INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE:-REMOTE SENSING AND GIS

(A70140) JNTUH-R15

B.Tech IV YEAR I SEM

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UNIT-1

PHOTOGRAPHY

AERIAL PHOTOGRAPHY

- Science of making photographs from the air for studying the surface of the earth
- Offers pictorial representation of earth’s surface and a synoptic ‘BIRDS EYE VEIW’ of the terrain which is of help for planning purposes
- Economizes and expedites natural resources surveys
- Used for Preparation of base maps in the field of geology, soils, land use, civil engineering and town planning

ADVANTAGES AERIAL PHOTOGRAPHS

- Saves time
- Larger coverage area
- More detailed ground surface than maps
- Can be studied anytime and at anywhere
- Studies on the photographs are cheaper than field studies
- Studies on the aerial photographs are easier than in the field
- The only disadvantage of the aerial photographs is the absence of the topographic contours and the geographic names.

HISTORICAL BACKGROUND

- Prior to the invention of airplanes, photographs taken from the ground borne cameras (i.e. Terrestrial Photographs) were used to extract the relationship between objects using geometric principles.

- Use of photograph in topographical map making started in 1840 by French geodesist "Aragon". The "Photo-theodolite" was the instrument used for taking terrestrial photographs.

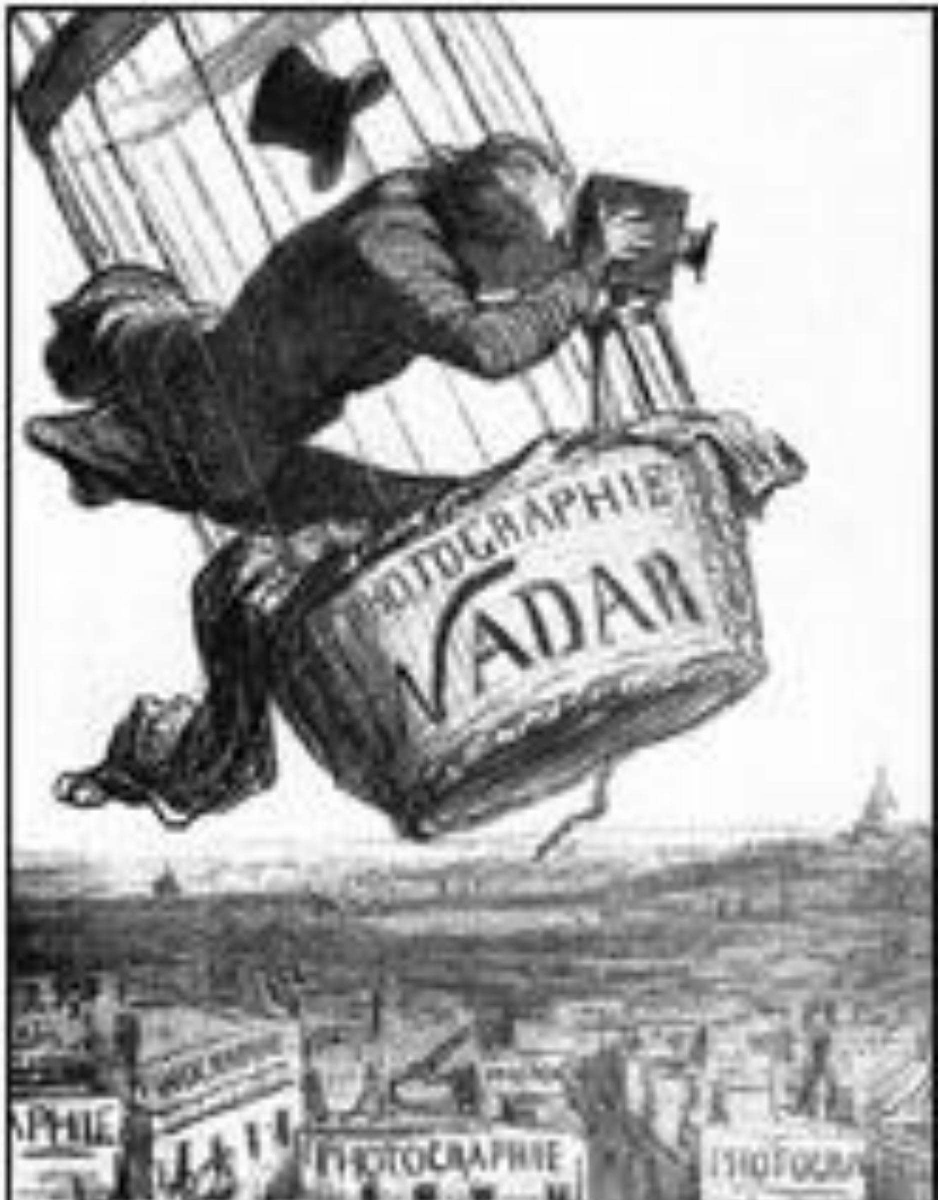
- The terrestrial photography owing to limitations such as less coverage, more cost effective and less known geometry were dispensed with. The aerial photographs replaced the same.

- 1783 - First manned balloon flight
- 1859 - Gaspard Tournachon a French amateur photographer ascended in balloon and photographed a village near Paris

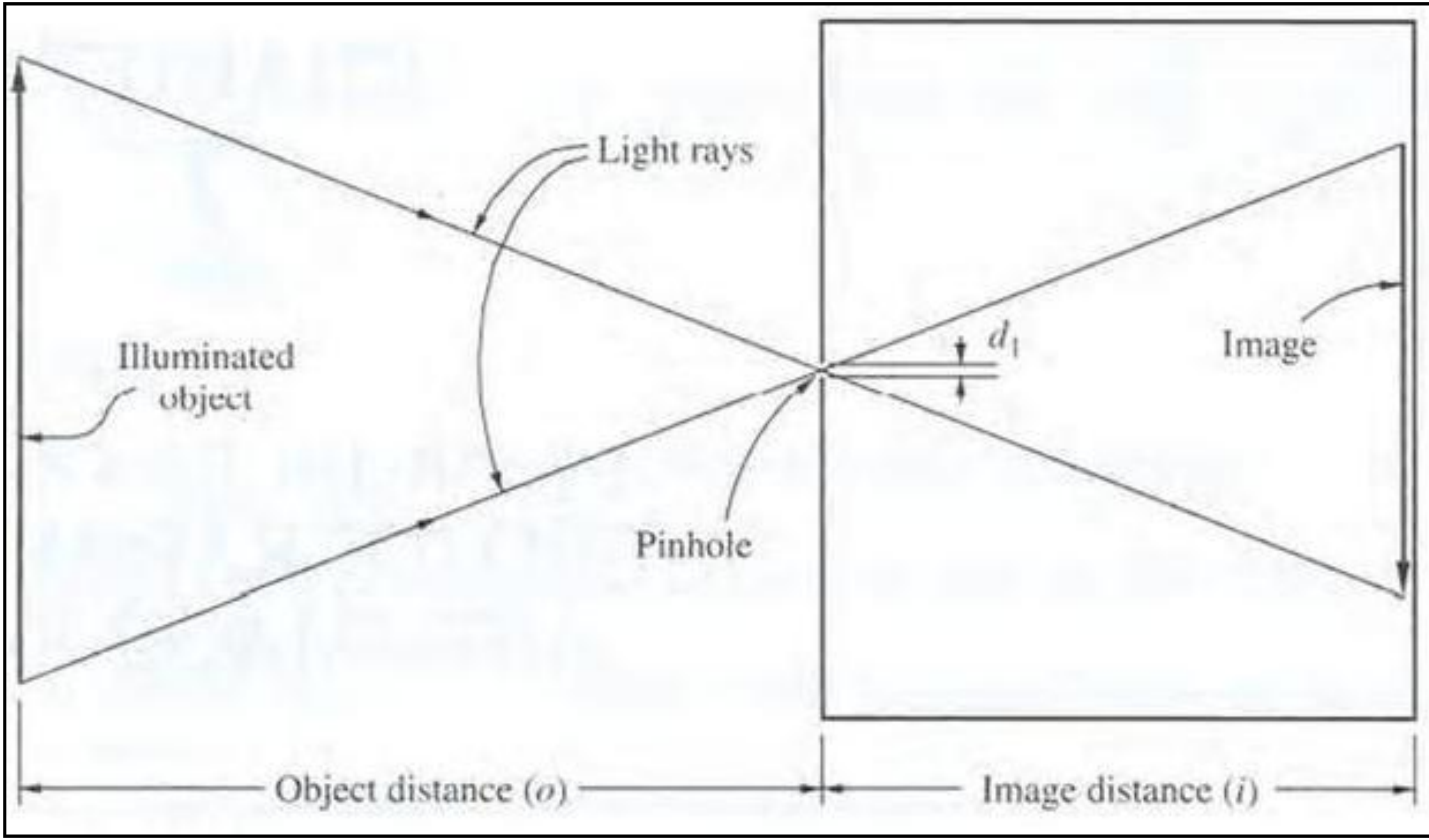
- Major break through for military applications during World War-I
- 1920s and 1930s - Significant use for cartography, forestry and geology developed.
- 1940s - Extensive use during world war II

- In India, SOI started terrestrial photogrammetry in 1899-1900
- 1939-40 - Aerial photography for topographic mapping by SOI
- 1980s - Full fledged aerial photography in mid 1950s and reached climax

First aerial photo in France



Pegions as Aerial Photographers


Light rays
Illuminated object
d_1
Image
Pinhole
Object distance (o)
Image distance (i)

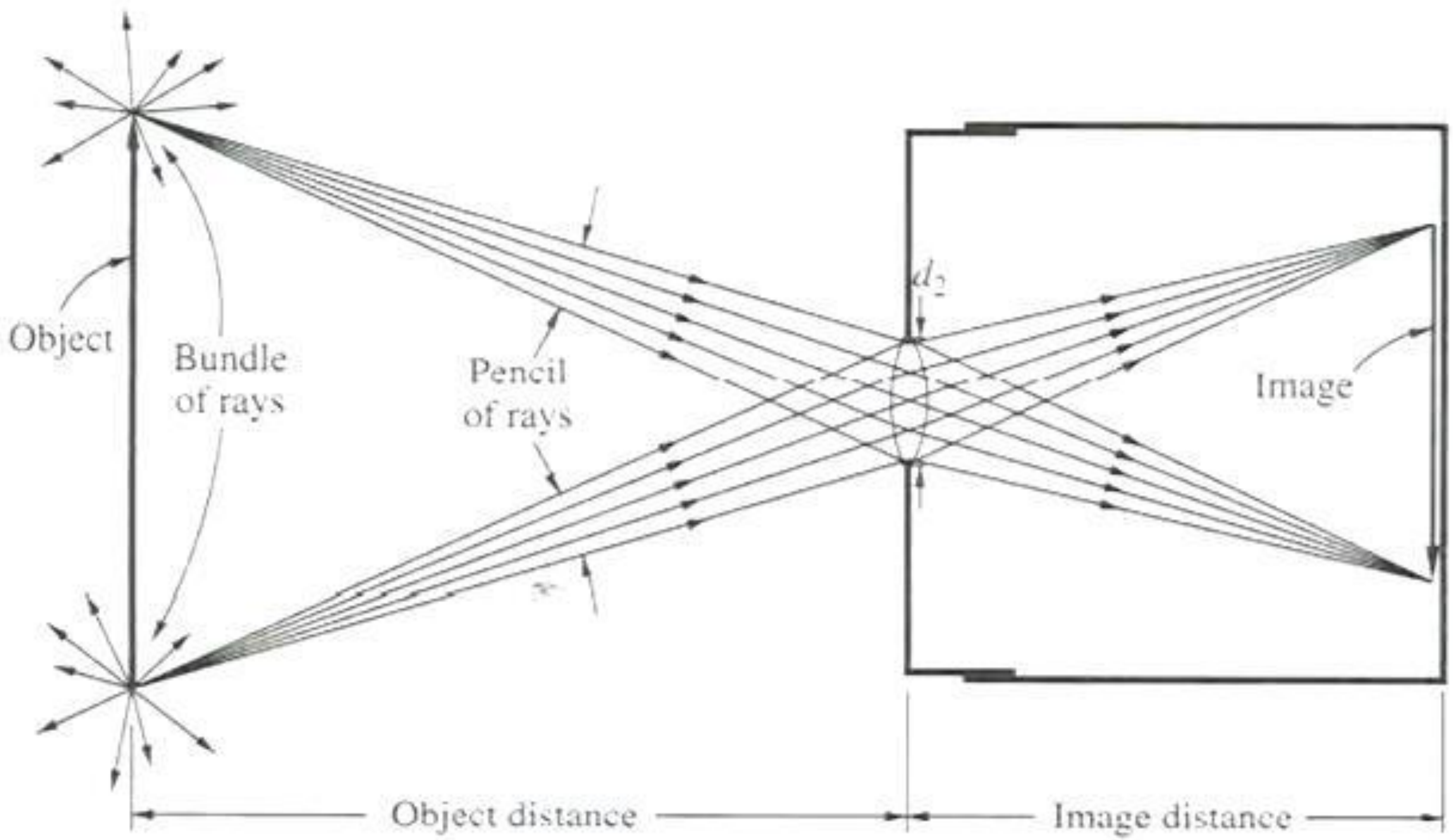


FIGURE 2-6
Pencils of light and image formation in a single-lens camera.

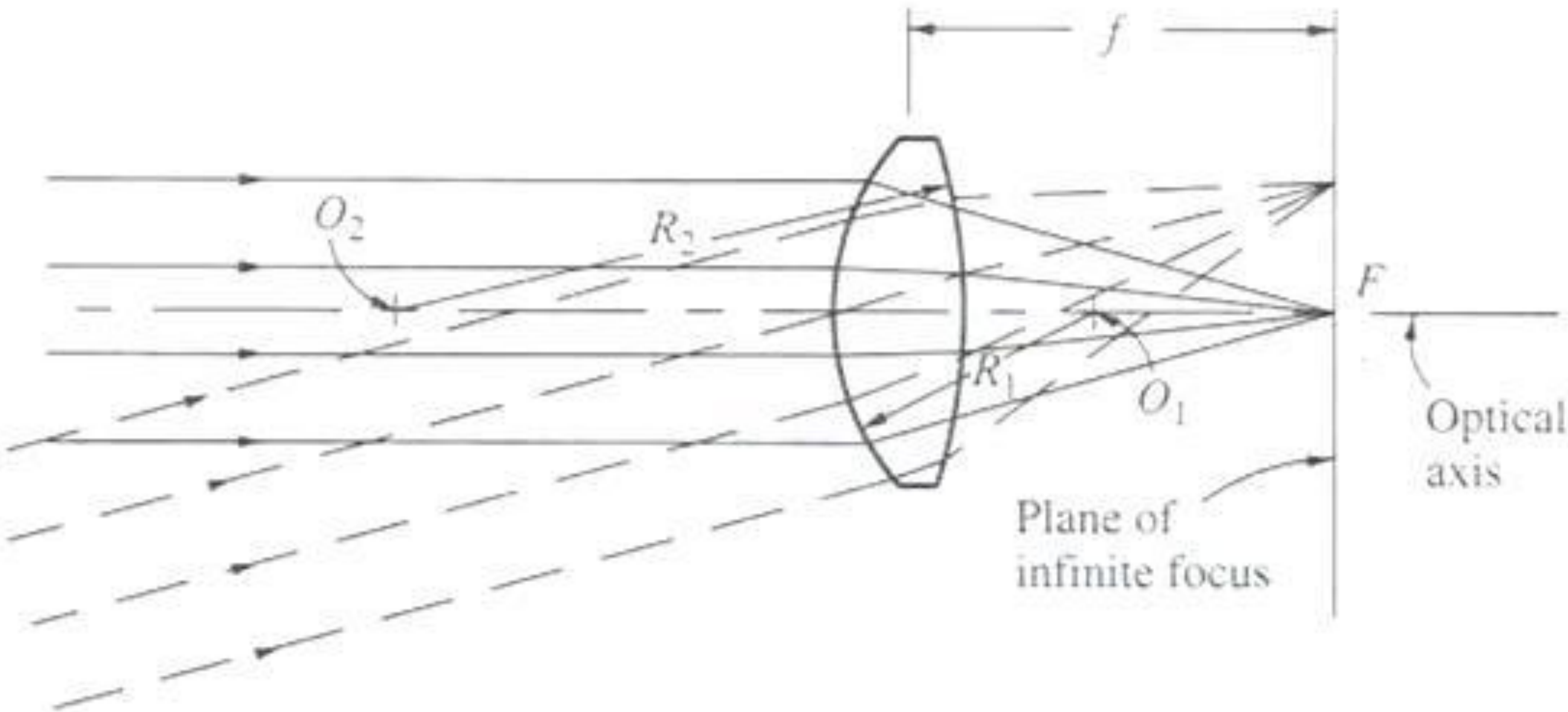
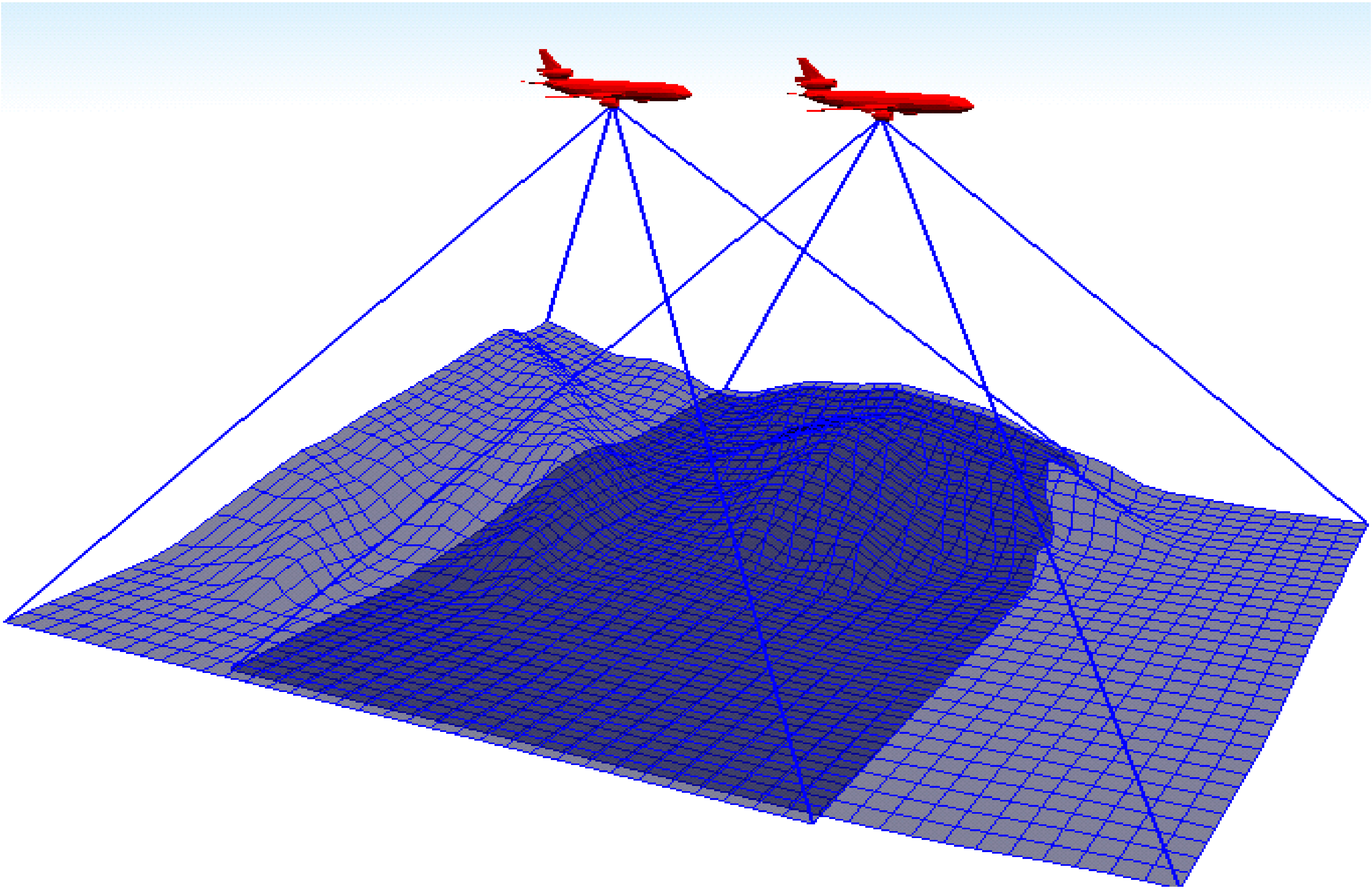


FIGURE 2-7

Optical axis, focal length, and plane of infinite focus of a lens.



