workers to collect and access geospatial data in the field.
- Precision farming promotes site-specific farming activities such as herbicide or fertilizer application.

Q.3 Explain components of GIS.

(A) Like any other information technology, GIS requires the following four components to work with geospatial data:

- **Computer System :** The computer system includes the computer and the operating system to run GIS. Typically the choices are PCs that use the Windows operating system (e.g., Windows 2000, Windows XP) or workstations that use the UNIX or Linux operating system. Additional equipment may include monitors for display, digitizers and scanners for spatial data input. GPS receivers and mobile devices for fieldwork, and printers and plotters for hard-copy data display.

- **GIS Software :** The GIS software includes the program and the user interface for driving the hardware. Common user interfaces in GIS are menus, graphical icons, command lines, and scripts.

- **People :** People refers to GIS professionals and users who define the purpose and objectives, and provide the reason and justification for using GIS.

- **Data :** Data consist of various kinds of inputs that the system takes to produce information.

- **Infrastructure (METHOD) :** The infrastructure refers to the necessary physical, organizational, administrative, and cultural environments that support GIS operations. The infrastructure includes requisite skills, data standards, data clearinghouses, and general organizational patterns.

Q.4 Explain the following terms - (a) Spatial Data, (b) Attribute Data

(A) (a) Spatial Data

Spatial data describe the locations of spatial features, which may be discrete or continuous. Discrete features are individually distinguishable features that do not exist between observations. Discrete features include points (e.g. wells), lines (e.g., roads), and areas (e.g., land use types). Continuous features are features that exist spatially between observations. Examples of continuous features are elevation and precipitation. A GIS represents these spatial features on the Earth's surface as map features on a plane surface. This transformation involves two main issues: the spatial reference system and the data model.

The locations of spatial features on the Earth's surface are based on a geographic coordinate system with longitude and latitude values, whereas the locations of map features are based on a plane coordinate system with x-y-coordinates. Projection is the process that can transform the Earth's spherical surface to a plane surface and bridge the two spatial reference systems. But because the transformation always involves some distortion, hundreds of plane coordinate systems that have been developed to preserve certain spatial properties are in use. To align with one another spatially for GIS operations, map layers must be based on the same coordinate system. A basic understanding of projection and coordinate systems is therefore crucial to users of spatial data.

(b) Attribute Data

Attribute data describe the characteristics of spatial features. For raster data, each cell has a value that corresponds to the attribute of the spatial feature at that location. A cell is tightly bound to its cell value. For vector data, the amount of attribute data to be associated with a spatial feature can vary significantly. A road segment may only have the attributes of length and speed limit, whereas a soil polygon may have dozens of properties, interpretations, and performance data. How to join spatial and attribute data is therefore important in the case of vector data.