Course: BSc CSIT

Madan Bhandari Memorial College

Geographic Information System

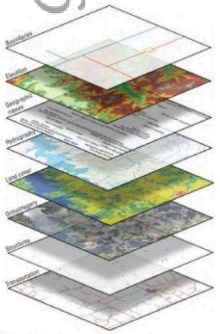
GIS Functions, Benefits, Applications and Scope

CSC482 Unit-1 Class 4

मधु सुदन अधिकारी

Geographic Information System

By: Madhu Sudan Adhikari



Agenda

- GIS Functions (Stages of spatial data handling)
- Benefits of GIS,
- Applications of GIS
- Scope of GIS

Stages of spatial data handling

- **Data entry and preparation**
- **Data Storage and Management**
- **Spatial Analysis and Modeling**
- **Visualization and Output**

Stages of spatial data handling

- **Data entry and preparation**
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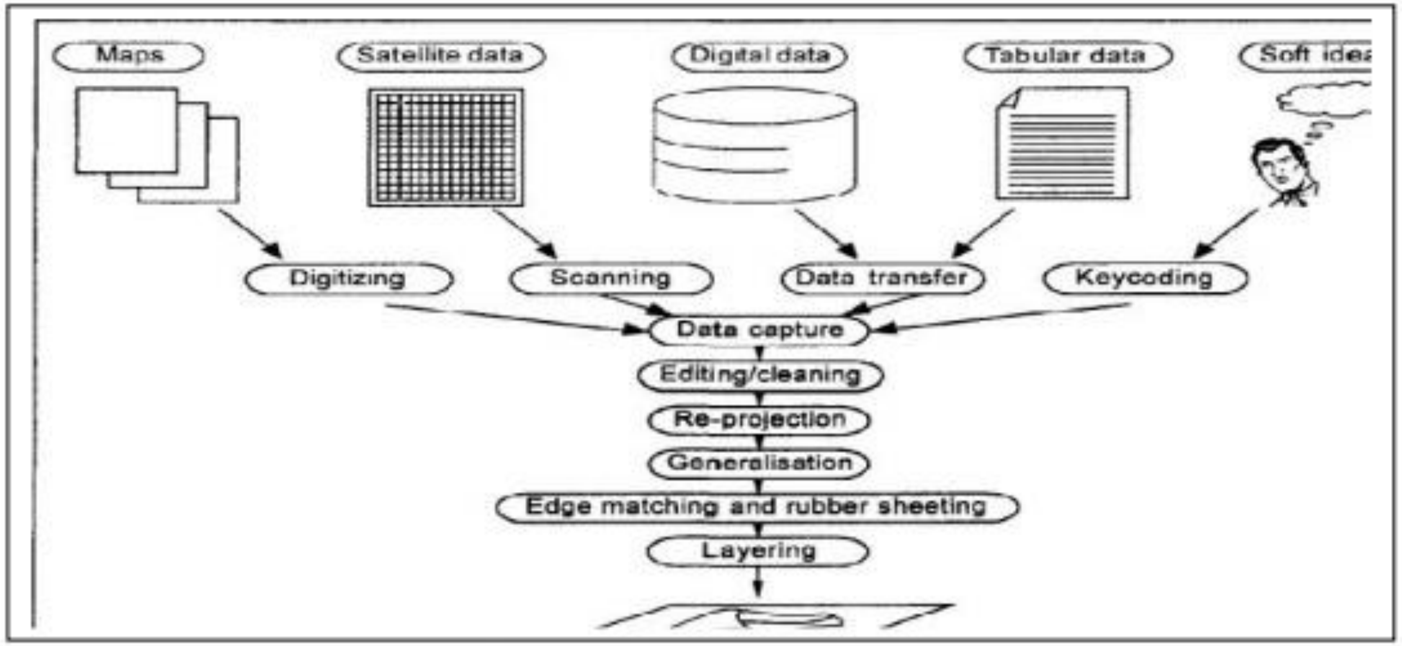
Data entry and preparation

- Building a GIS database starts with data collection and integration.
- GIS must handle various data types.
- Users often create their own GIS datasets.
- Data input in GIS is called data encoding.
- Encoding and editing together form the data stream.



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Data entry and preparation

- GIS Collects both spatial data (location) and attribute data (descriptive info).
- Methods of data input:
  - GIS uses four main methods to input data,
    1. Typing data via keyboard (e.g., entering coordinates or attribute information manually)
    2. Digitizing data manually (e.g., tracing map features using a digitizing tablet)
    3. Using automated digitization tools (e.g., converting satellite images into vector data automatically)
    4. Capturing data through scanning (e.g., scanning paper maps to create digital versions)
  - Additionally, GIS can import data by directly converting files without manual input, known as direct file translation (e.g., importing CAD or shapefiles directly).