AERIAL PHOTO AND TOPOSHEET - DIFFERENCE

	Toposheets	**Aerial Photos**
Projection	Orthographic	Centre Perspective
Scale	Uniform	Not uniform
Objects	Shown as symbols	Actual photo features of the ground

TYPES OF AERIAL PHOTOGRAPHS

Aerial photographs are generally classified according to the orientation of the optical axis of the camera

1. Vertical -camera pointing vertically downwards.
2. Oblique -when the optical axis is considerably inclined from the vertical.
3. High oblique photographs - inclination is sufficiently great to permit photography of the horizon
4. Low oblique -less inclination

VERTICAL PHOTOGRAPH

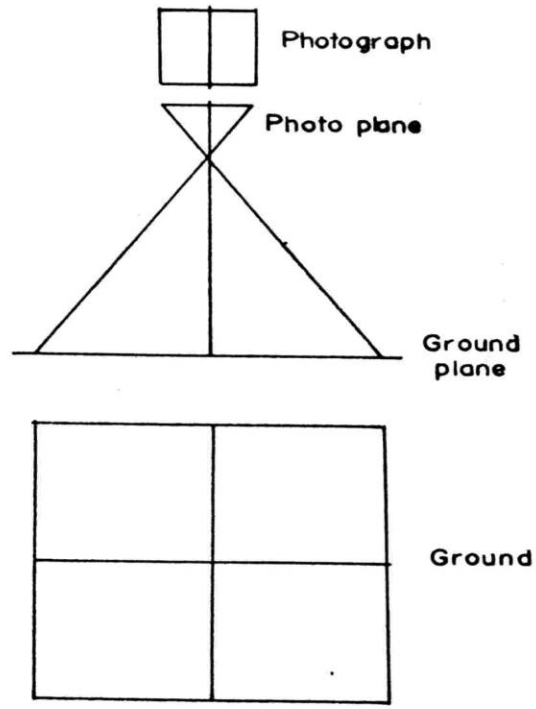


Fig-1.a.

LOW OBLIQUE PHOTOGRAPH

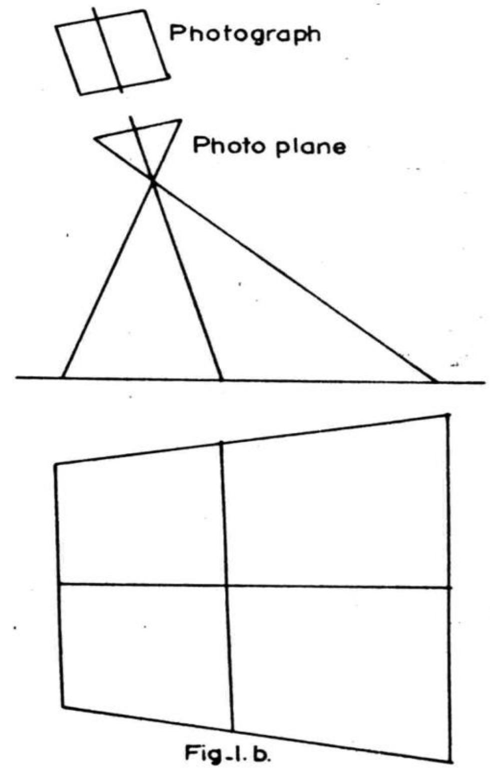
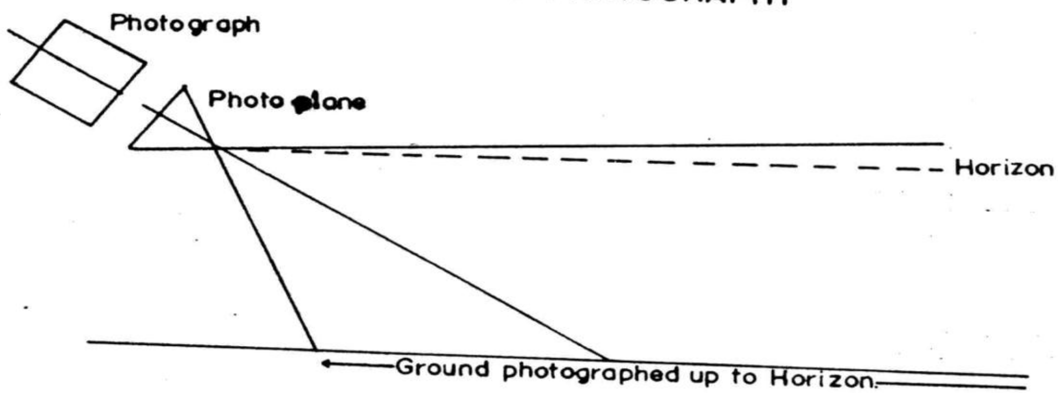


Fig.-1. b.

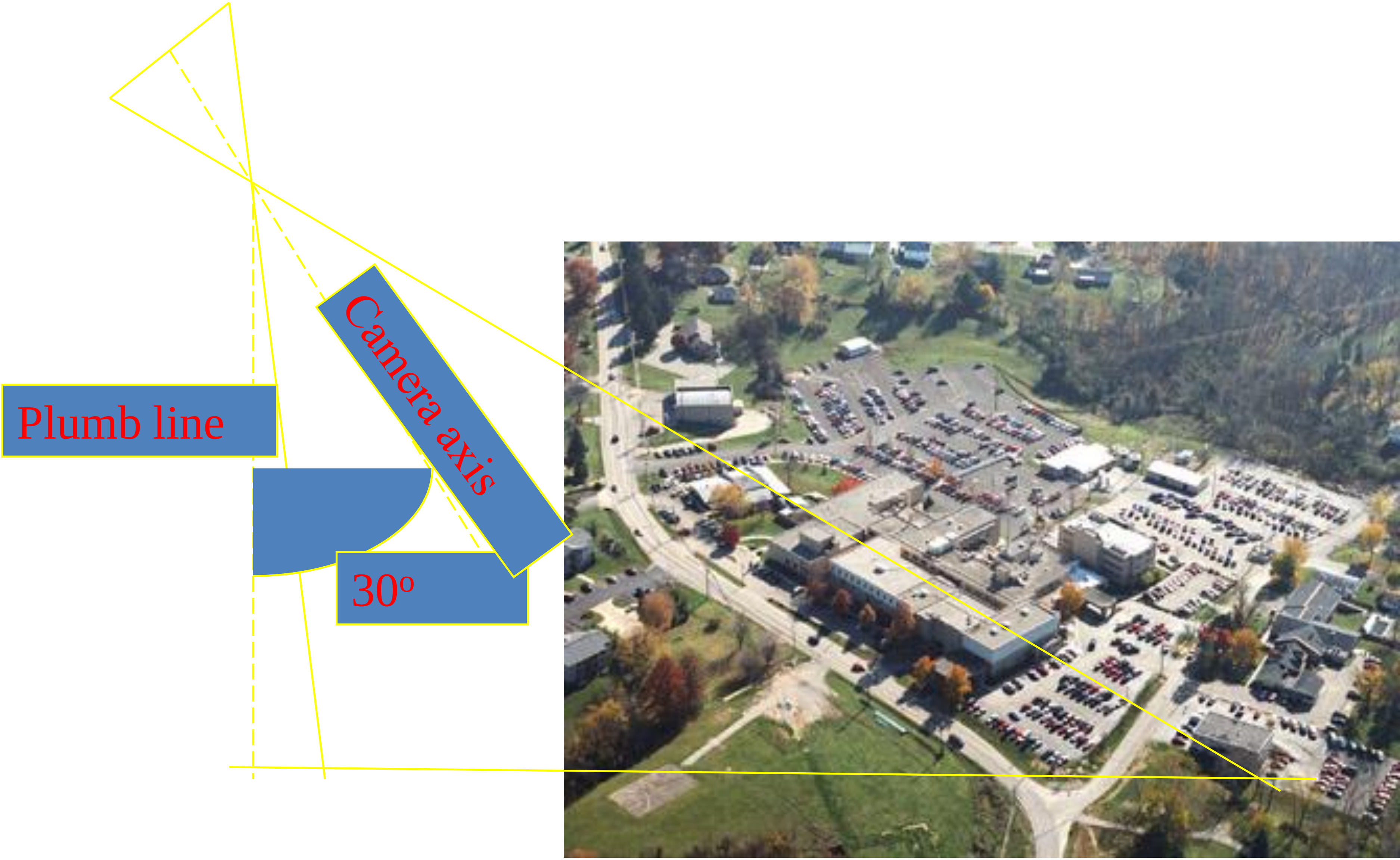
HIGH OBLIQUE PHOTOGRAPHY



VERTICAL PHOTOGRAPH

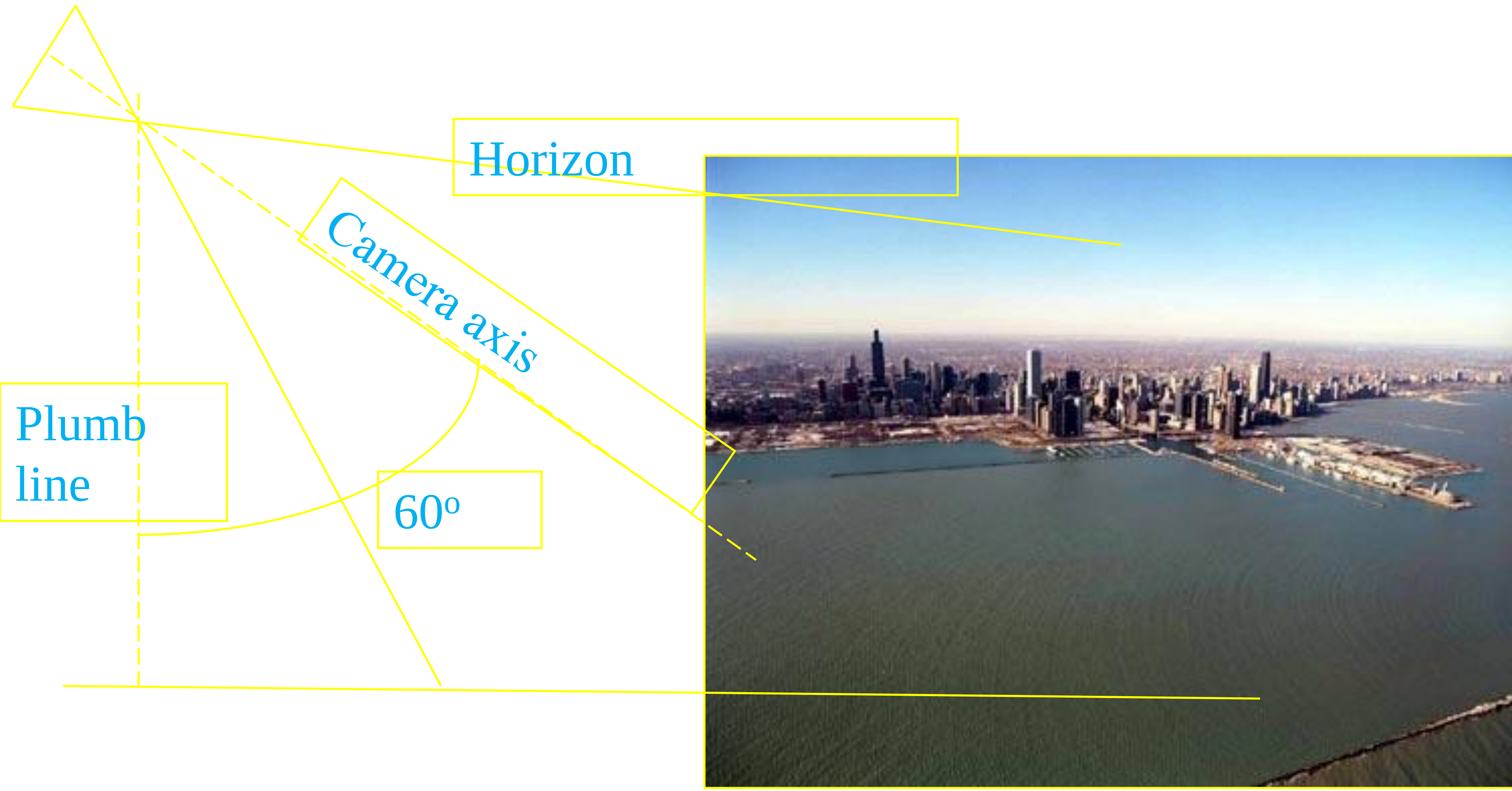
Vertical Aerial Photograph

LOW OBLIQUE PHOTOGRAPH




copyright Bluesky

HIGH OBLIQUE PHOTOGRAPH



UNIT-2

PHOTOGRAPHY

AERIAL CAMERA-types

1. Frame type - most common – successive exposures are taken on the entire frame format

2. Strip type - the film is moved continuously along the focal plane and a narrow slit like aperture is kept open constantly. Film speed is adjusted to the aircraft speed.

3. Panoramic -the portion of the lens near the optical axis is used with the lens scanning through large angles across the direction of flight and the film is advanced parallel to the direction of scanning at rates compatible with the vehicle speed

4. Multispectral – for obtaining image of the terrain on different spectral bands. An assemblage of cameras with identical lens systems but different filters imaging either on the different parts of the same film roll or different film rolls

Panoramic photo of Sydney Bridge

AERIAL CAMERAS (contd.)

Type of Camera	Focal length	Coverage
Normal or standard	200 –300 mm	Up to 75^{0}
Wide angle	100 – 150 mm	75^{o} – 100^{o}
Super wide angle	45 – 90 mm	>100^{o}

Modern aerial survey cameras produce negatives measuring 23cms x 23cms (9 x 9in)

Up to 600 photographs may be recorded in a single film roll.

PHOTOGRAPHIC SCALE

Focal length of camera/Flying height (f/h)

The scale is not uniform

Variation in scale is due to

Centre Perspective projection

Optical or photographic deficiencies

Inferior camera

Faulty Optical shutters

Optical photographic deficiencies: These are caused by optical distortions due to inferior, camera lens, faulty shutters, film shrinkage or failure of film flattening mechanism in camera focal plane.

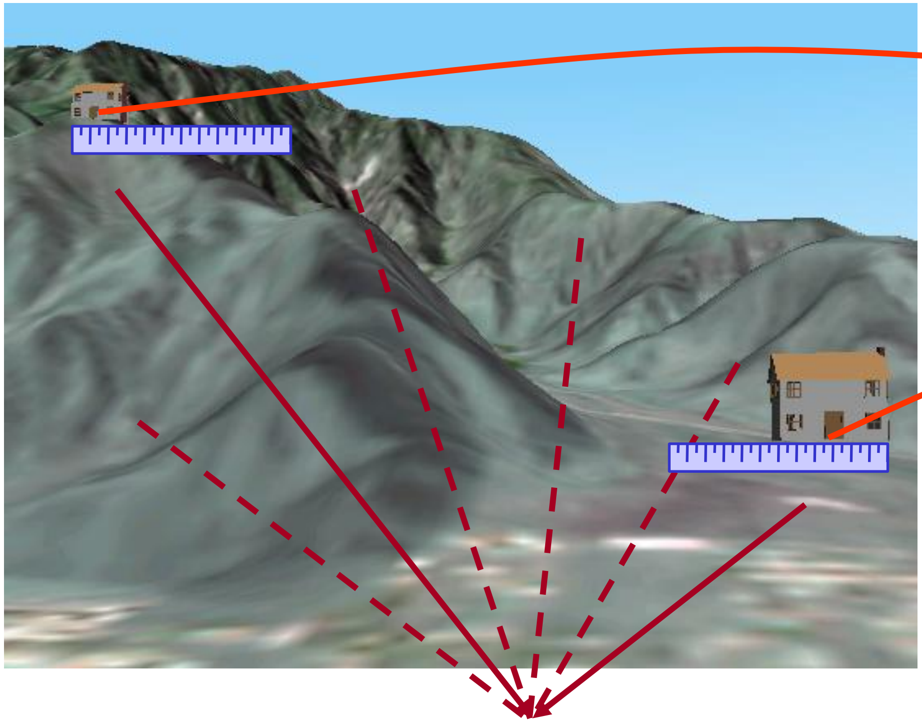
Inclination of optical axis: Such inclination / tilt caused by movement of camera normal to the direction of flight. The images are displaced radially towards the isocentre on the upper side of a tilted photograph and away from the isocentre on the lower side. Along the axis of tilt, there is no displacement Topographic relief of the terrain:

All the objects that extend above or below a specified ground datum have their photographic images displaced. The images of ground objects with greater elevation will be displaced radially outwards from the Centre of the photograph. Conversely, ground points lying below a selected datum plane are displaced radially inward.

Scale Variation

- **Occurs in all photography**

House width = 8m



2 cm

Scale is 1:400

6 cm

Scale is 1:133

Scale varies across the photograph

Scale in oblique photographs

In the case of tilted photograph the scale is not constant even if the terrain if flat.
The scale is constant only along a particular line on the photo, parallel to the axis of tilt. Such lines are called “plate parallels”.

Scales used in natural resource surveys vary between 1:5,000 and 1:50,000 depending upon the purpose for which the photographs are used.

- For general regional mapping purpose in the field of geology 1:50,000 scale are used.
- For detailed mapping (Specialized Thematic Mapping) 1:25,000 scales are more suitable.
- These scales have the advantage of corresponding to the scale of modern toposheets.
- Selection of scale often depends on relief and other considerations. The higher the relief of the terrain and higher the density of vegetation, smaller should be the scale selected.

PLANNING AND EXECUTION OF PHOTOGRAPHY

- Aerial photography is a delicate operation and demands painstaking preparation and professional execution.

- Many factors must be considered and many problems solved before the execution of a photographic flight.

- The purpose of the project largely determines the scale and other specifications required. The proper camera, necessary filters, suitable film, the photographic plate and other equipment will be selected and the flight mission is assigned to trained photographic crew.

- Area to be photographed: The limits of the area should be indicated on the existing degree sheets or maps of scale 1:2,50,000. Large area may be divided into blocks A,B,C etc.

- Purpose of photography: This is important as it helps in the designing of the photographic specifications and planning of the flight mission.

Planning and Execution of Photography (contd)

Season of Photography

Selection of the season for photography depends on various factors such as seasonal changes in light reflection, seasonal changes in vegetation cover, seasonal changes in climatological factors. In India : September - October and March to April.

The purpose of photography however dictates the season to a great extent.

For photogrammetric, geological and soil surveys the ground should be visible as clearly as possible. In forested areas such a time will be when the trees shed their leaves. In higher latitudes and altitudes the melting of snow has to be awaited. The soil should be without standing crops. Thus, for these purposes early spring to beginning of summer is most suitable.

In forestry surveys, the density of foliage is important.

For the land use surveys, it is preferable to have the photography when the crops are standing. Therefore, for these purposes the later part of the year from the end of rainy season to the beginning of winter is suitable.

Planning and Execution of Photography (contd)

Time of Photography

The time of photography should be so decided as to avoid long shadows and haze conditions. Long shadows obscure the detail and bring down the interpretational value of the photographs.

Normally the time is confined to the period when the sun is between 30^0 and 60^0 (8 to 10 AM and 2 to 4 PM are preferred).

In mountainous areas however the period around noon is preferred to avoid shadows of the hills.

In tropics where the atmospheric haze is the main consideration, the time is limited to 1.5 to 3 hrs after the sunrise.

Planning and Execution of Photography (contd)

Flight Direction

In aerial photography E-W direction of flight is generally preferred on account of the winds. Some other direction may also be decided upon in consideration of other factors. The direction along the length of the area is commonly decided upon to keep the number of strips to minimum.

For geological interpretation, flight direction across the strike of the formations (cross stripping) is preferred in highly folded areas to ensure sufficient overlap across the strike. It is also preferred in high mountainous areas where relief displacement is more.

Planning and Execution of Photography (contd)

Flying Height

Flying height is decided depending upon the scale desired and the terrain.

As the scale of photography is the function of focal length of the camera lens and flying height, the less the flying height the more the scale variations in a rugged country.

To keep the scale variations within tolerable limits the flying height should be kept more in rugged mountainous area.

The desired scale can in such cases be maintained by using camera lens of proportionately longer focal length.

Planning and Execution of Photography (contd)

Flying Height of the Aircrafts commonly used in India

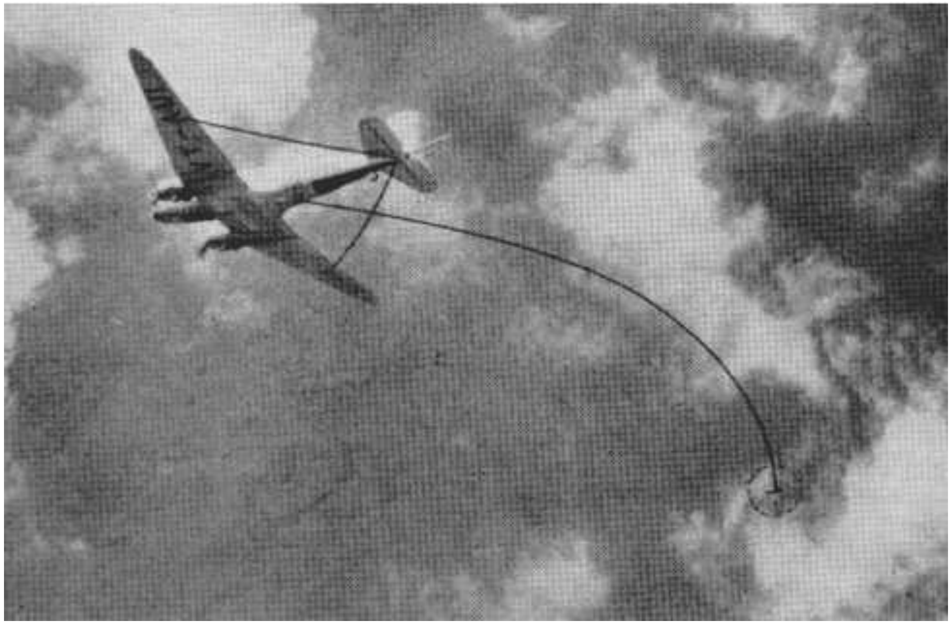
Aircraft	Flying Height (km)	Speed km/hr
Dakota	5.6 – 6.2	240
Avro	7.8	600
Cessna	9	350
Canberra	14	560
U –2	21	798
Rockell X - 15	108	6620

Aircrafts deployed for aerial photography/survey

Dakota

Casa 212

KingAir



DC3

Beechcraft Kingair prepared for installation

AERIAL PHOTOGRAPHY MISSION

- When a mapping project requires aerial photographs, one of the first tasks is to select the photo scale factor, type of the lens to be and the desired overlap for stereo viewing.
- Forward overlap usually around 60%, while sideways overlap is around 20%. Furthermore, the date, time and season of photography should be considered for light condition and shadow effect.
- If the required scale is defined, the following parameters can be determined-
- Flying height required above the terrain.
- Ground coverage of a single photograph.
- Number of photo required along a flight line.
- Number of flight lines required.

MISSION PLANNING:

- ***Inputs***

  . Area extents (lat / long)

  2. Scale of photography

  3. Focal length

  4. Format size

  5. Forward and lateral overlaps

  6. Average terrain heights

- ***Navigation***

  - Computer Controlled Navigational System with GPS

MISSION EXECUTION

- After entering a number of mission parameters, a computer programme determines the 3D coordinates of all position from which photos are to be taken and stored in a job data base.

- On, board the crew can obtain all relevant info from that data base, such as project area, camera type, film, sun angle, season, atmospheric condition etc. Also the list of camera position is loaded to a guidance system.

- The pilot is then guided along the flight lines, such that the deviation from the ideal line (horizontal and vertical) and the time of exposure is shown on display.

- When the plane passes close enough to the pre determined station, the Camera is fired automatically.

Organisations Identified for mission execution

In India three Organisations are identified for carrying out Aerial Survey/Photography.

- Indian Air Force(Task A)
- Air Survey Company, Kolkota (Task B)
- National Remote Sensing Centre, Hyderabad (Task, C)

PLANNING OF FLIGHT LINES

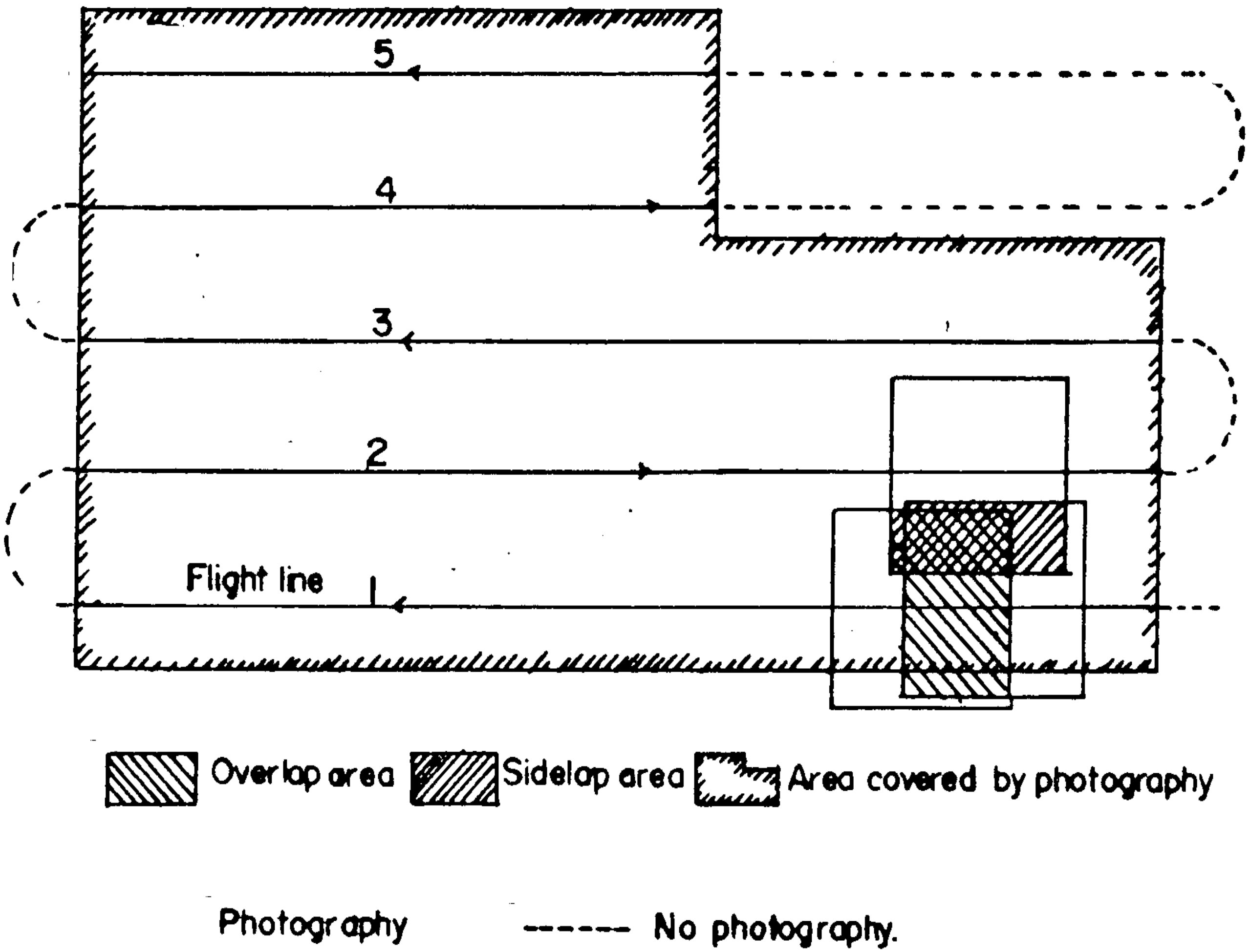


Fig-2 c

CRAB EFFECT AND CAMERA ORIENTATI

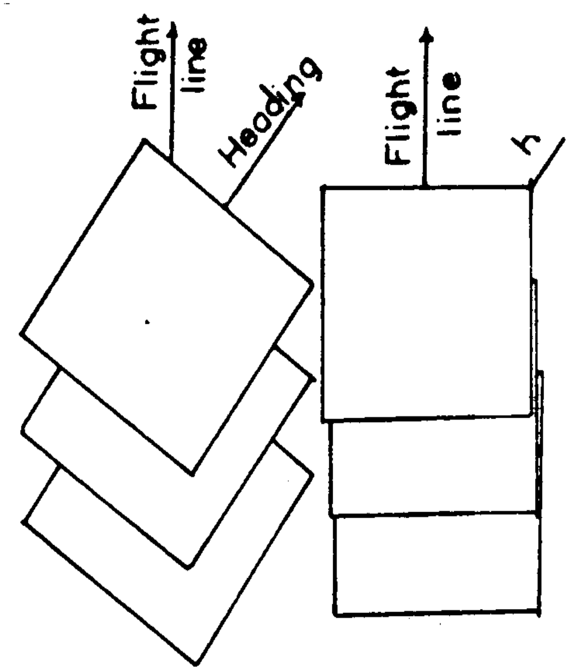


Fig-2 d

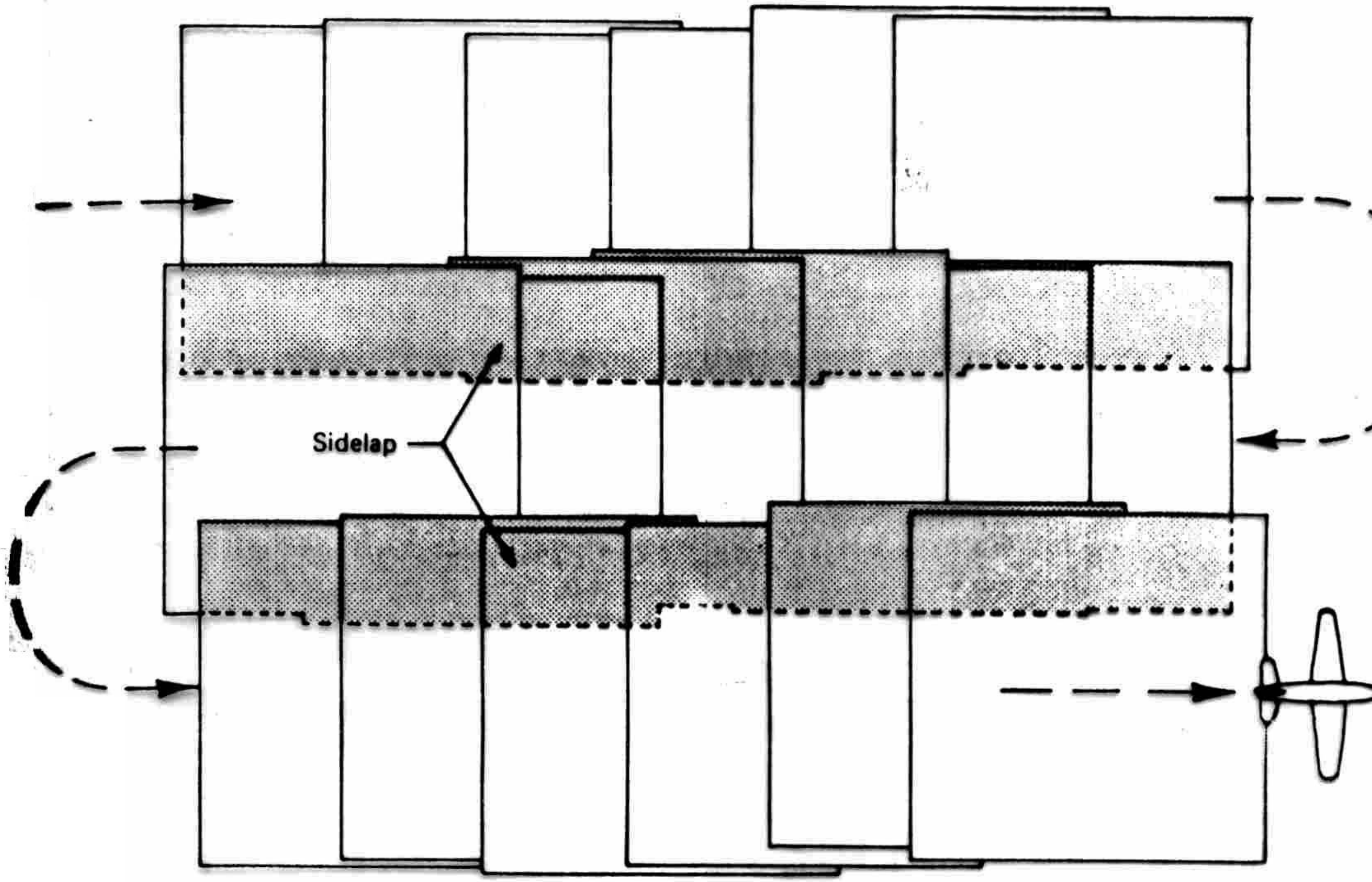


FIGURE 2.42 Adjacent flight lines over a project area.

Forward and Lateral Overlaps

Essential - In order to get stereo vision of the ground objects

Forward overlap – 60 ± 5 %

Lateral overlap – 20 ± 5%

OVERLAP AND SIDELAP IN VERTICAL AERIAL PHOTOGRAPHS

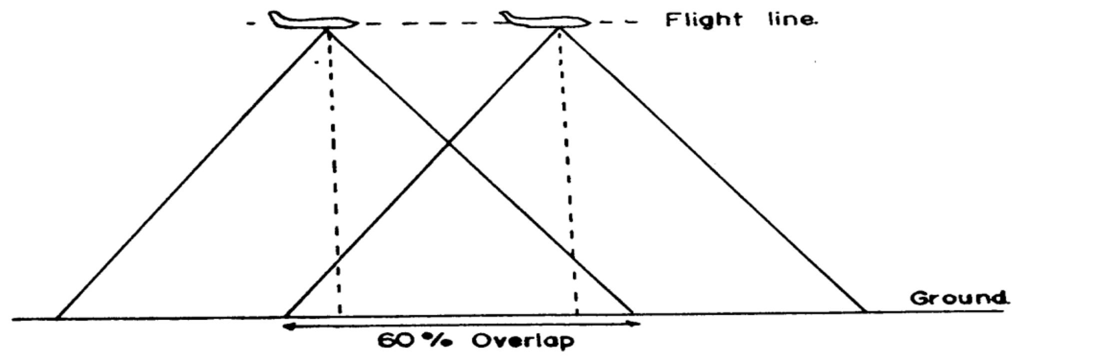


Fig-2a.

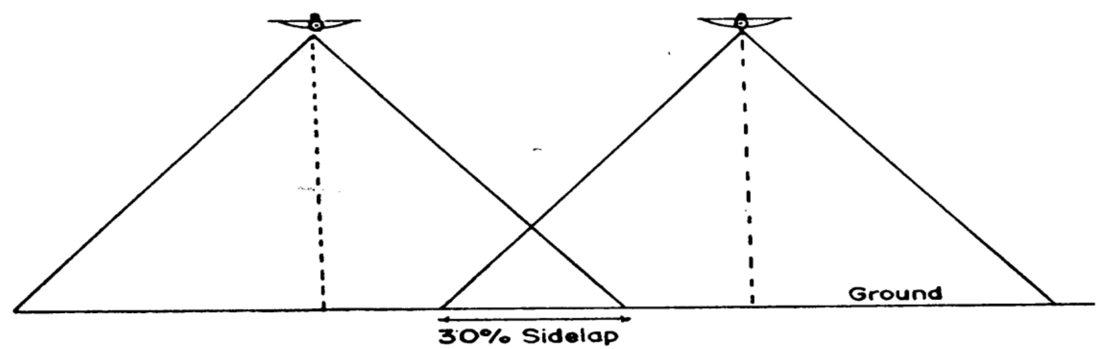


Fig-2b.

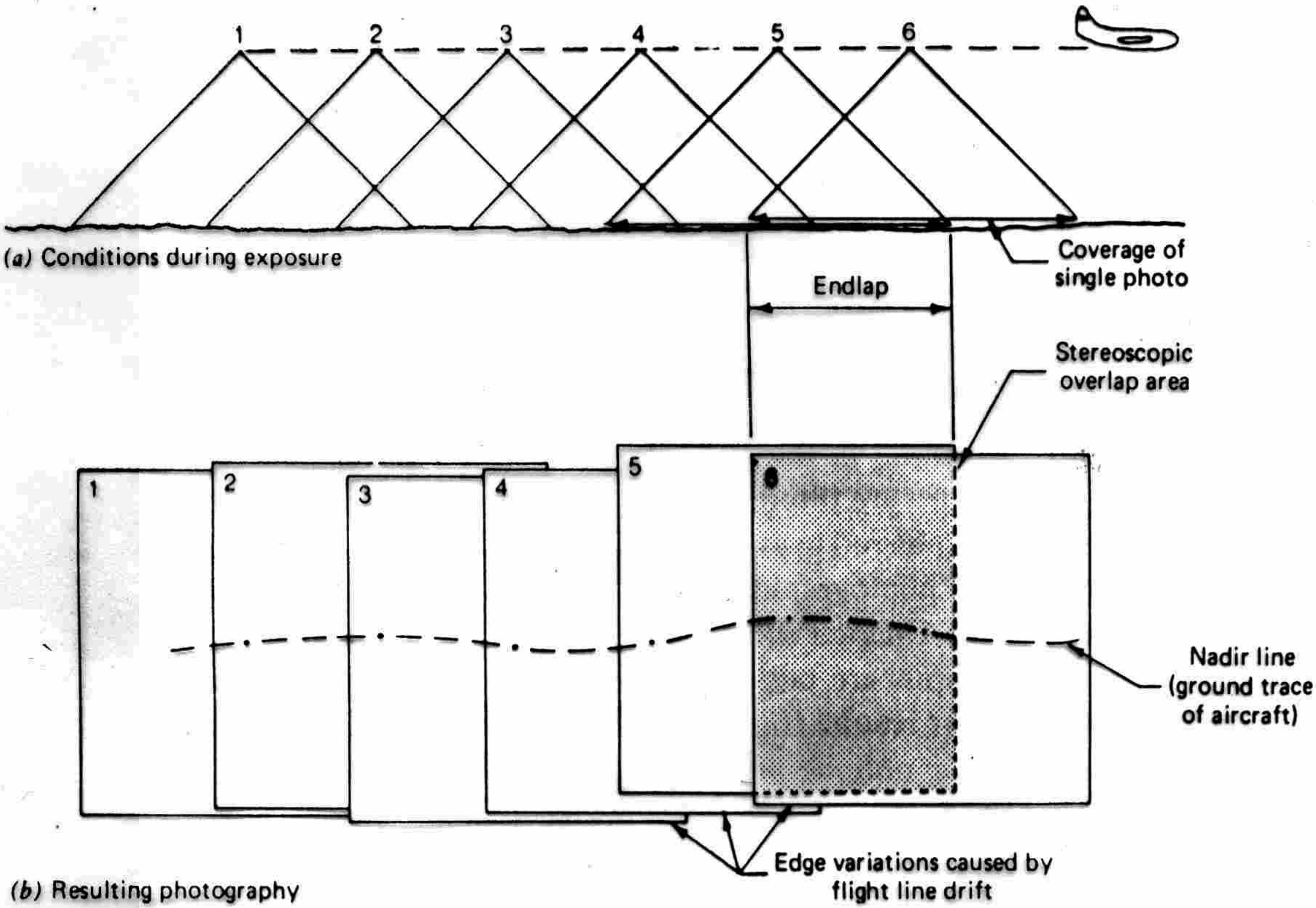


FIGURE 2.39 Photographic coverage along a flight strip.