Spatial data capture

Primary Data

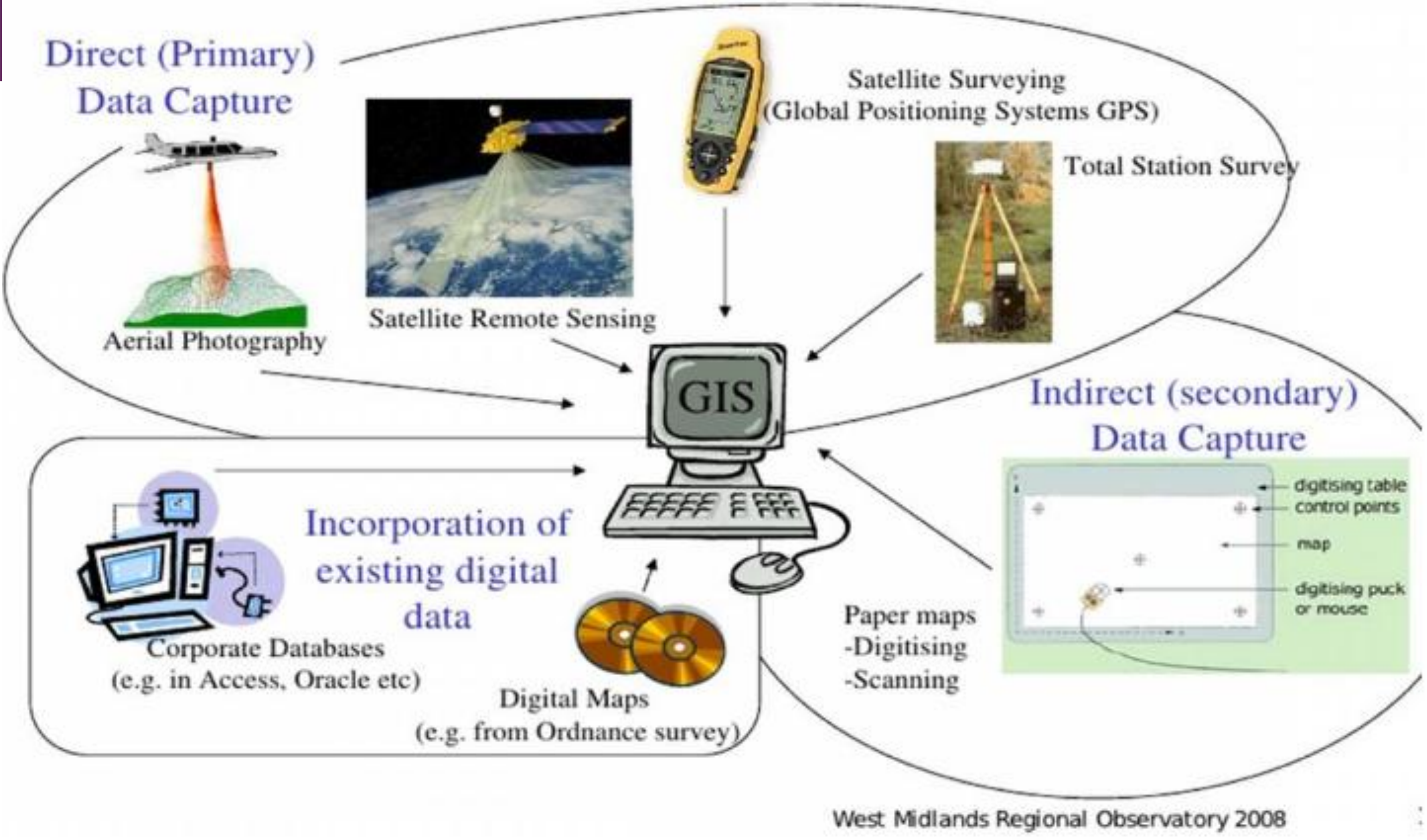
Data which is captured directly from the environment is known as primary data.

Secondary Data

Any data which is not captured directly from the environment is known as secondary data.

Data entry and preparation

- **Supports diverse data sources:**
  - **Surveys, remote sensing imagery, databases, APIs, etc.**



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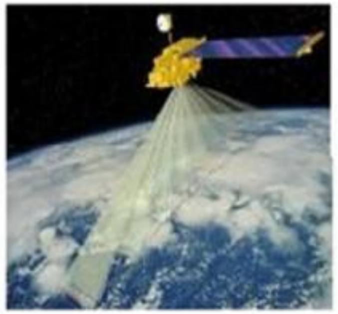
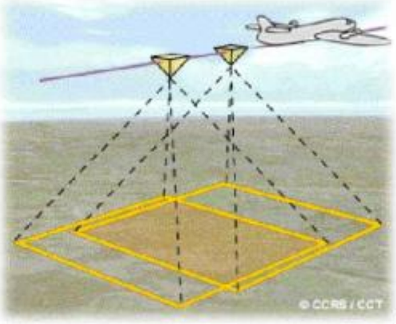
Data entry and preparation

- **Methods of entering spatial data into GIS**
  - **Direct entry from scratch**

field survey data





remotely sensed images

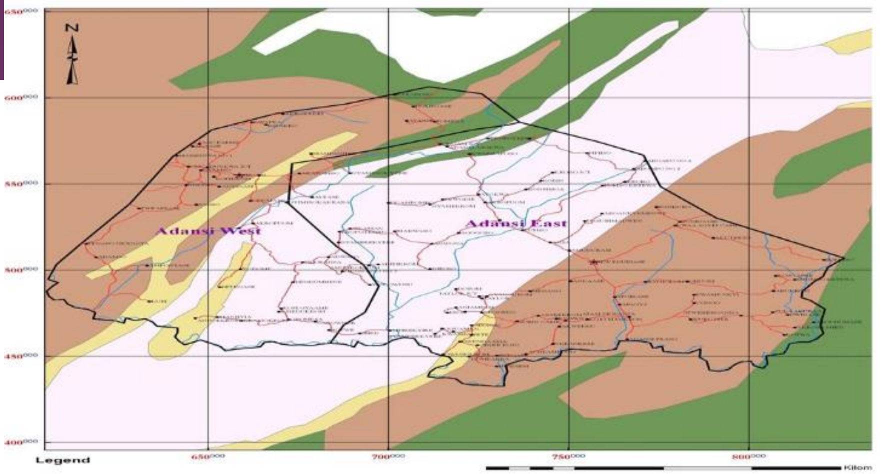
This is the primary, and the most ideal way to obtain spatial data

- **Ground-based techniques remain the most reliable data source;**
- **high quality data;**
- **often customized for specific project or use**
- **Data from these sources are costly;**
- **lots of time needed to get data**

Data entry and preparation

- **Methods of entering spatial data into GIS**
  - **Indirectly from secondary data sources**

Digitization

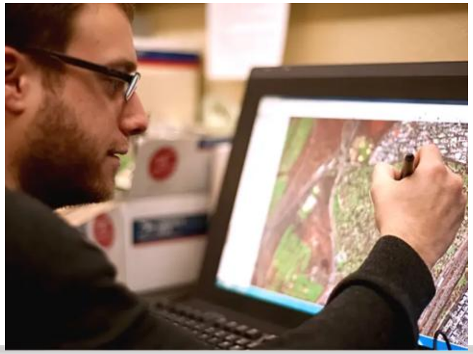


scanning

Manual digitizing

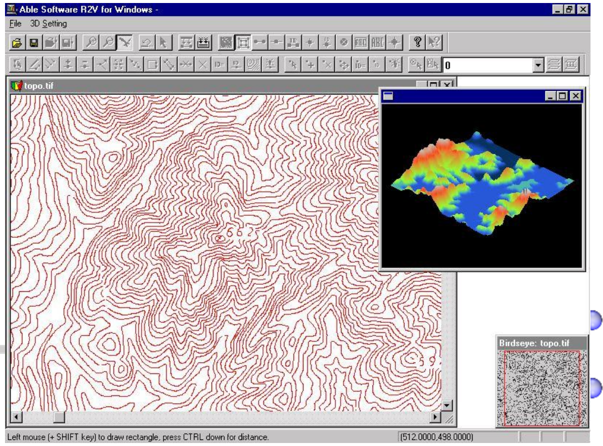
On-tablet digitizing

Semi-automatic digitizing



On-screen digitizing

automatic digitizing



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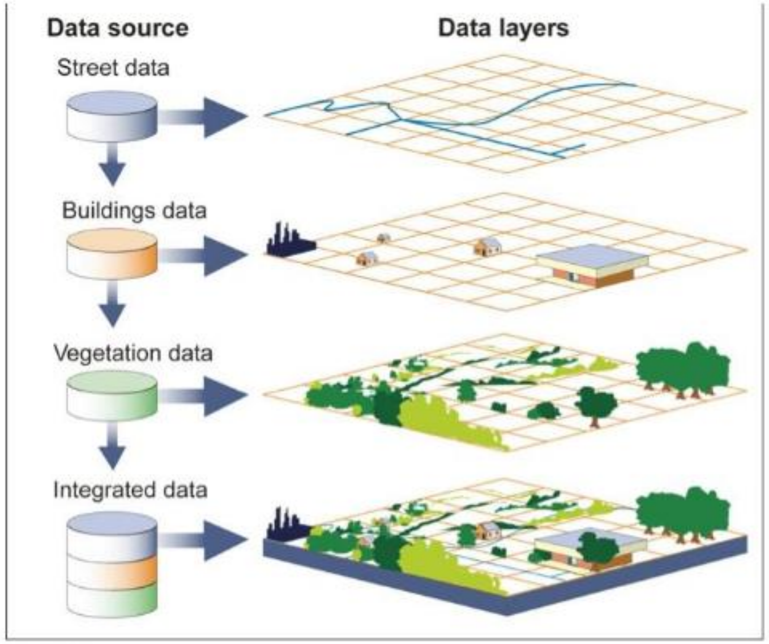
Data entry and preparation

- Converts raw data into usable GIS formats
  - Transforms unstructured or external data into GIS-readable formats (e.g., shapefiles, GeoJSON, geodatabases).
  - Georeferences scanned maps or images to align them with real-world coordinates.
  - Supports data format conversion between vector and raster as needed (e.g., digitized parcels to raster land cover).



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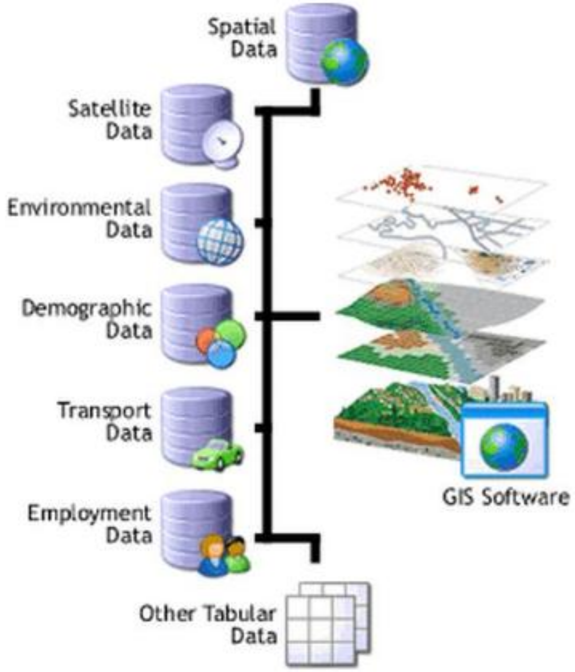
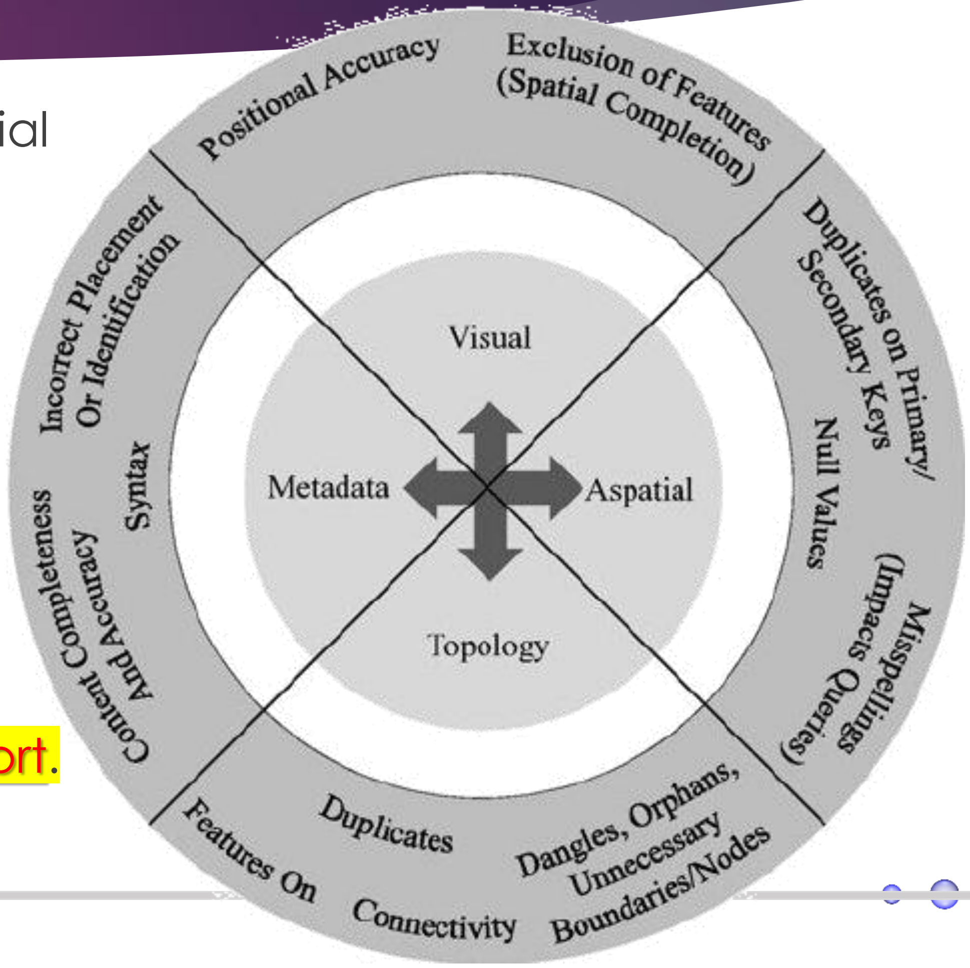