INFORMATION RECORDED ON AERIAL PHOTOGRAPHS

•**Fiducial marks:** Fiducial marks or collimating marks for the determination of the principal points.

•**Altimeter reading**: for knowing the flying height of the aircraft above mean sea level (msl) at the time of exposure.

•**Time:** Recording of time at the moment of exposure.

•**Level bubble:** To indicate the tilt of the camera axis at the moment of exposure (not very accurate).

•**Principal distance**: For determining the scale of the photograph.

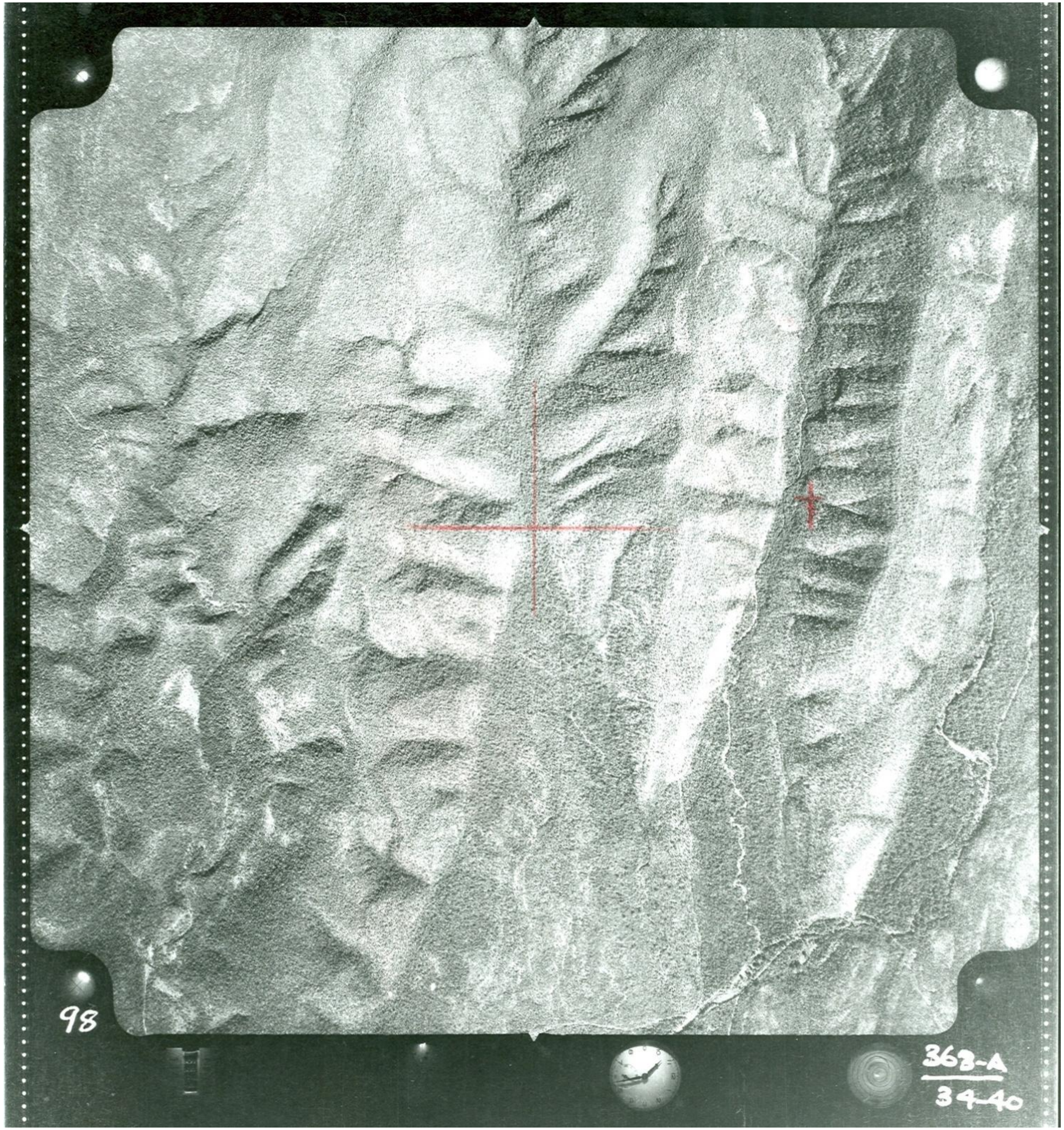
•**Number of the photograph**: e.g. 342-A 52-13

•342 - Job number, (A - Indian Air Force, B - Air Survey Co. C - NRSC),

52 - Strip number 13 - Photo number

•**Number of camera:** Useful for obtaining camera calibration report, if required.

•**Date of photography:** Written later on.


98
363-A
34-40

NUMBERING OF AERIAL PHOTOGRAPHS

- **Agencies for Aerial photography: Indian Air Force (IAF), Air Survey Company (A.S. Co) and National Remote Sensing Centre (NRSC) – controlled and coordinated by Surveyor General of India**
- **Job Number:** Every photographic task is allotted a job number by the Surveyor General of India for easy reference and handling. eg:346-A, 331-B.
- Task by I.A.F. - suffixed by letter 'A'
- Task by A.S Co. – suffixed by latter 'B'
- Task by NRSC – suffixed by letter 'C'
- **Strip Number:** If the strips are flown E-W, numbering of the strips is given from N to S. If they are flown N-S, the numbering is given from W to E.
- **Photo Number:** If the strip is flown E-W, the photos of the strip are numbered from W to E. If the strip is flown N-S, the photos are numbered from S to N.

PREPARATION OF PHOTO INDEX

- To show the position of any one photo relative to the other and also its approximate geographical position on a published map.

Prepared for the areas where no reliable map coverage exists and for reconnaissance operations.

Line index It is photo layout with flight lines, photo-numbers etc. It is prepared on 1:250,000 scale and the longitude and latitude are marked at intervals of 15 minutes.

Digital Camera

- These include Airborne Digital Sensor (ADS) of LH (Leica Helava) system and Digital Modular Camera (DMC) of Z/I (RMK-TOP) system.
- The sensors developed have characteristics that relate both to a camera and to a multispectral scanner. Charge couple devices (CCD) are used to record the EM.
- The main advantages over film camera are simultaneous acquisition of multispectral data with overlapping (multi angle) images along the track, enabling generation of DEM.
- Allows recording of data over a larger spectral domain.
- The resulting data being in digital format are amenable for image processing and direct integration in to the GIS data base.

Factors Influencing the Image Quality of Photographs

1. Reflectivity of the object	Light intensity and distribution, shade, colour
2. Atmospheric factors	Haze, clouds
3. Aircraft	Vibration, steadiness
4. Camera	Rigidity of the lens, shutter and magazine assembly, efficiency of shutters, scatter and loss through filters, optional flatness of filter, light loss and scatter, spectral transmission through filter, distortion and aberrations of the lens
5. Negative and positive base and emulsions	Speed and sensitivity of the emulsion, flatness of the base, dimensional stability of the base
6. Processing and printing	Mode of processing of negative, condition of printing equipment, mode of printing; quality of chemicals

AERIAL MOSAICS

It is an array of overlapping aerial photographs systematically assembled to form a continuous pictorial representation of a terrain

- Planning purpose.
- It provides the overview of the terrain- nature and distribution of the materials and features occupying the terrain.
- Scale variation from photo to photo will be known causing gap in the overlap
- A mosaic annotated with local information on rivers,villages etc helps in knowing about the geographic position of the area interpreted.

TYPES OF MOSAICS

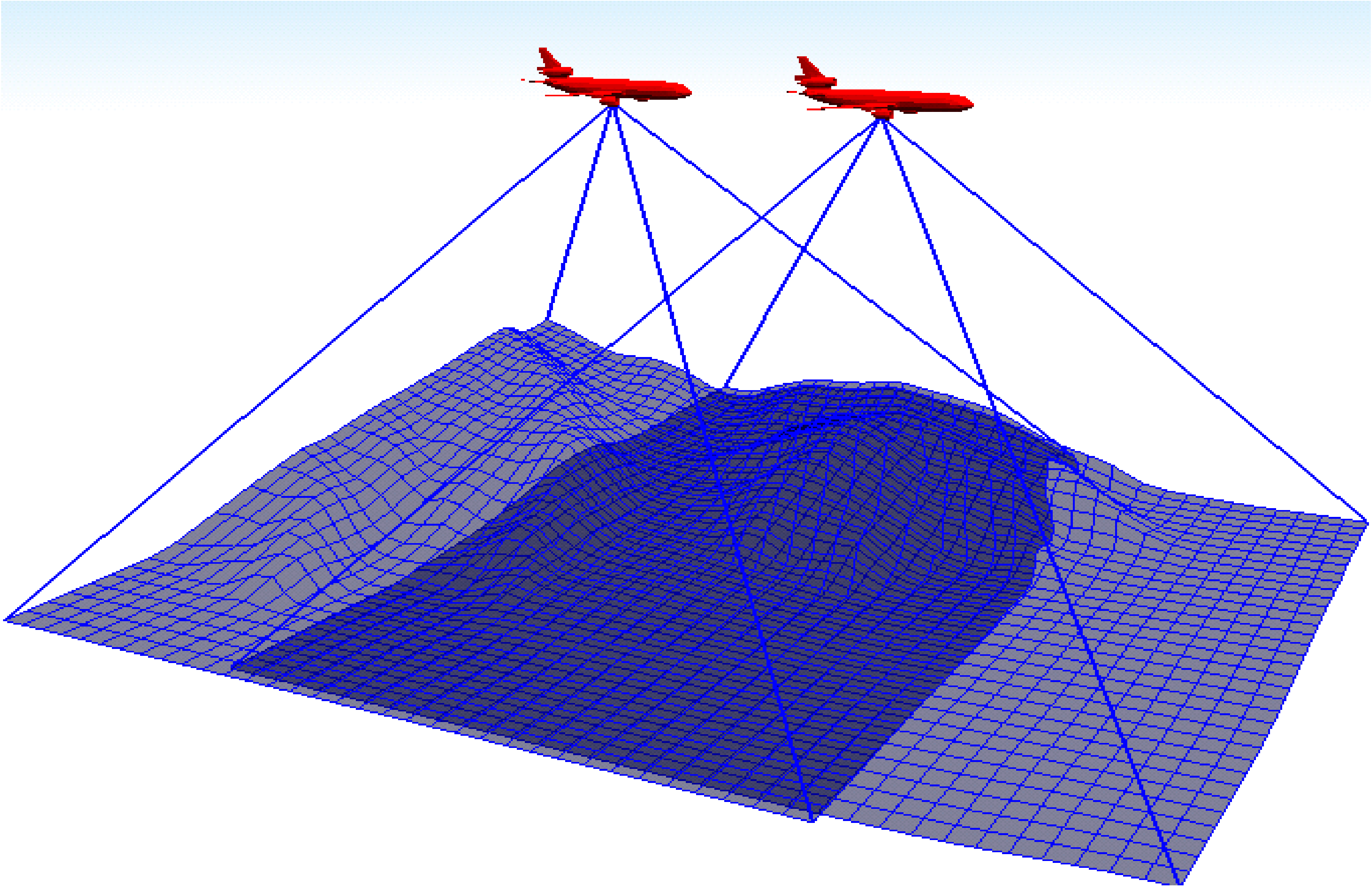
Uncontrolled mosaic: The photographs are oriented in to a position by matching corresponding images on adjacent photos.

Semi-controlled mosaic: This is a compilation of photographs without using rectified photographs but using control for positioning of each photograph.

Controlled mosaic: It is a compilation of scaled and rectified photographs assembled to fit plotted controlled points. The task of controlled mosaic is generally entrusted to an air survey company or photogrammetric organization.

Topographic map and Mosaic – Difference

Projection,	Map is an orthographic where all rays from object to the map are perpendicular	Mosaic is a central perspective projection, where all rays from the object surface to the image plane, pass through a point called perspective center.
Scale	uniform	Mosaic suffers from non-uniformity of scale
Features	represented by symbols	Mosaic shows actual photographic image of ground surface



STEREOSCOPIC VISION

- Aerial photography, and some satellite systems, allow the terrain to be imaged from two different viewpoints

- An overlapping pair of photographs or images can be used to form an optical relief model or stereoscopic model

- Stereoscopic models can be used for
  - 3-dimensional interpretation
  - measurement of terrain heights

CONDITIONS OF STEREOSCOPY

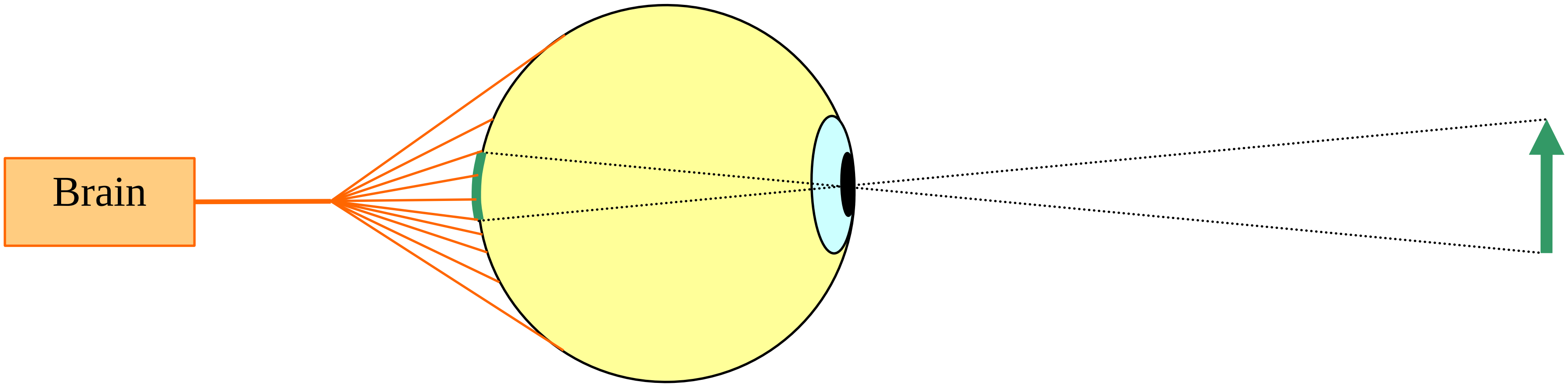
1. The optical axes of the camera must be approximately in one plane though the eyes can accommodate to a limited degree.
2. The ratio of the distance between the exposure stations and the flying height or the base – height ratio (B/H) must have an appropriate value. If this value is < 0.2 the depth perception is no stronger than if only one photograph is used. The ideal value, though not exactly known is about 0.25.
3. The scale of the two photographs should be approximately the same. Differences up to 15% may be successfully fused. For continuous observations, however, differences > 5% may be disadvantageous.
4. Each photograph of the pair should be viewed with one eye only.
5. The brightness of the photographs should be similar.
6. While viewing the photographs should be given the same relative position as they had during the time of exposure.

NATURAL STEREOSCOPIC VISION

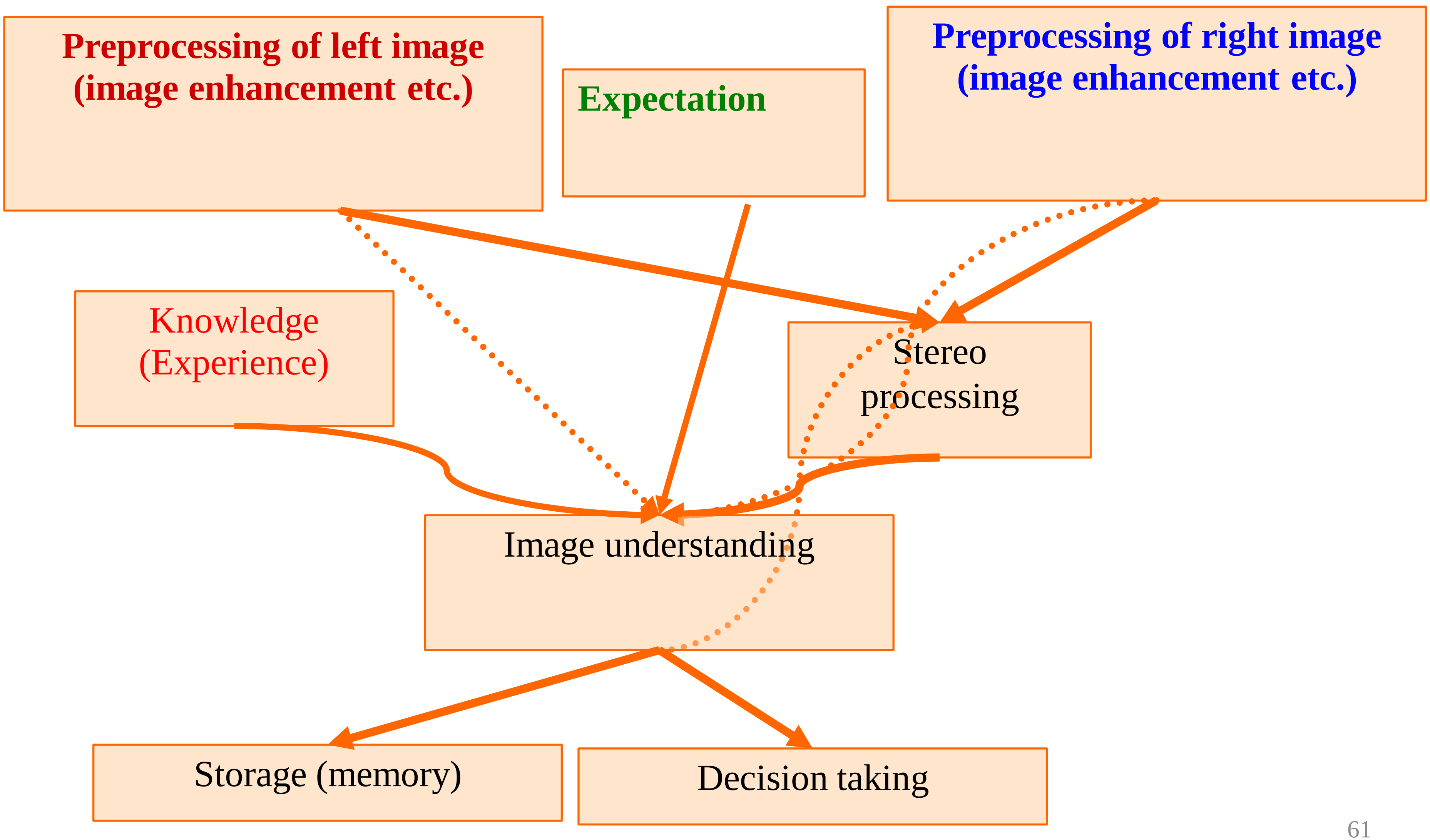
- The shape of the lens of the human eye may be altered to change its focal length
  - the eye is ***accommodated*** to view objects at different distances

- The lines of sight of our two eyes can be made to *converge* when viewing at different distances

Human Vision

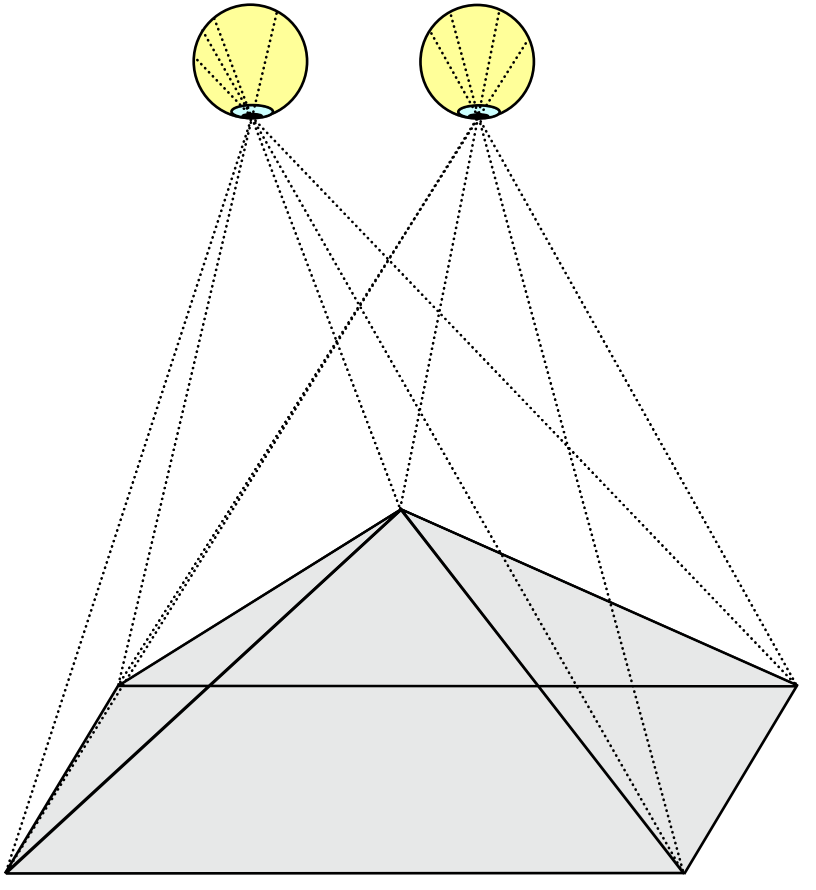


In The Brain

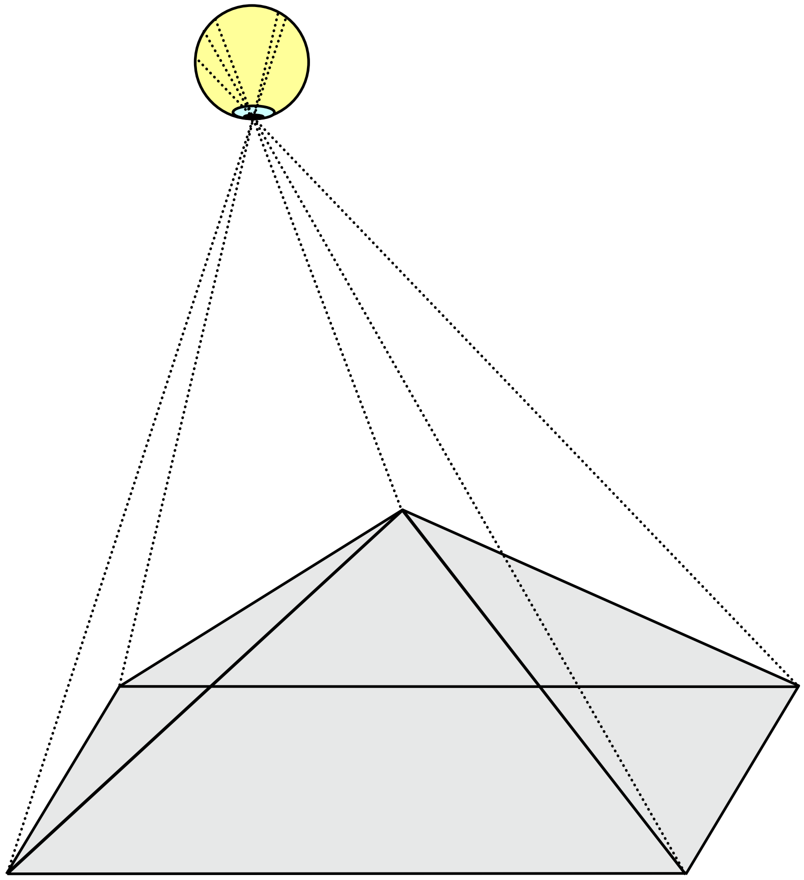


Preprocessing of left image
(image enhancement etc.)
Expectation
Preprocessing of right image
(image enhancement etc.)
Knowledge
(Experience)
Stereo
processing
Image understanding
Storage (memory)
Decision taking

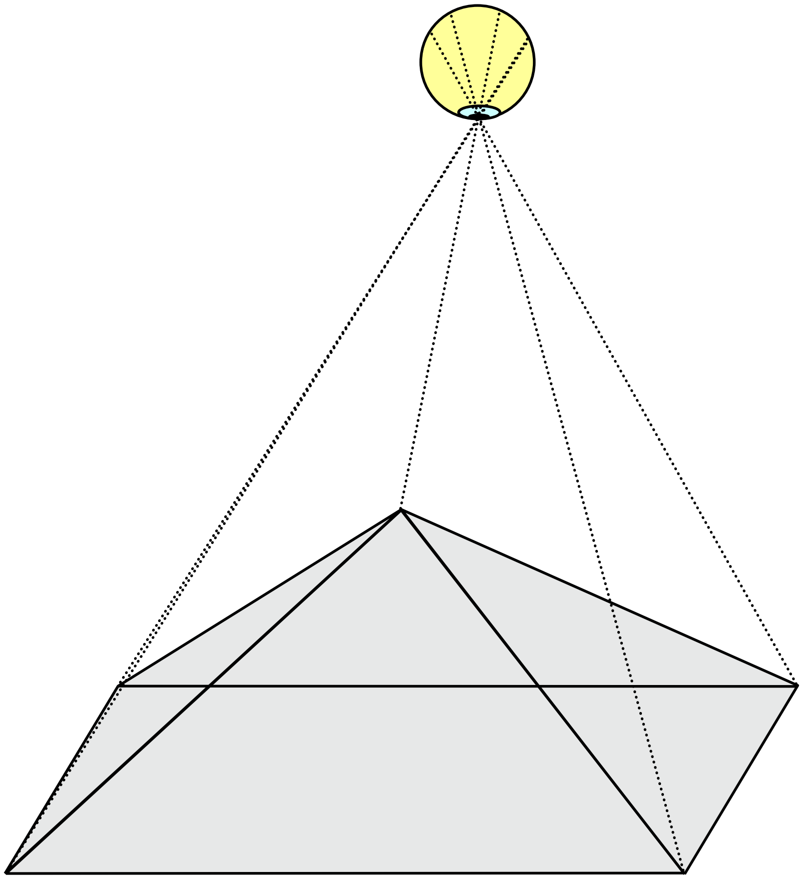
Viewing a 3D Object



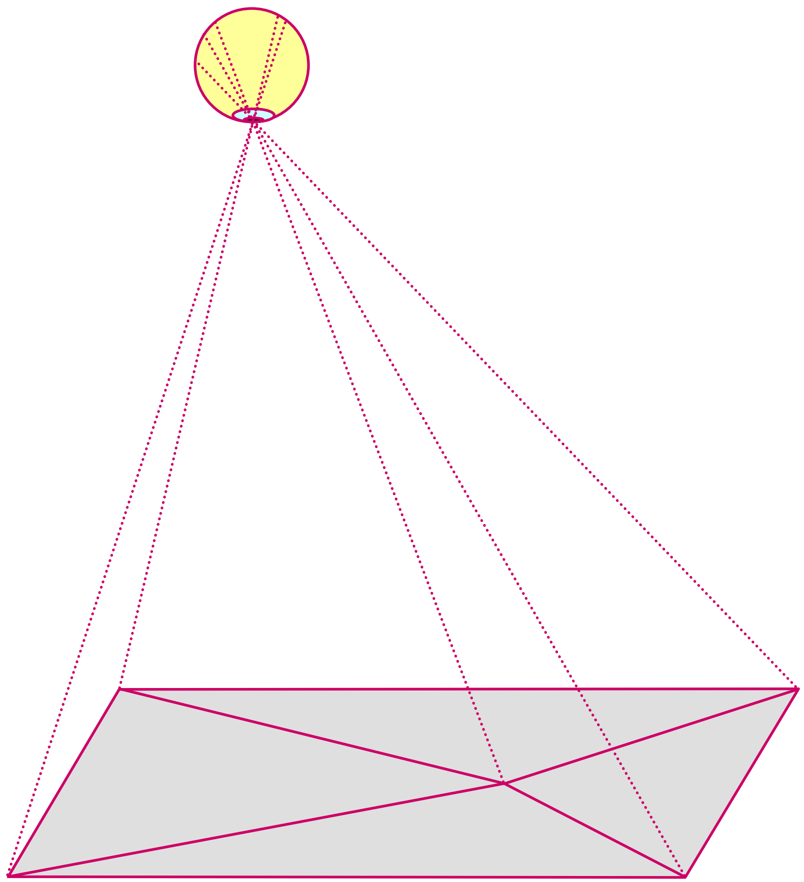
The Left Eye's View (Real Object)



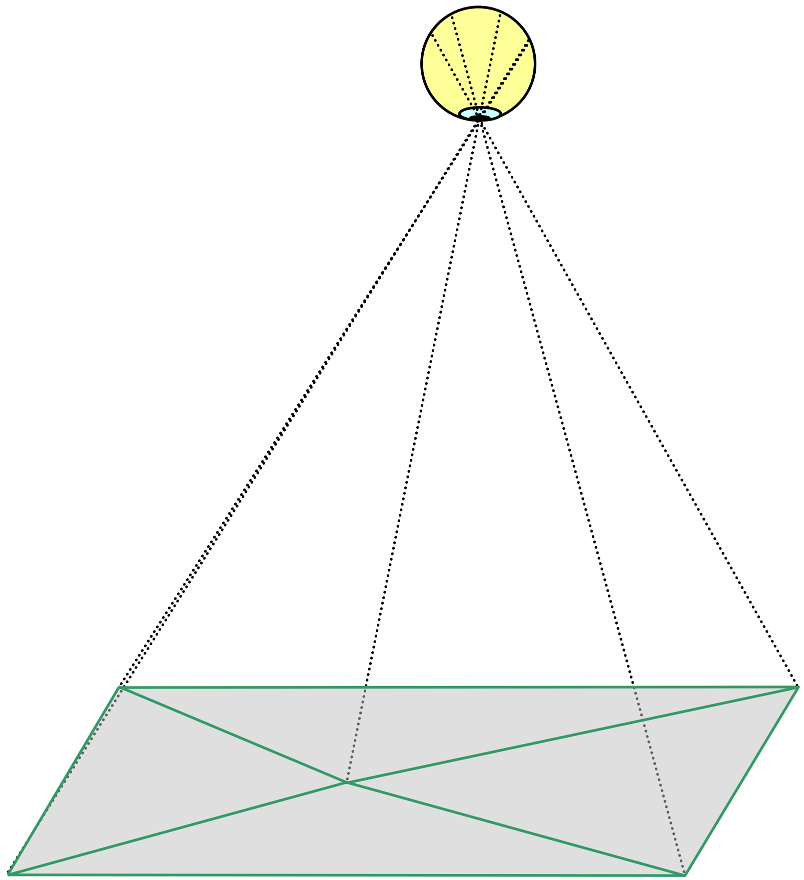
The Right Eye's View (Real Object)



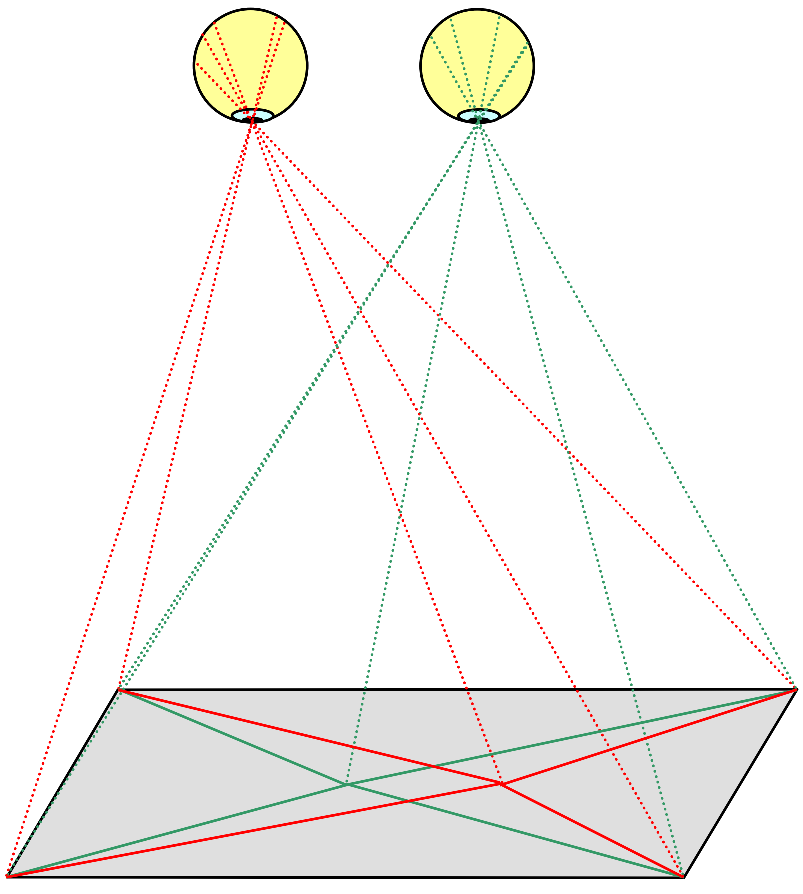
The Left Eye's View (Image)



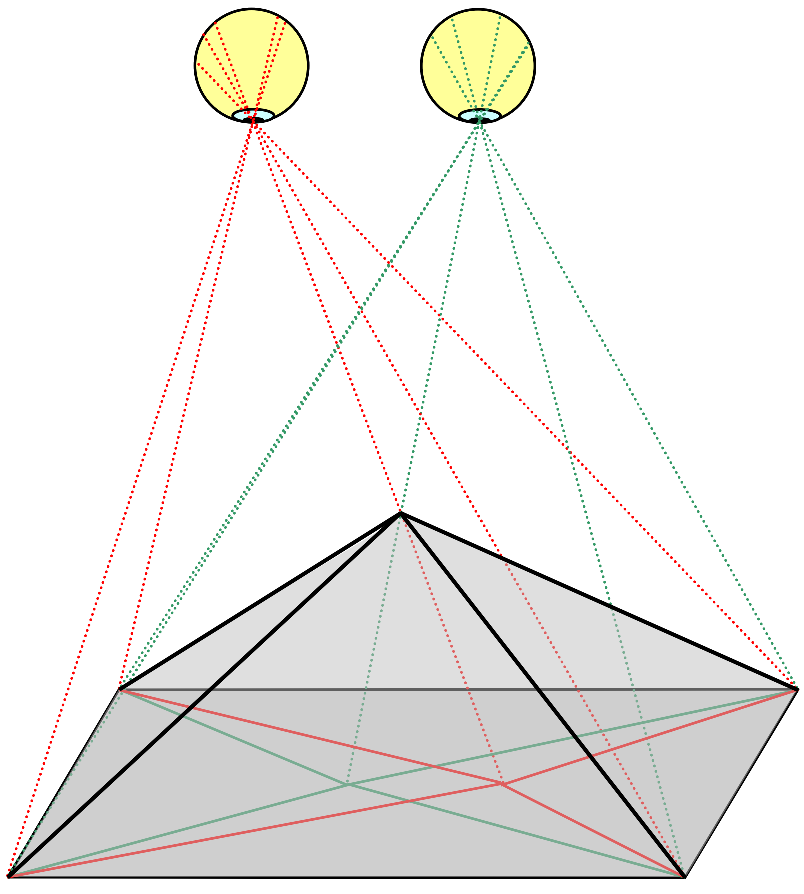
The Right Eye's View (Image)