Data entry and preparation

- Addresses the critical first step in GIS: building the spatial database.
- Offers quality control tools to reduce errors.
  - Validates geometry (e.g., checks for gaps, overlaps, or invalid shapes in digitized features).
  - Flags attribute inconsistencies, such as missing values, incorrect data types, or duplicates.
- Supports standardized data formats to improve interoperability.

Data collection can account for up to 80% of project effort.



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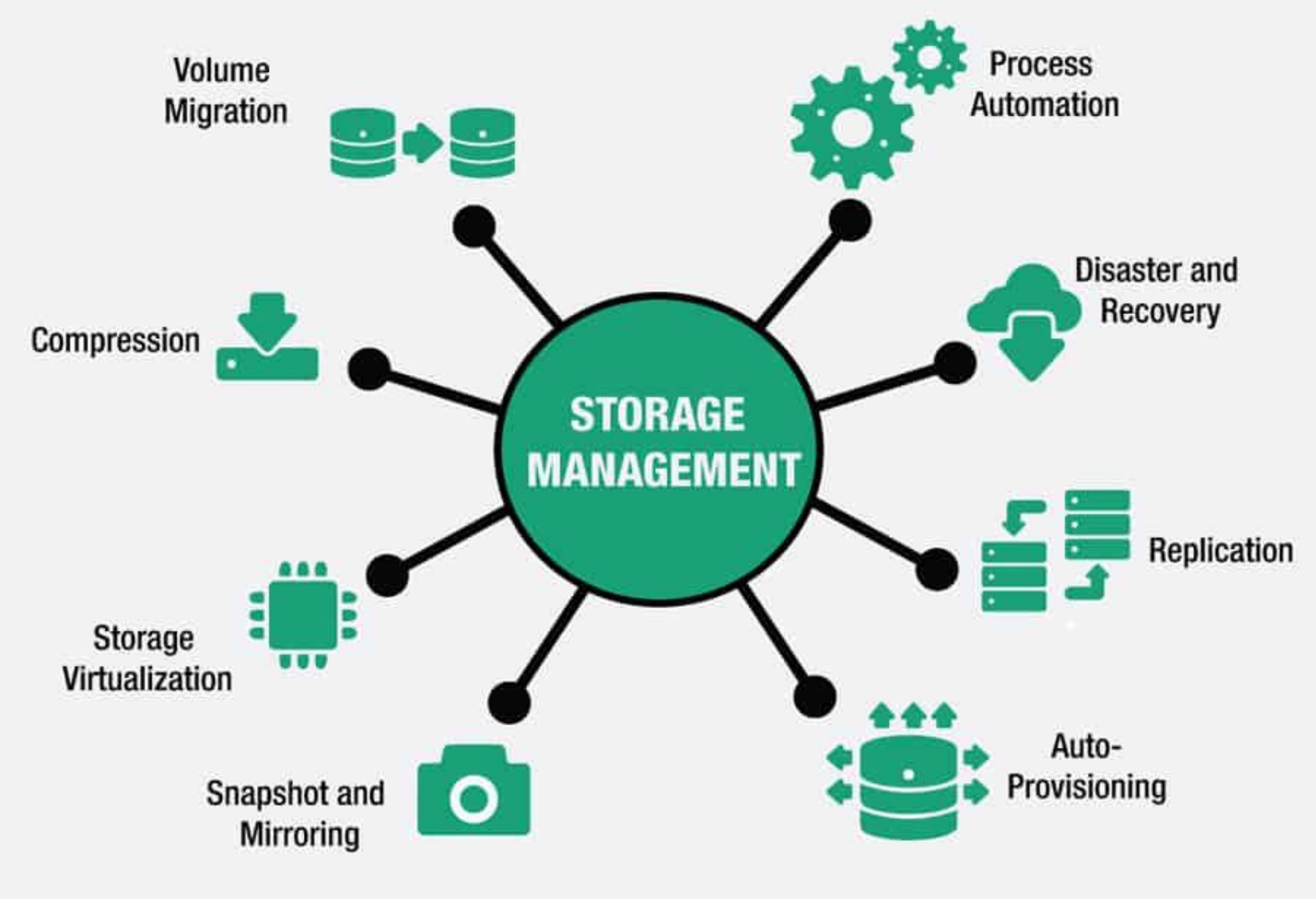
Stages of spatial data handling

- Data entry and preparation
- **Data Storage and Management**
- Spatial Analysis and Modeling
- Visualization and Output

Data Storage and Management



Data Storage and Management

💾 GIS Data Storage

- GIS stores **data in databases**, not as static maps.
- Links **spatial (location)** data with **attribute (non-spatial)** information.
- 📦 **Geodatabases**: Most efficient and widely used for managing spatial data.
- 🖥️ **Desktop vs. Cloud** storage:
    - Desktop: Local control, limited collaboration.
    - Cloud: Easier sharing, real-time access, enhanced scalability/security.

Data Storage and Management

🛠️ **GIS Data Maintenance**

🔍 **Data Quality Control**: Ensures accuracy, reliability, and consistency through defined roles and review processes.

📄 **Metadata**: Describes data origin, collection method, and limitations for informed use.

🧾 **Version Control**: Tracks edits and supports collaborative data updates over time.

Data Storage and Management

🔓 **Data Access and Retrieval**

- 📁 **Organization**: Structured folders, geodatabases, and consistent naming enhance clarity and usability.
- ⚡ **Indexing**: Speeds up queries and analysis, especially in large datasets.
- 🔐 **Access Control**: Defines user permissions through governance policies to manage who can view or edit the data.

Stages of spatial data handling

- Data entry and preparation
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- **Spatial Analysis and Modeling**
- Visualization and Output

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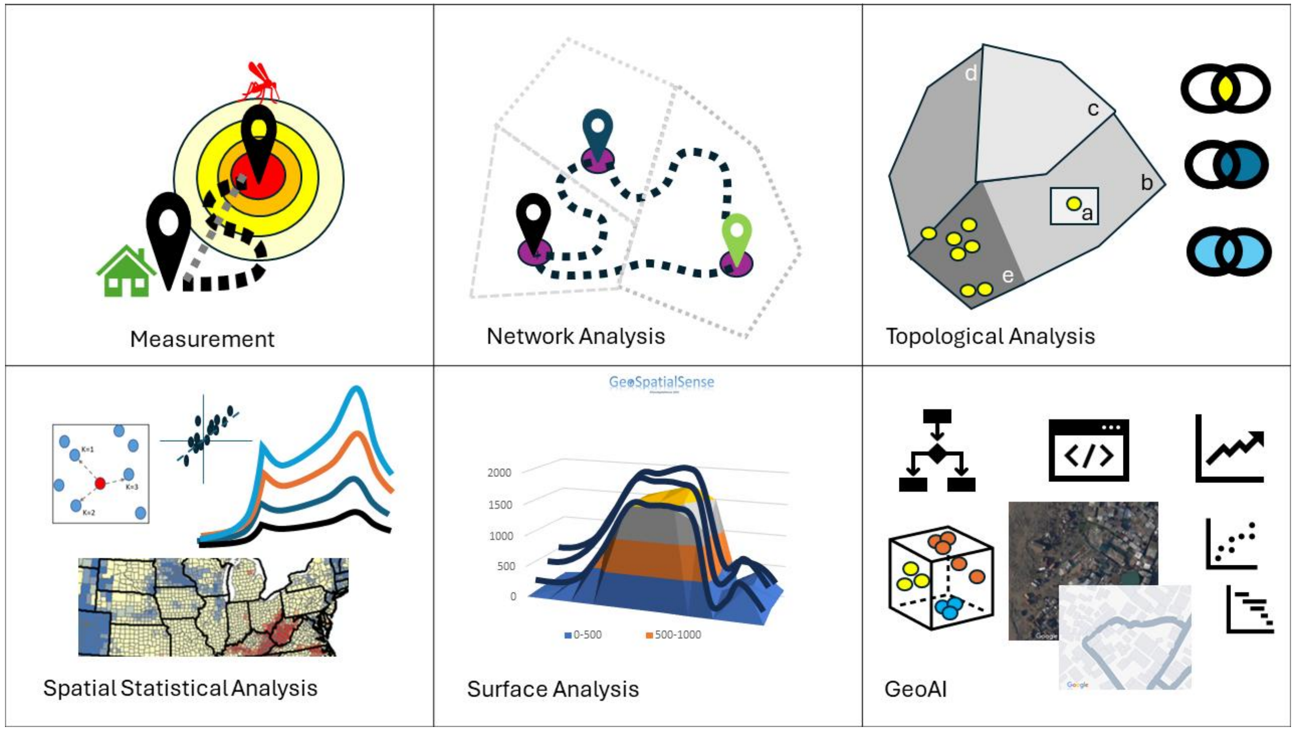
Spatial Analysis and Modeling

- **Spatial data manipulation: Classic GIS tasks like spatial queries, measurements, buffering, and overlaying map layers**
- **Spatial data analysis: Descriptive and exploratory analysis using data manipulation and visualization**
- **Spatial statistical analysis: Hypothesis testing to determine if data patterns are expected or unexpected based on statistical models**
- **Spatial modeling: Predictive modeling of spatial processes to forecast outcomes and conduct "what if" analyses**



Spatial Analysis and Modeling

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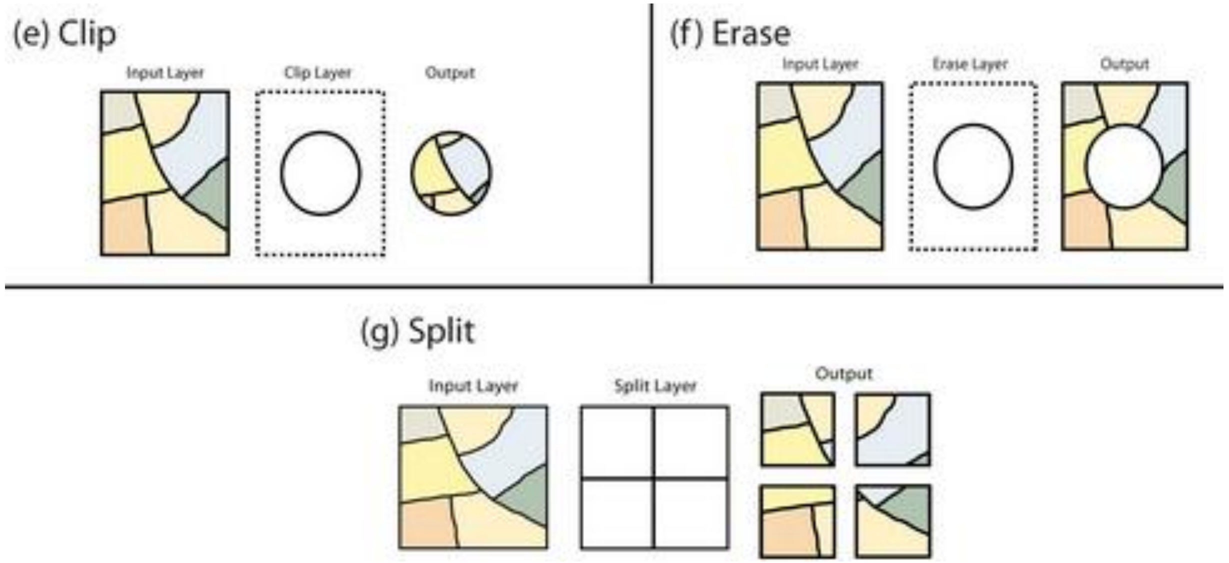
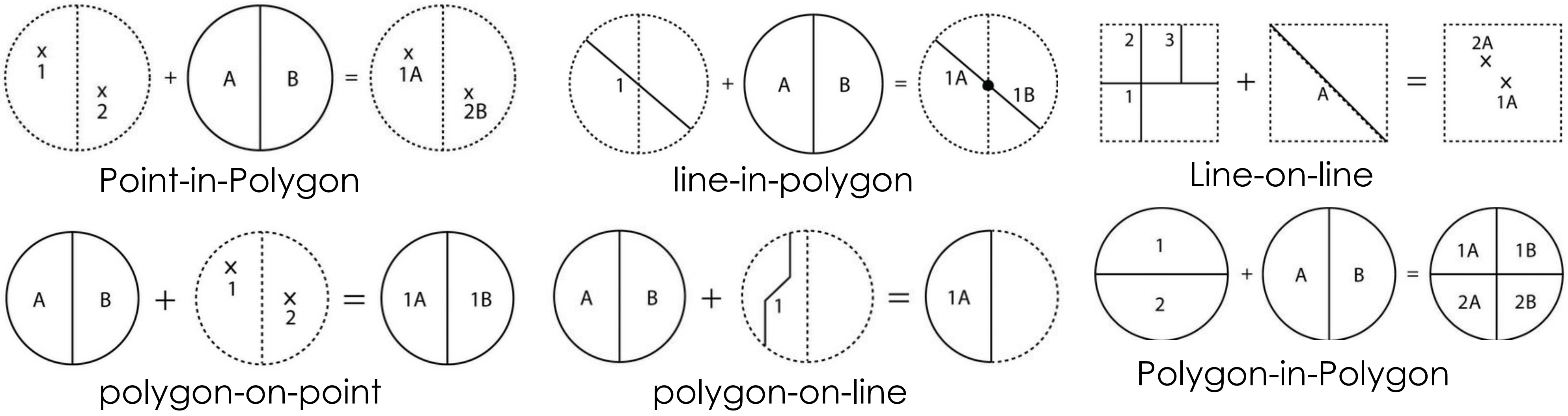
- **Vector Spatial Analysis** means working with specific parts of map data to study them.
- **Extraction methods** are ways to cut out or pick parts of the data:
    - Clip (cut out a section)
    - Split (divide into parts)
    - Select (choose specific items)
    - Erase (remove parts)