Viewing these two Images

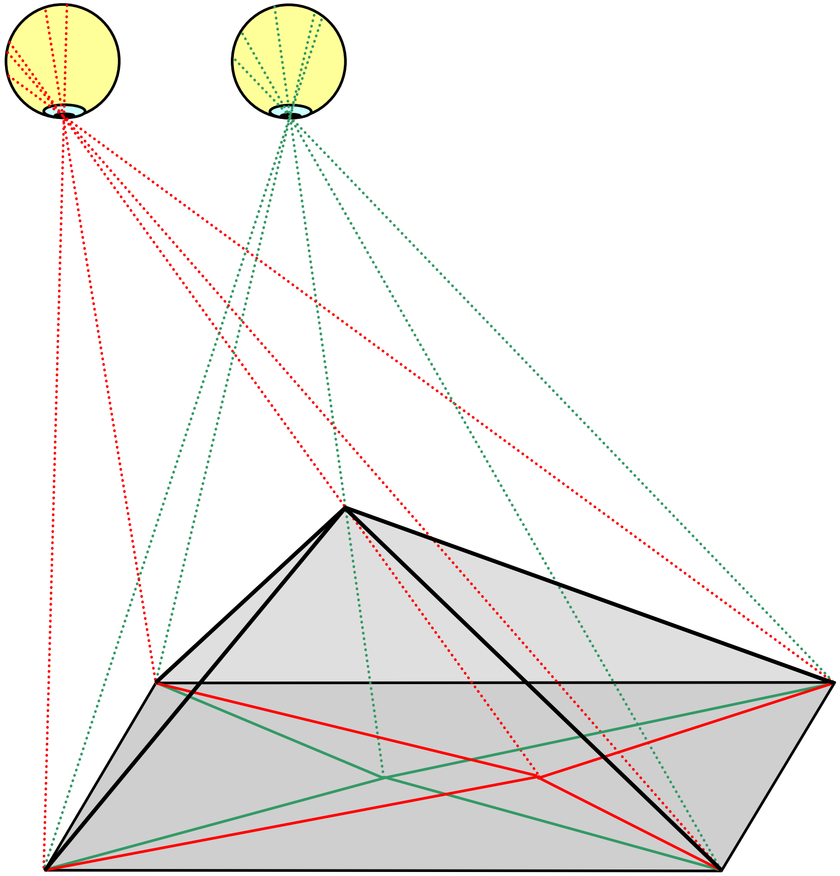


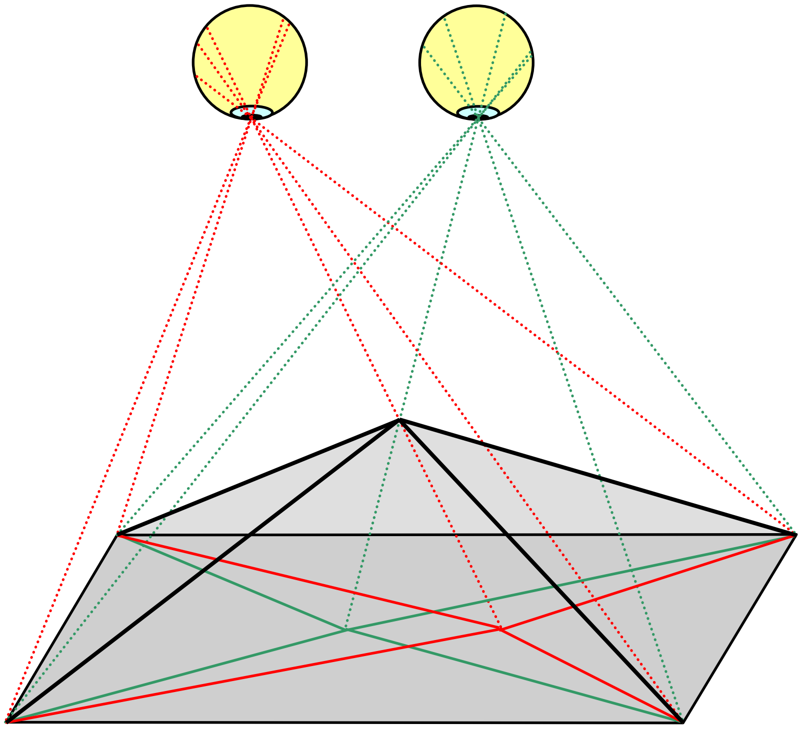
Gives a 3D Impression



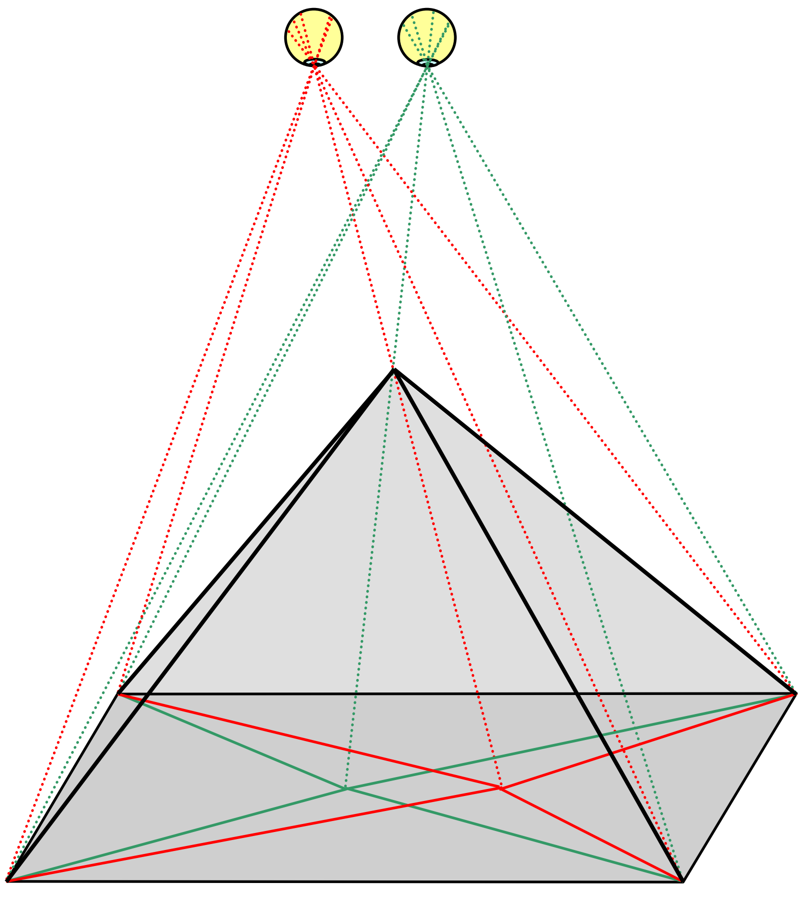
Depending on Viewing Position

And Viewing Distance





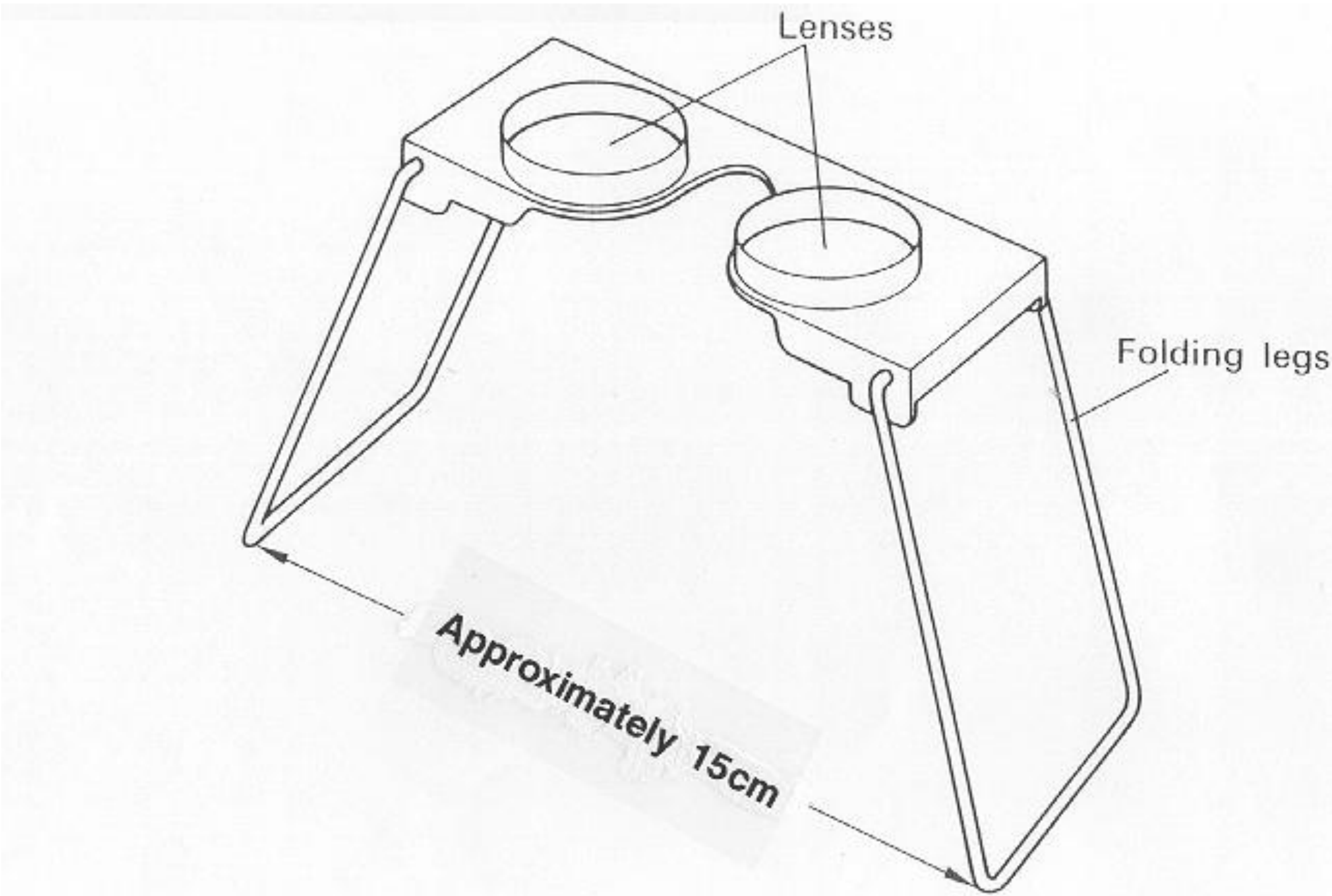
And Magnification



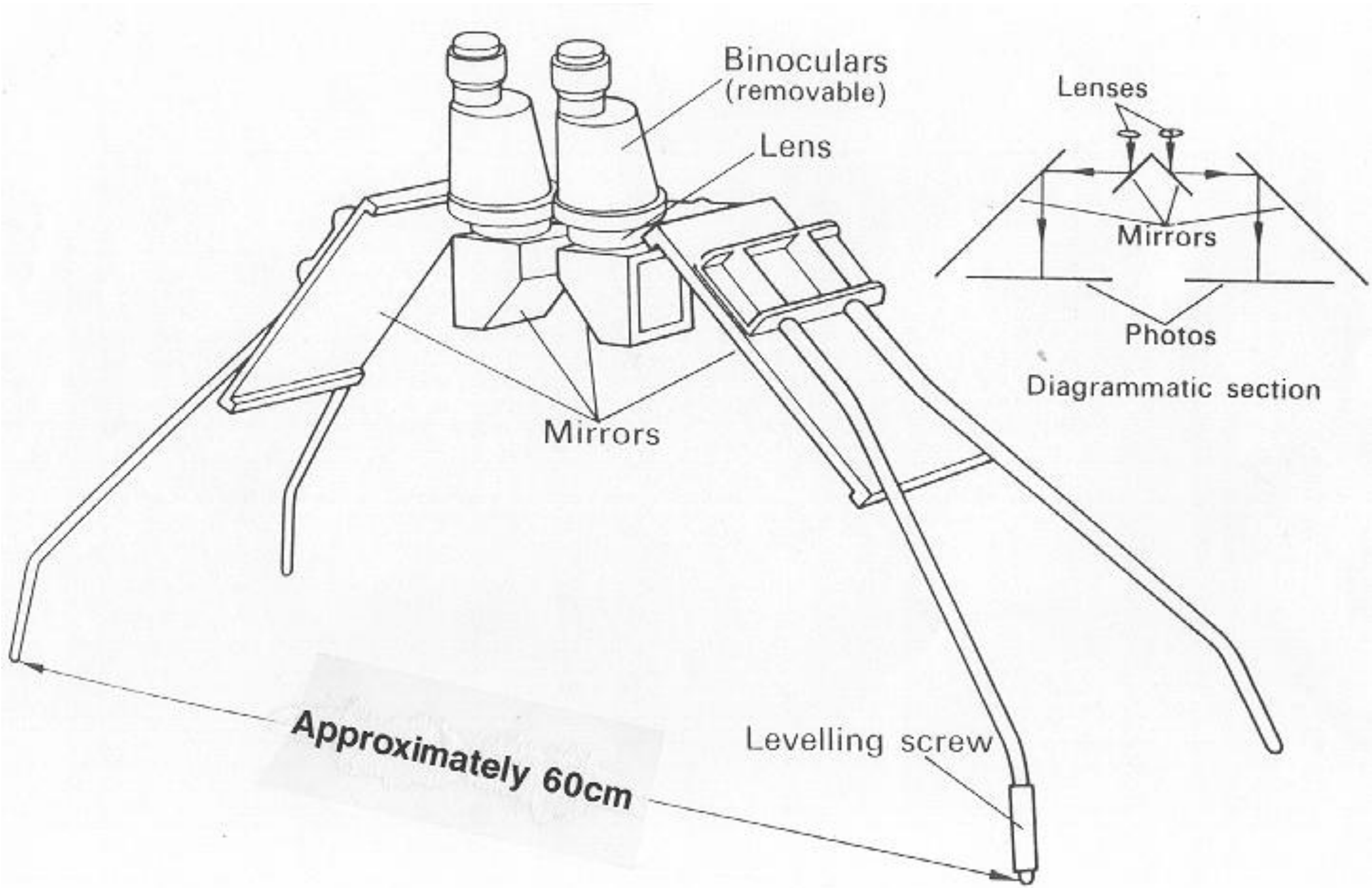
Artificial Stereoscopic Vision

- To observe stereoscopic pair of photographic prints, they must be
  - separated
  - viewed with parallel eye axes
- The observer's eyes must therefore be
  - accommodated at 250mm
  - converged to infinity
  - ***this cannot be done naturally !!***

Pocket Stereoscope



Mirror Stereoscope



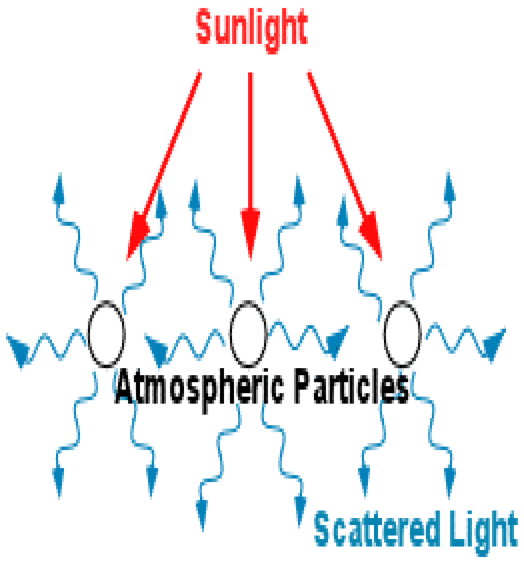
Energy interactions in the atmosphere

- The composition of the atmosphere influences both the incoming solar radiation and the outgoing terrestrial radiation

- The radiance (the energy reflected by the surface) received at a satellite is a result of electromagnetic radiation that undergoes several processes which are wavelength dependent

Scattering

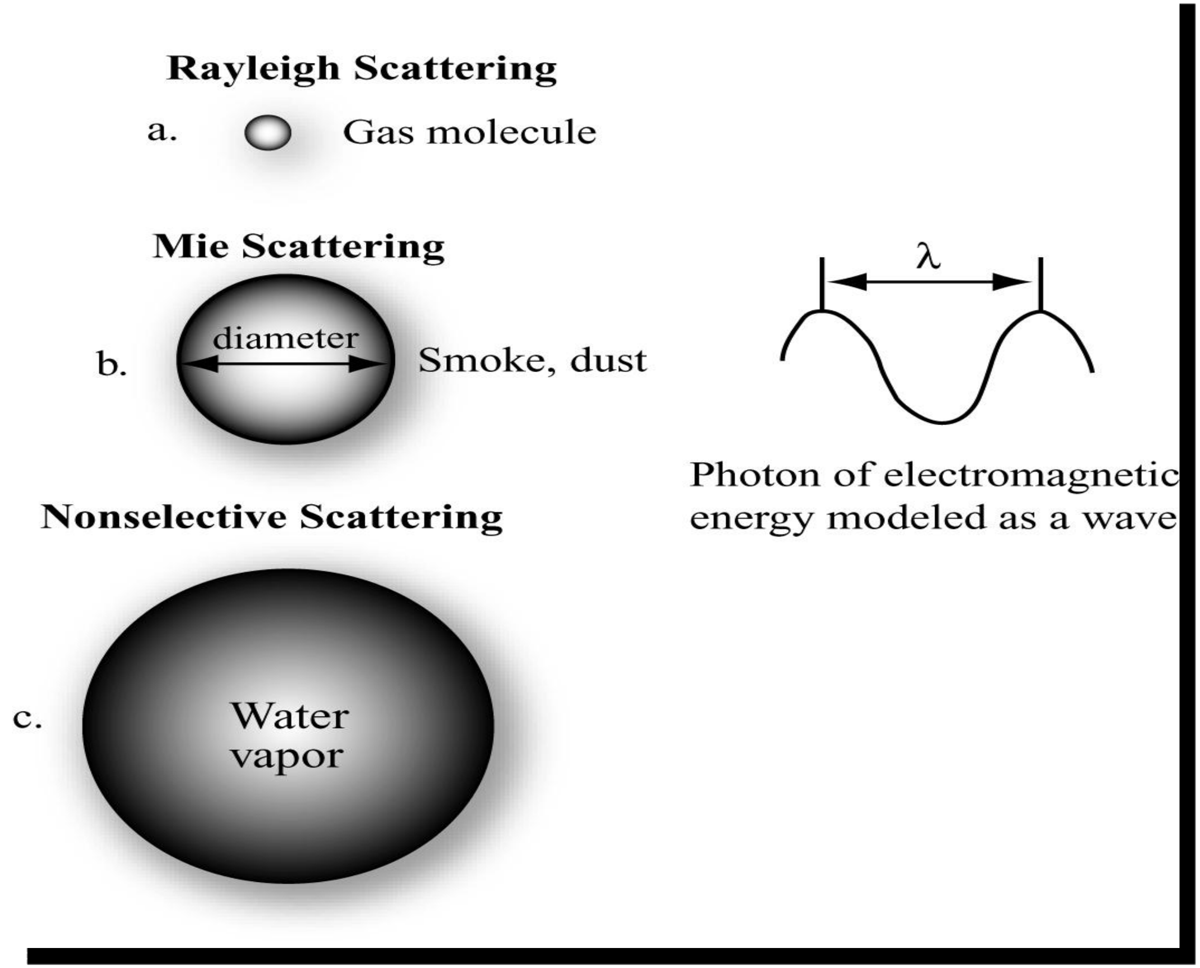
- The redirection of EM energy by particles suspended in the atmosphere or large molecules of atmospheric gases
- Scatter differs from reflection in that the direction associated with scattering is unpredictable, whereas the direction of reflection is predictable
- Type of scattering is a function of:
  - the wavelength of the incident radiant energy, and
  - the size of the gas molecule, dust particle, and/or water vapor droplet encountered.



Scattering

- Types of scattering
  - Rayleigh scattering
  - Mie scattering
  - Nonselective scattering

Atmospheric scattering



Rayleigh scattering

- It occurs when atmospheric particles' diameters are much smaller than the wavelength of the radiation d<<l

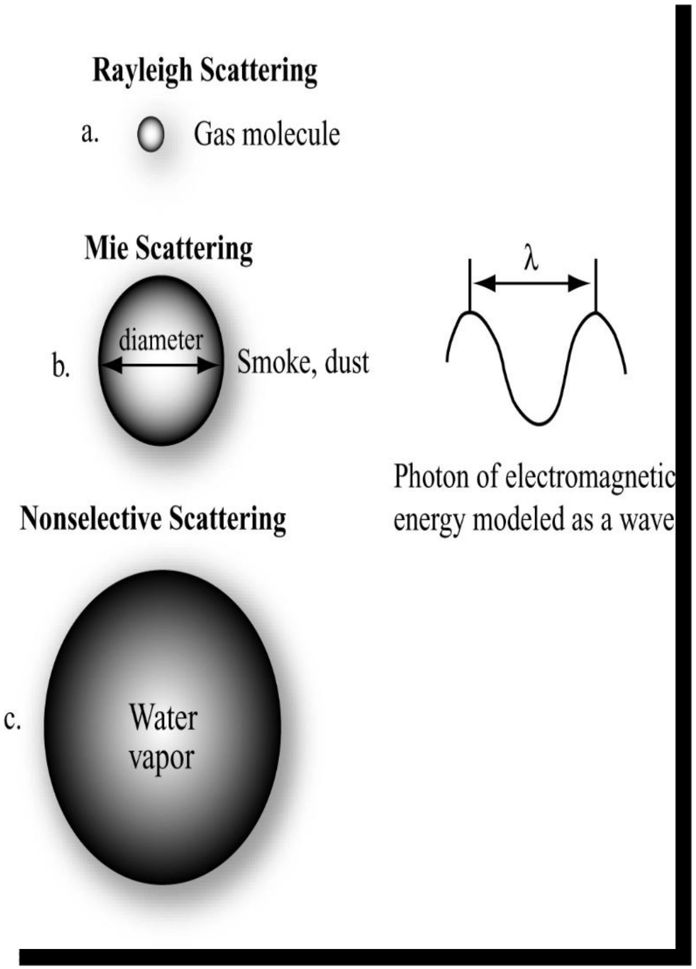
- It is common in the high atmosphere (3-8 km)

- Rayleigh scattering is proportional to the inverse of the wavelength raised to the fourth power: shorter wavelengths are scattered more than longer wavelengths

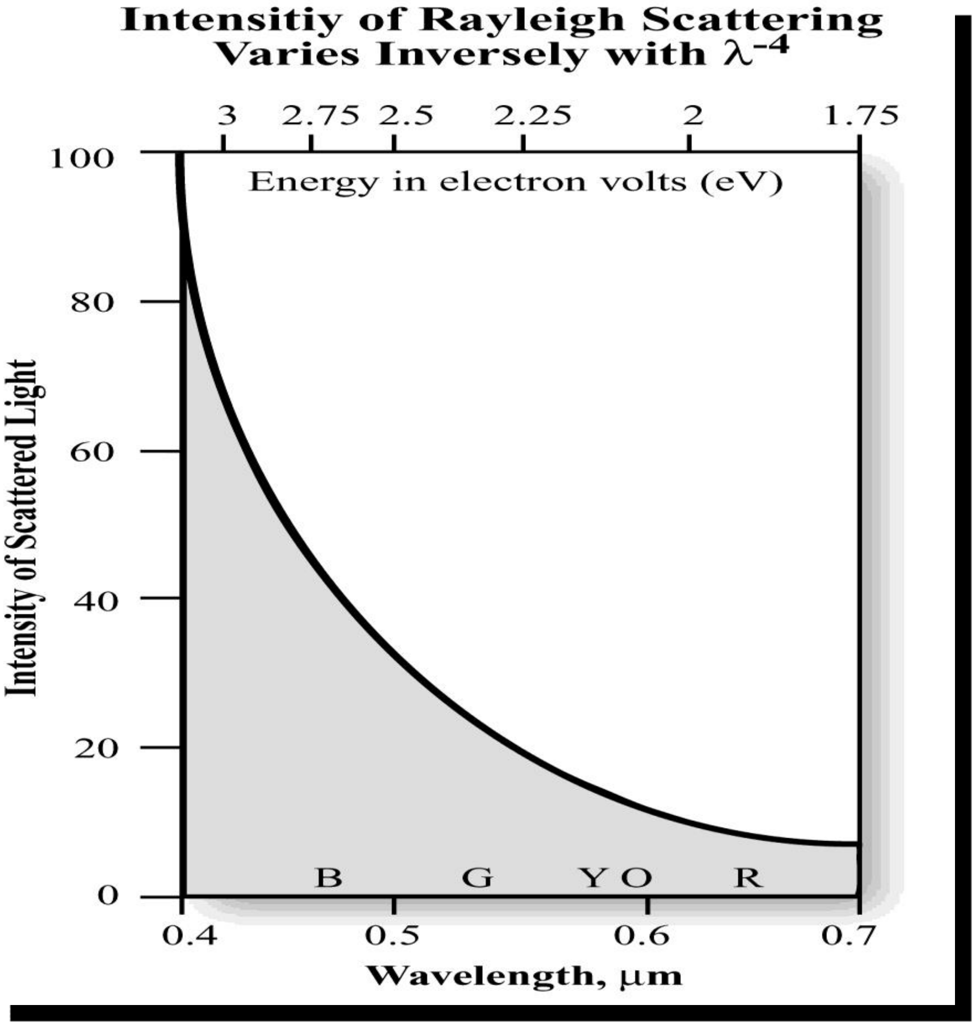
- At daytime, the sun rays travel the shortest distance through the atmosphere- Blue sky

- At sunrise and sunset, the sun travel a longer distance through the Earth's atmosphere before they reach the surface- The sky appears orange or red.

- Tends to dominate under most atmospheric conditions

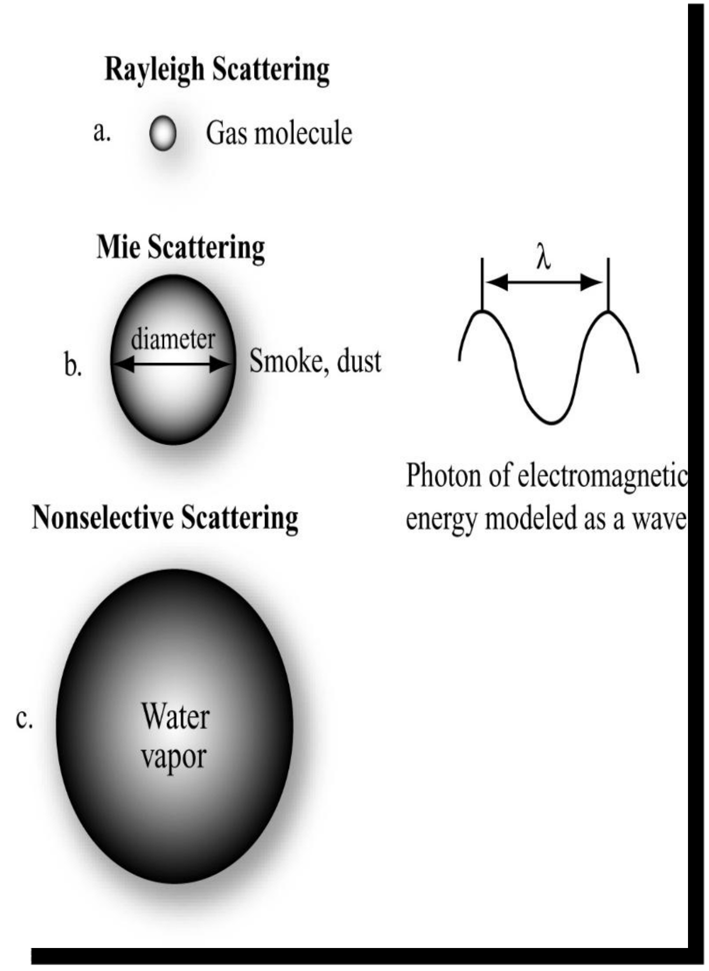


Rayleigh scattering



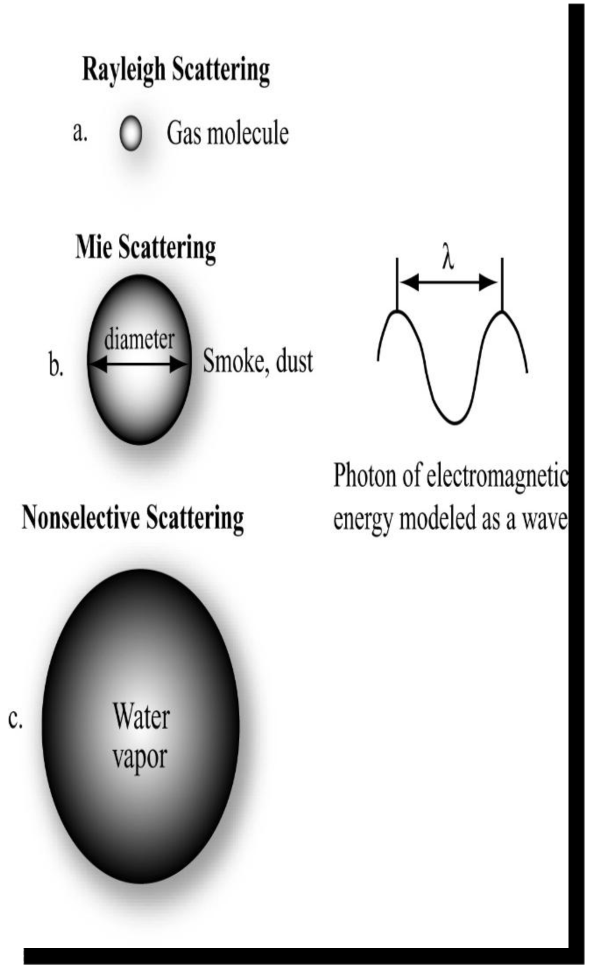
Mie scattering

- Particles' diameters are equivalent to the wavelength d ≈ l
- Water vapor and dust are major causes of Mie scattering
- Mie scattering tends to influence longer wavelengths.
- It is common in lower atmosphere where large particles are more abundant, and dominates under overcast could conditions.



Nonselective scattering

- Particles are much larger than the wavelength d>>l
- Water droplets (5-100 μm) and larger dust particles
- Non-selective scattering is independent of wavelength
- All wavelength are scattered equally (A could appears white)
- It scatters all visible and near to mid IR wavelengths.



Absorption

- Absorption is the process by which radiant energy is absorbed and converted into other forms of energy

- The atmosphere prevents, or strongly attenuates, transmission of radiation through the atmosphere

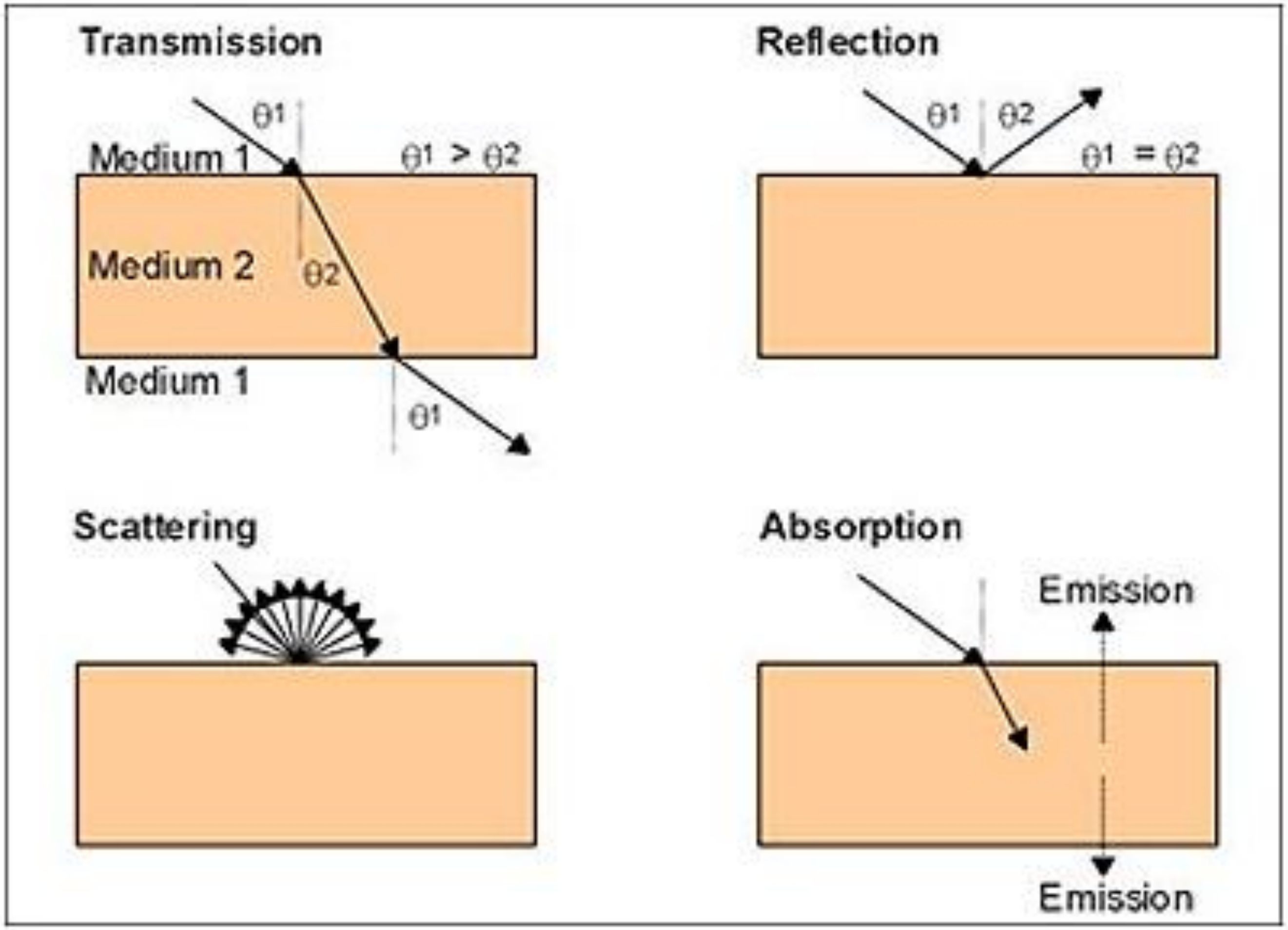
- An absorption band is a range of wavelengths (or frequencies) in the electromagnetic spectrum within which radiant energy is absorbed by substances such as water (H_2O), carbon dioxide (CO_2), oxygen (O_2), ozone (O_3), and nitrous oxide (N_2O).
- Three gases:

  - Ozone (O_3): absorbs ultraviolet radiation high in atmosphere

  - Carbon-dioxide (CO_2): absorbs mid and far infrared (13-17.5 μm) in lower atmosphere

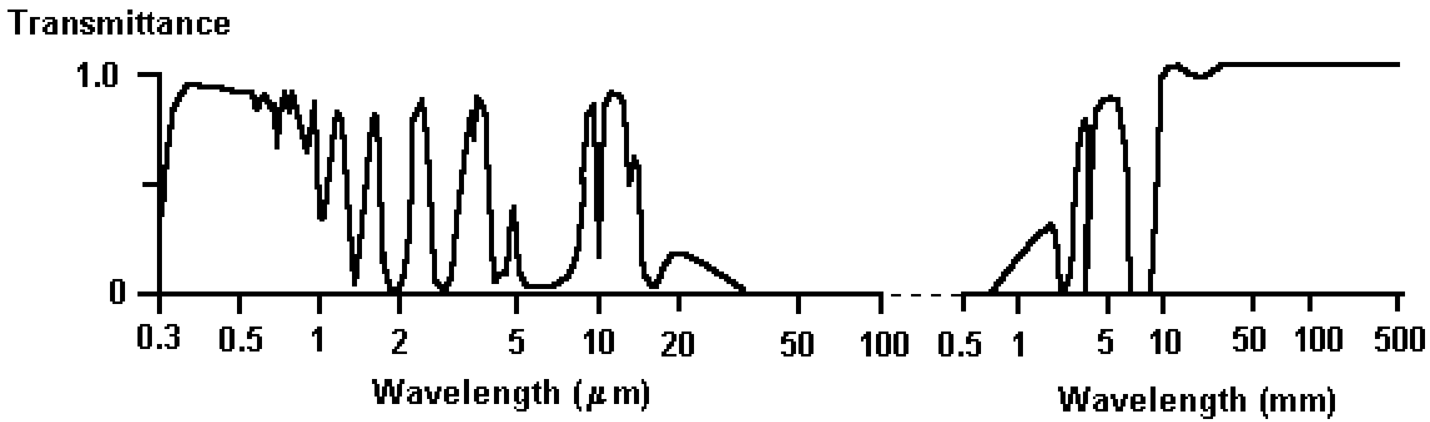
  - Water vapor (H_2O): absorbs mid-far infrared (5.5-7.0, >27 μm) in lower atmosphere

Transmission, reflection, scattering, and absorption



Atmospheric windows (transmission bands)

-The wavelength ranges in which the atmosphere is particularly transmissive



Atmospheric Windows

- The windows:
  UV & visible: 0.30-0.75 mm
  Near infrared: 0.77-0.91 mm
  Mid infrared: 1.55-1.75mm, 2.05-2.4 mm
  Far infrared: 3.50-4.10 mm, 8.00- 9.20 mm,
  10.2-12.4 mm
  Microwave: 7.50-11.5 mm, 20.0+mm
- X-Rays and UV are very strongly absorbed and Gamma Rays and IR are somewhat less strongly absorbed.
- The atmospheric windows are important for RS sensor design

Energy Interactions with Earth Surface Features

Reflection, absorption, and transmission

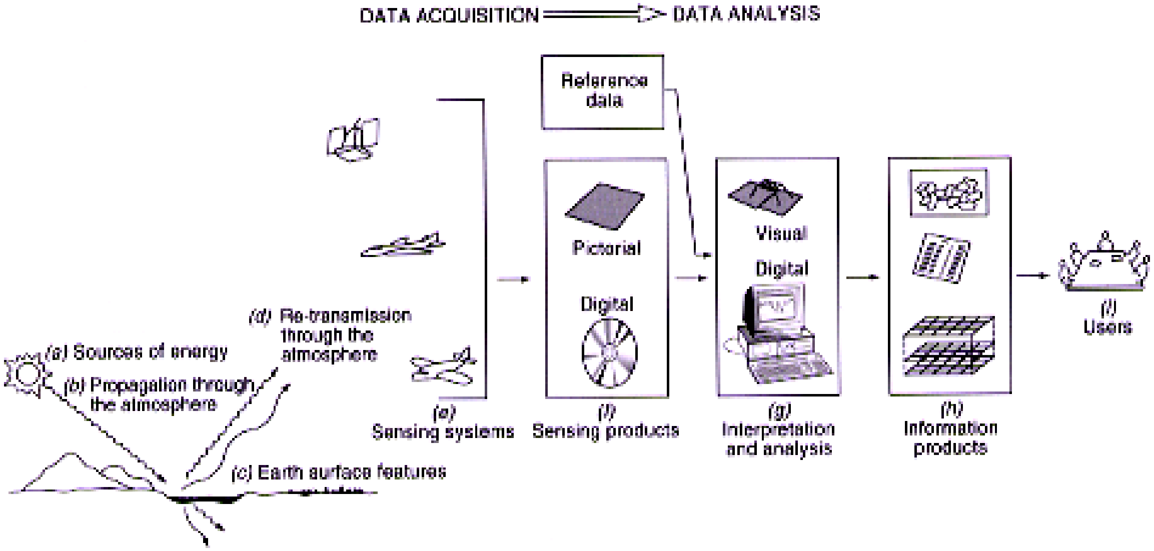
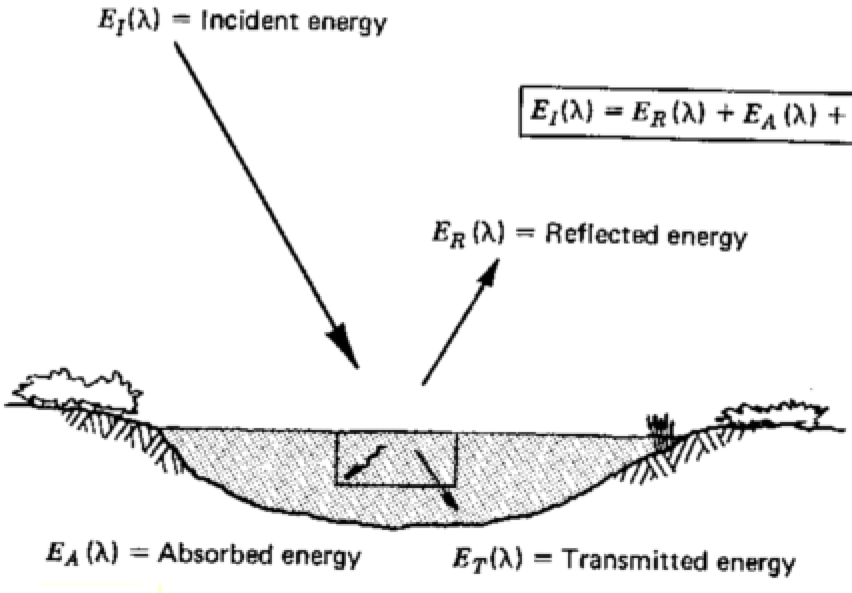


Figure 1.1 Electromagnetic remote sensing of earth resources.

Energy Interactions with Earth Surface Features

- All EM energy reaches earth's surface must be reflected, absorbed, or transmitted
- The proportion of each depends on:
  - the spectral reflectance properties of the surface materials
  - the surface smoothness relative to the radiation wavelength
  - wavelength
  - angle of illumination

Energy Interactions with Earth Surface Features



Energy Interactions with Earth Surface Features

- Light ray is redirected as it strikes a nontransparent surface
- Albedo - Spectral reflectance R (λ): the average amount of incident radiation reflected by an object at some wavelength interval

$$R(\lambda) = ER(\lambda) / EI(\lambda) \times 100$$

Where

ER(λ) = reflected radiant energy

EI (λ) = incident radiant energy

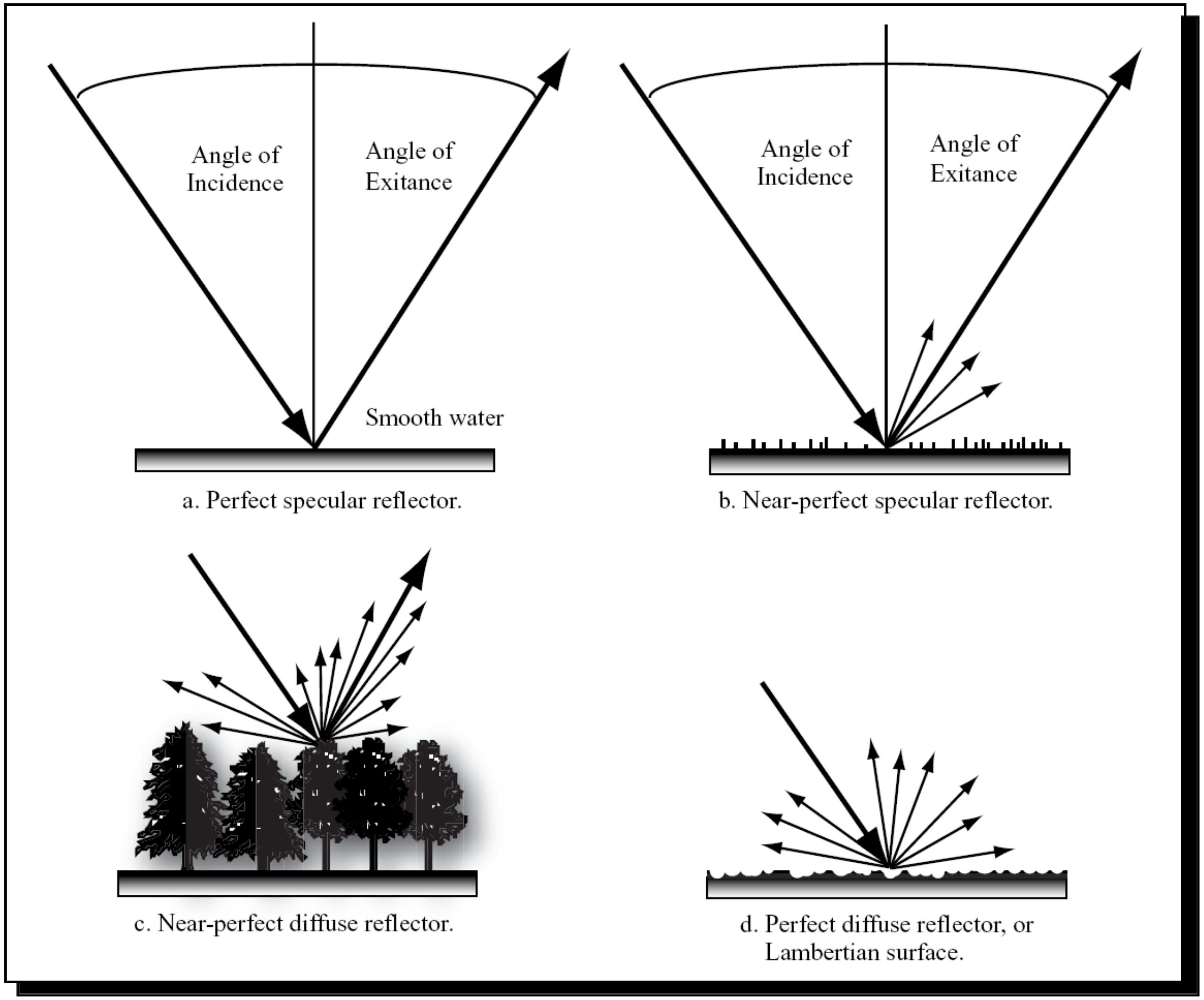
Specular versus diffuse reflectance

- Specular reflectors are flat surfaces that manifest mirrolike reflections. The angle of reflection equals the angle of incident.