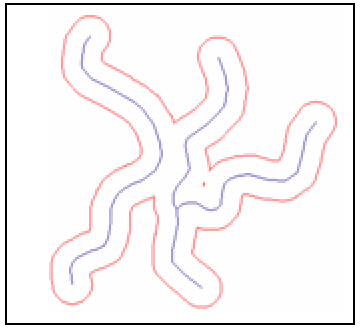
Spatial Analysis and Modeling

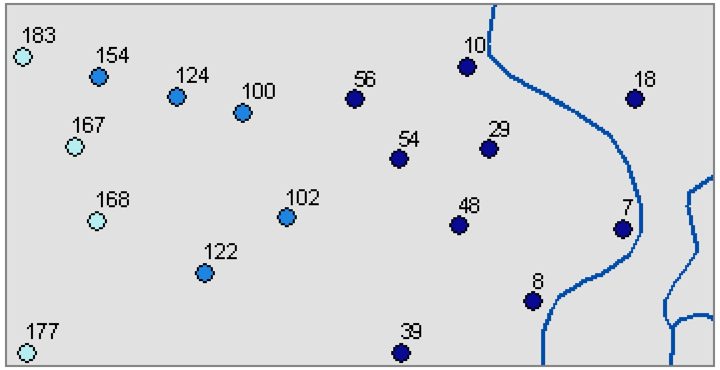
Overlay techniques show how different map features fit together:

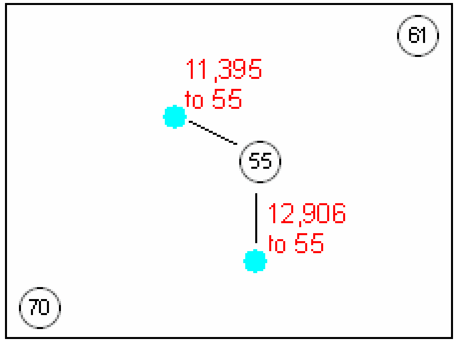


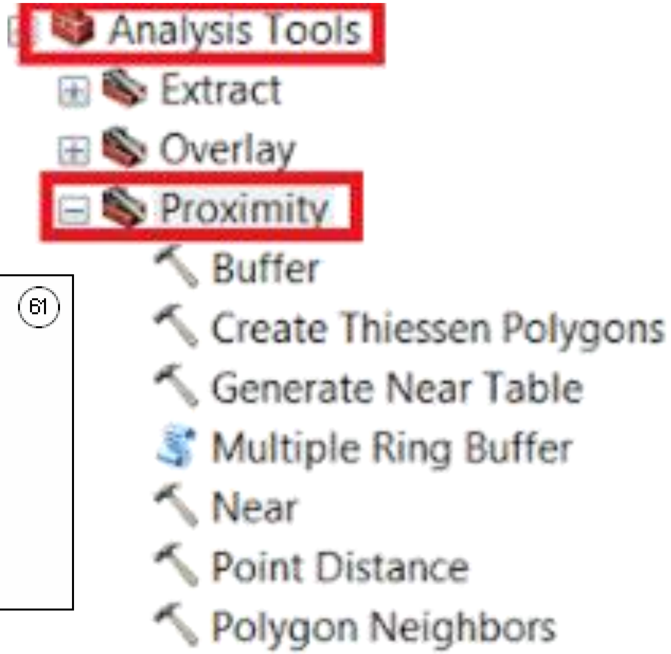
Spatial Analysis and Modeling

- Proximity tools help measure distances and create zones around features:
  - Buffer (create a zone around a feature)
  - Near (find the closest feature)
  - Point Distance (measure distance between points)









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Spatial Analysis and Modeling

Raster Spatial Analysis

a) Surface Analysis
   a) Slope
   b) Aspect
   c) Contour
   d) Hill Shade
   e) Viewshed
b) Local Functions and Statistics
c) Neighborhood Functions and Statistics
d) Zonal Functions
   a) Distance
   b) Straight-line
   c) Shortest path

Spatial Analysis and Modeling: Modeling

- One of many uses of GIS analysis tools is to build models.
- What is a model?
- A model is a simplified representation of a phenomena or a system.
- A map is a model.
- So are the vector and raster data models for representing spatial features.

Spatial Analysis and Modeling: Modeling

- Models are used in many different ways,
  - simulations of how the world works,
  - evaluations of planning scenarios
  - creation of indicators of suitability or vulnerability
- Model is a simplification of reality in be viewed as a model.

Application of GIS Modeling

- Road construction
- Construction in mountainous areas is complex engineering task, Cost factors, such as the number of tunnels & bridges to be constructed,
- Volume of rock & soil to be removed.
- GIS can help to compute such costs on the basis of an up-to-date DEM and soil map.

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Spatial Analysis and Modeling

- Classification of GIS Models
  - Descriptive or Prescriptive
  - Deterministic or Stochastic
  - Static or Dynamic
  - Deductive or Inductive

Stages of spatial data handling

- Data entry and preparation
- Data Storage and Management
- Spatial Analysis and Modeling
- **Visualization and Output**

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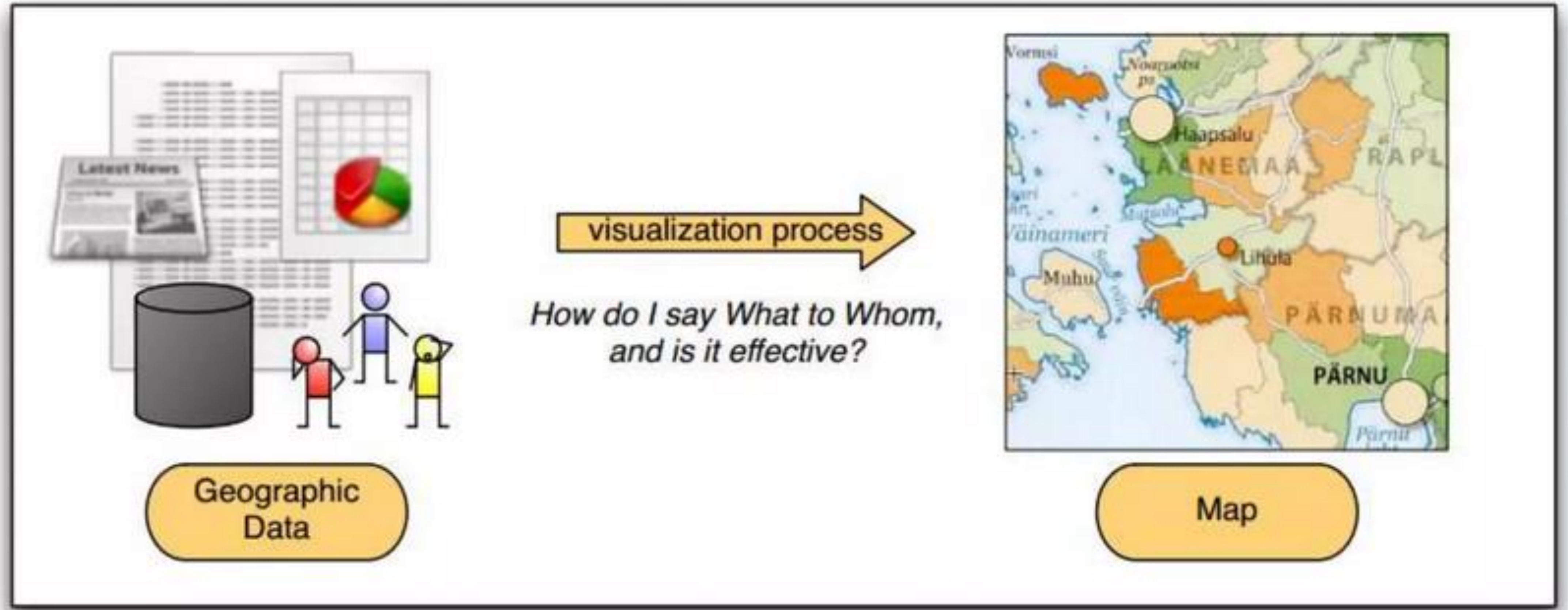
Visualization and Output

- How do producers disseminate geospatial data (i.e. how do they bring the data to the users)?
- in digital format
- by means of spoken / written language
- by means of numbers (e.g. in tables)
- by means of RS imagery
- by means of video
- by means of 3D / Virtual Reality imagery
- by means of maps or map displays

Visualization and Output



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Visualization and Output

How do	→ cartographic method technique
I	→ cartographer / map maker
say	→ symbols / semantics
what	→ geographic data
to whom	→ audience / purpose
and is it effective	→ does it work?

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Visualization and Output

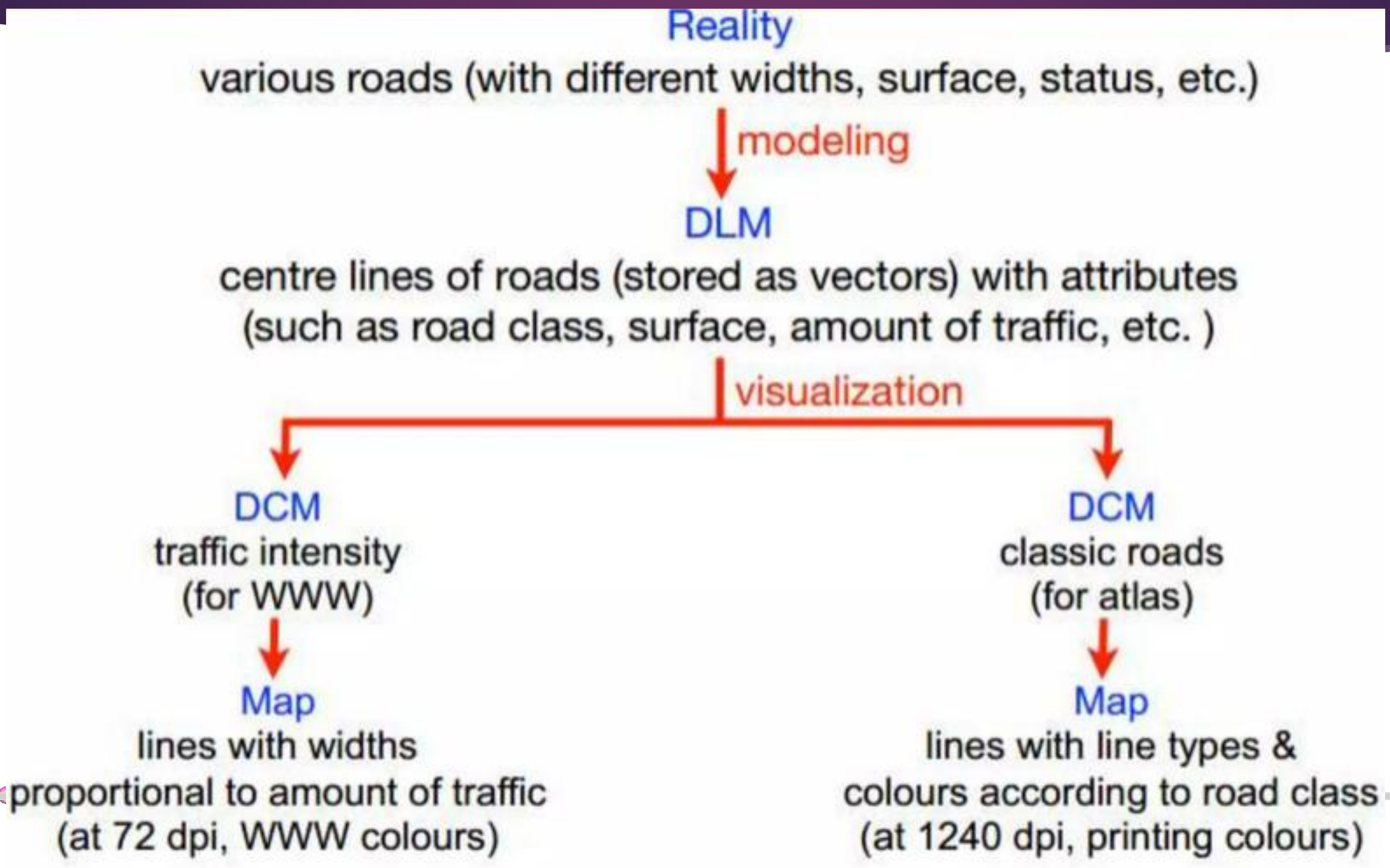
Digital Landscape Model (DLM):

- contains a selection from the real world
- stores geometry (points, lines, areas, volumes, raster)
- stores attributes (linked to geometry)
- stores time (linked to geometry)

Digital Cartographic Model (DCM)

- one or more visualization(s) of the DLM
- visualizations are tuned to: the use goals, users,
- use environments, representation scales, etc..
- also stores graphic attributes (line type, colour, etc)

Visualization and Output



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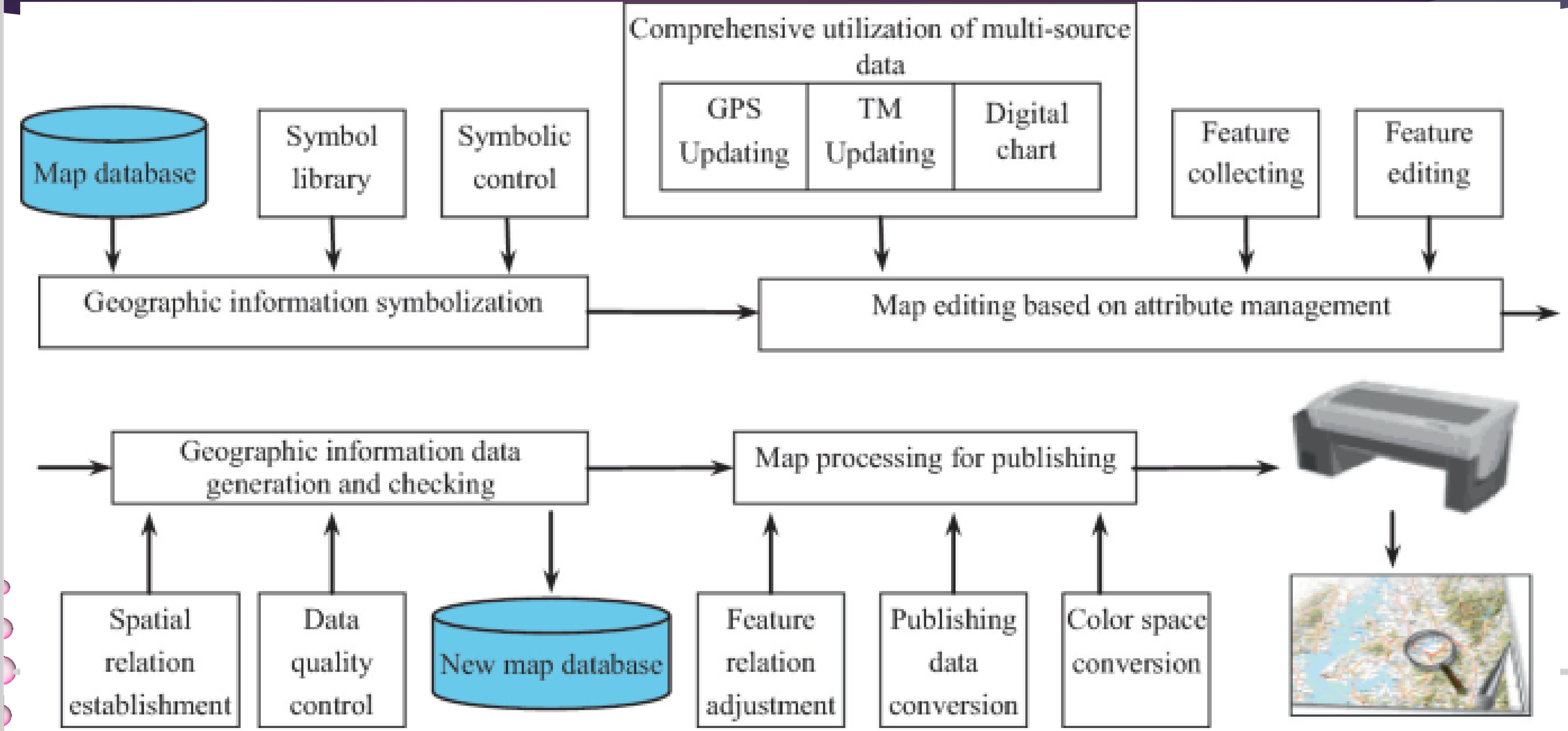
Visualization and Output



Thank You