- Diffuse (or Lambertian) reflectors are rough surfaces that reflect uniformly in all the directions
  - If the surface is rough, the reflected rays go in many directions, depending on the orientation of the smaller reflecting surfaces
- Diffuse contain spectral information on the color of the reflecting surface, whereas specular reflections do not.

- In remote sensing we are often interested in measuring the diffuse reflectance of objects.

Specular versus diffuse reflectance



Transmission

- Radiation passes through a substance without significant attenuation

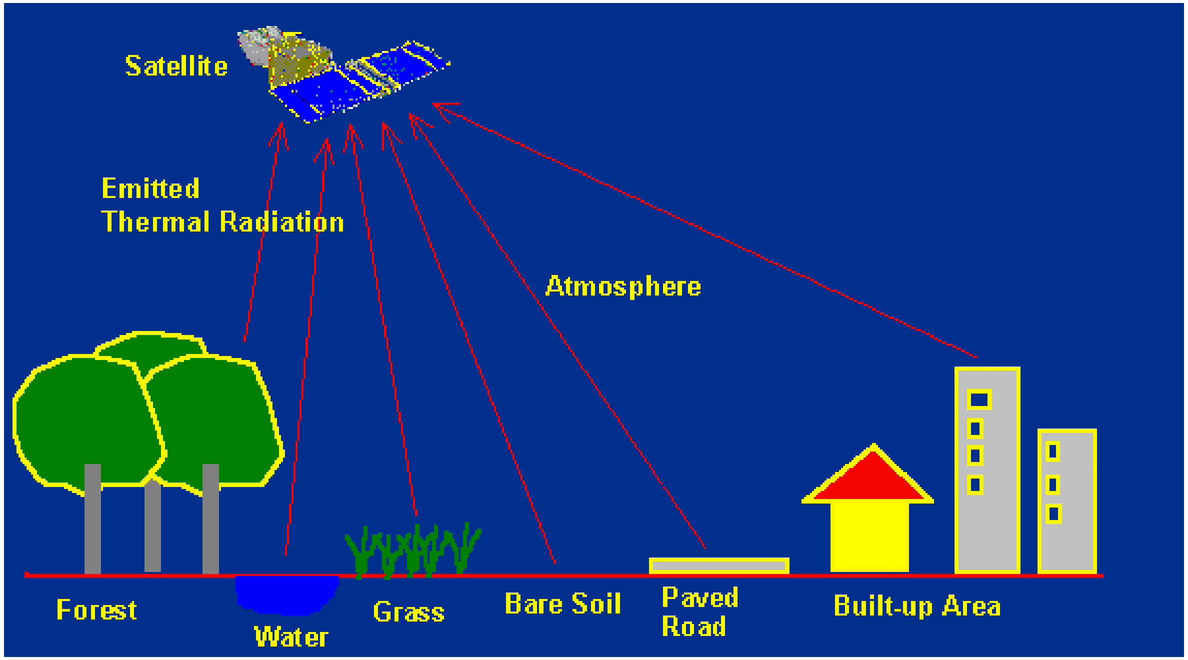
- Transmittance (t):

$$t = \frac{\text{transmitted radiation}}{\text{incident radiation}}$$

Absorption

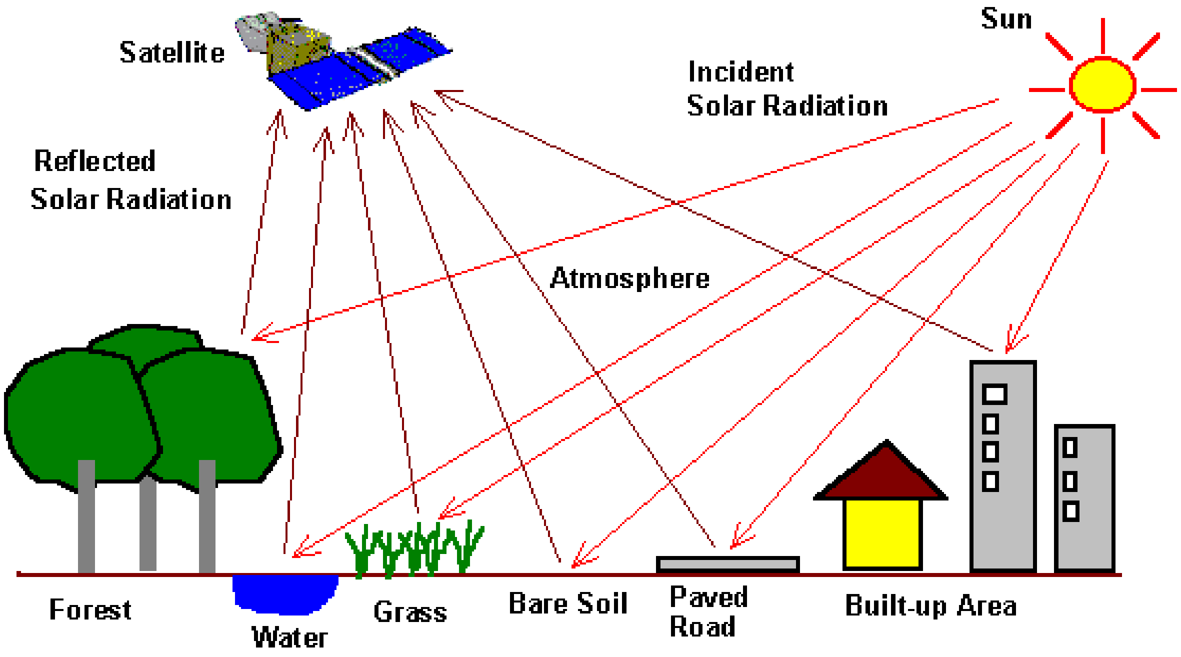
Reflection + Transmission + Absorption = 100%

Emission

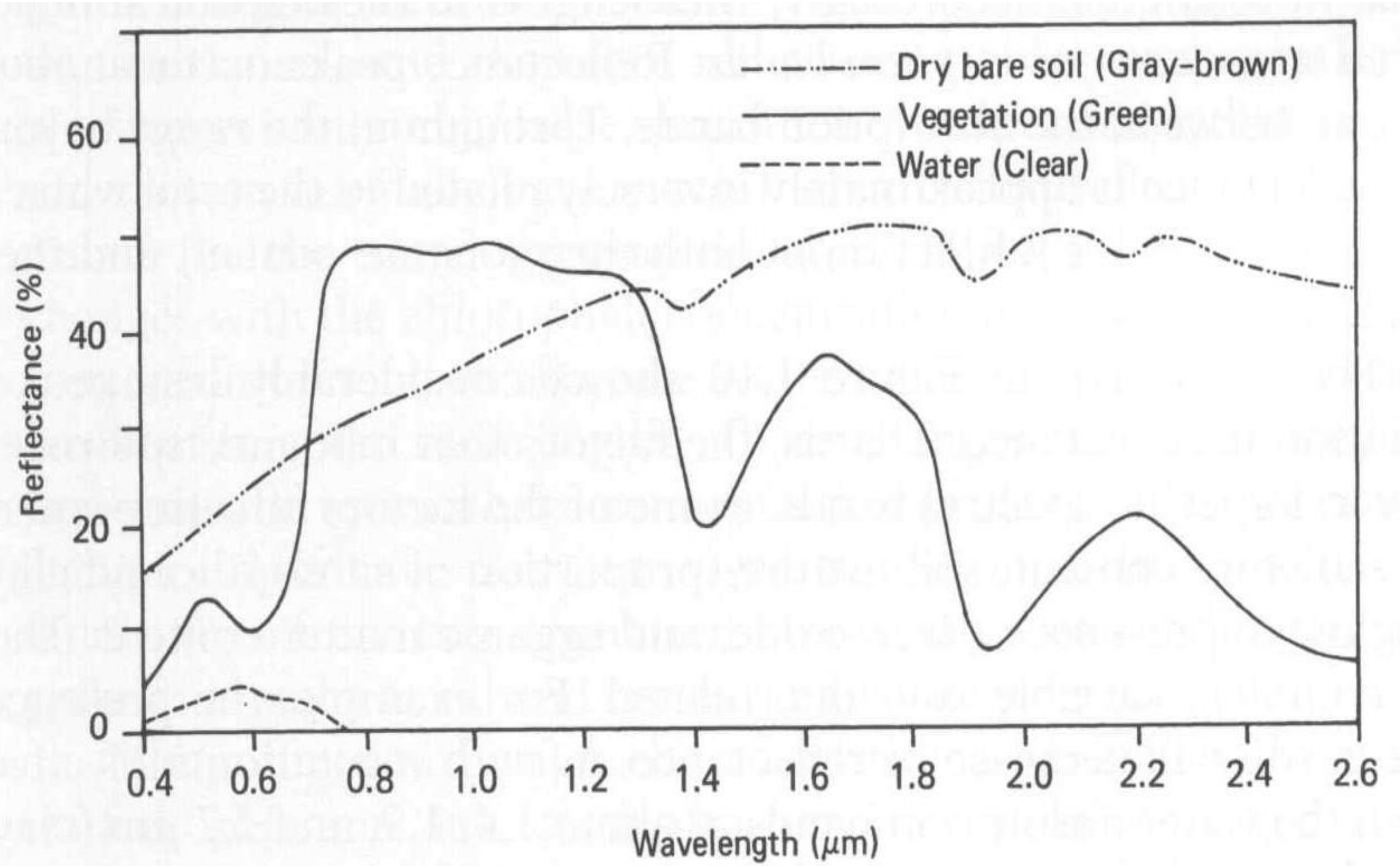


Satellite
Emitted
Thermal Radiation
Atmosphere
Forest
Water
Grass
Bare Soil
Paved
Road
Built-up Area

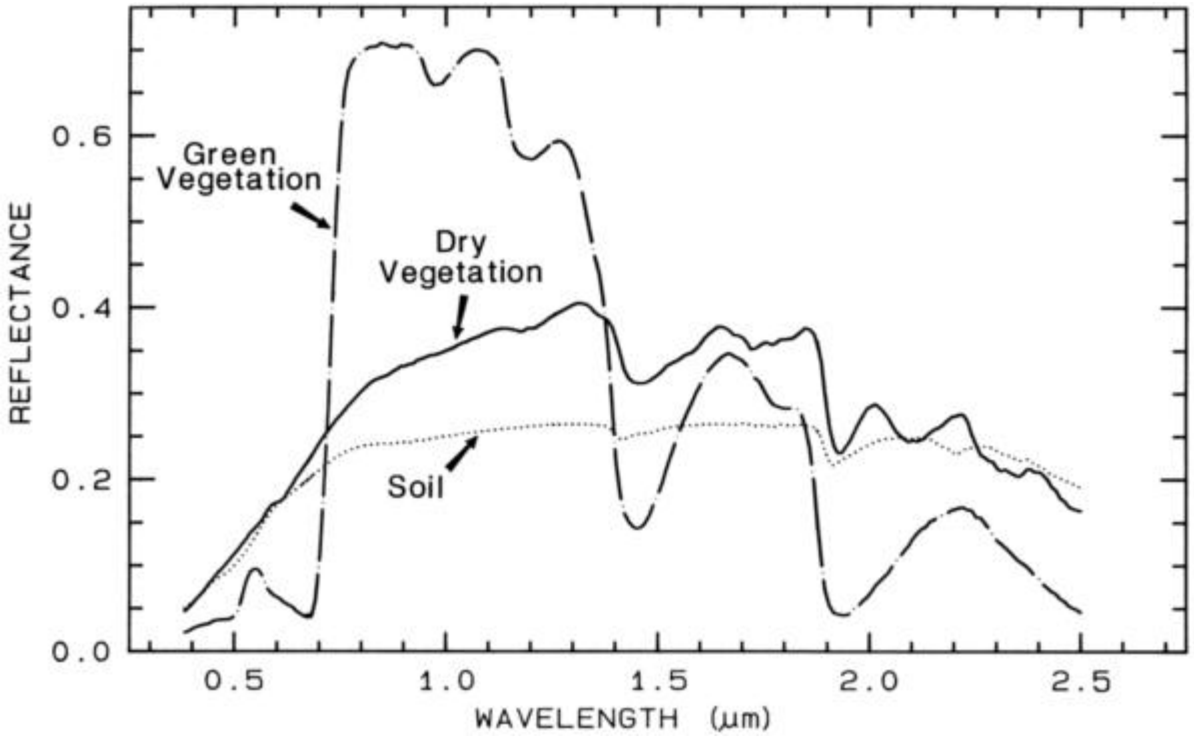
Spectral Characteristics of Features



Spectral reflectance curves for vegetation, soil, and water

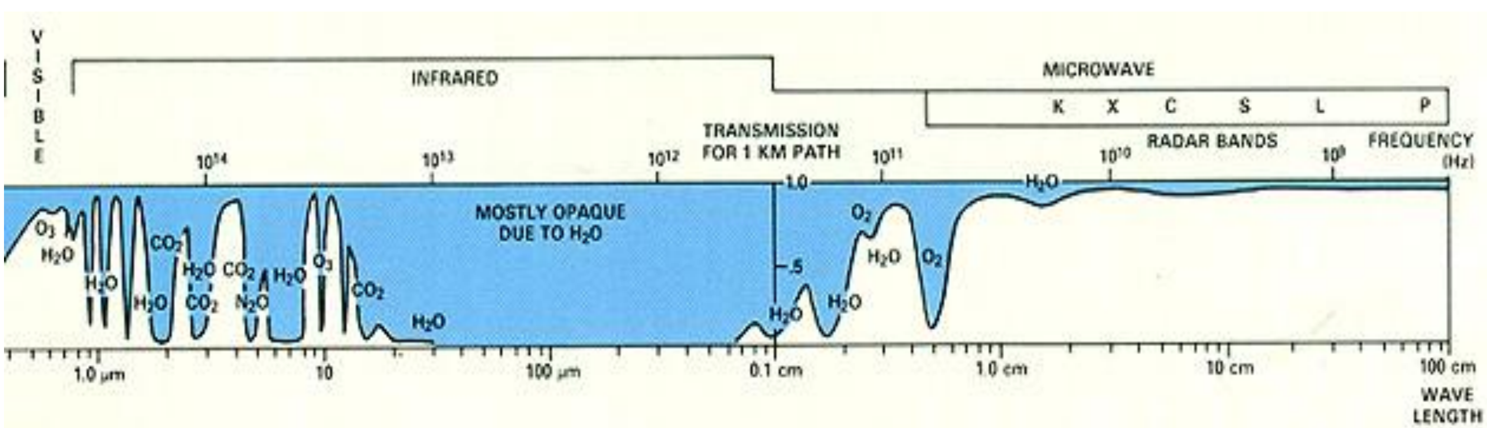


Identification of Surface Materials Based on Spectral Reflectance

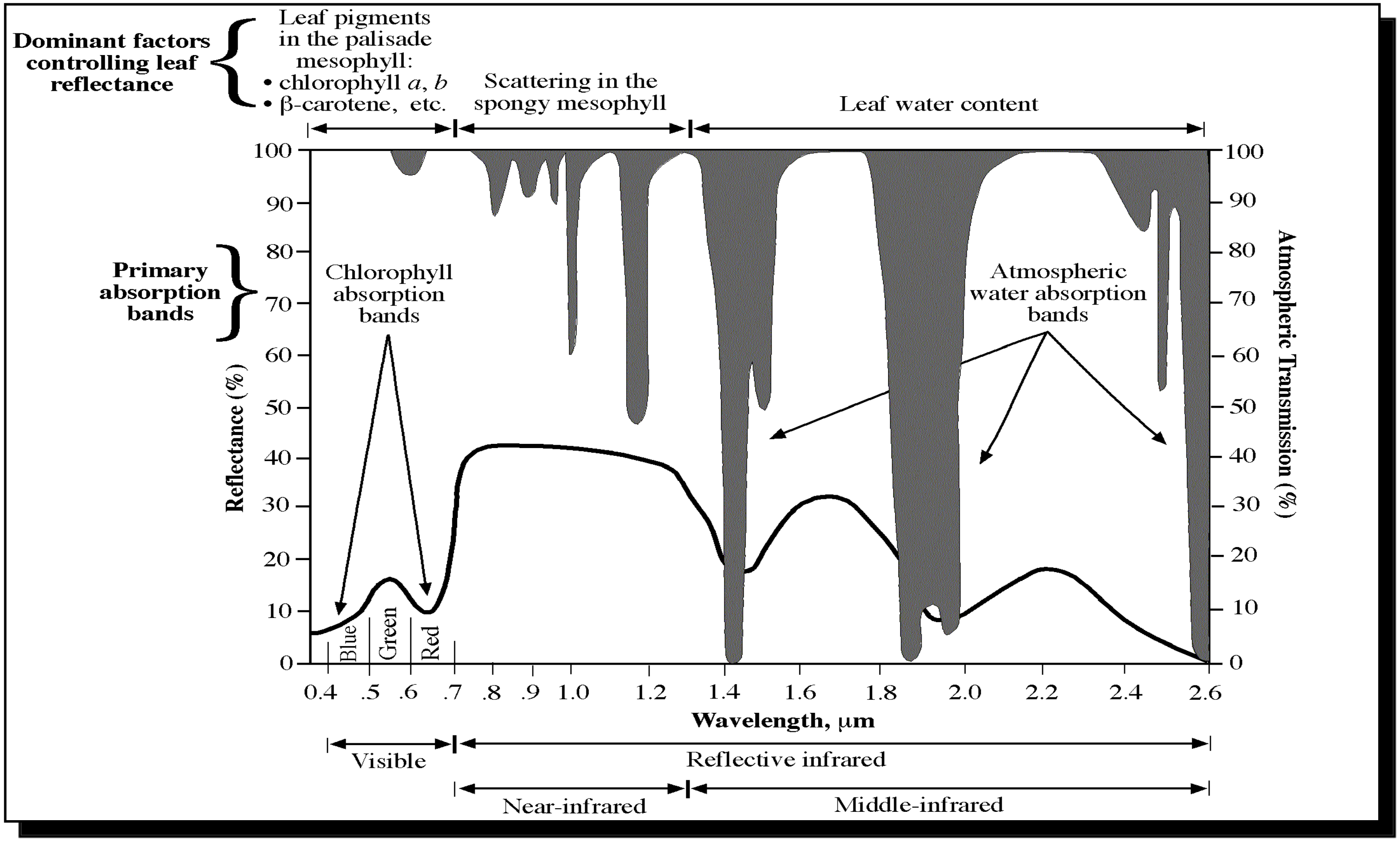


Spectra of vegetation

- Chlorophyll absorbs blue and red, reflects green
- Vegetation has a high reflection and transmission at NIR wavelength range
- Reflection or absorption at MIR range, the water absorption bands



Spectra of vegetation



Absorption is dominant process in **visible**
Scattering is dominant process in **near infrared**
Water absorption is increasingly important with increasing wavelength in the infrared.

Spectra of soil

- What are the important properties of a soil in an RS image

  -Soil texture (proportion of sand/silt/clay)

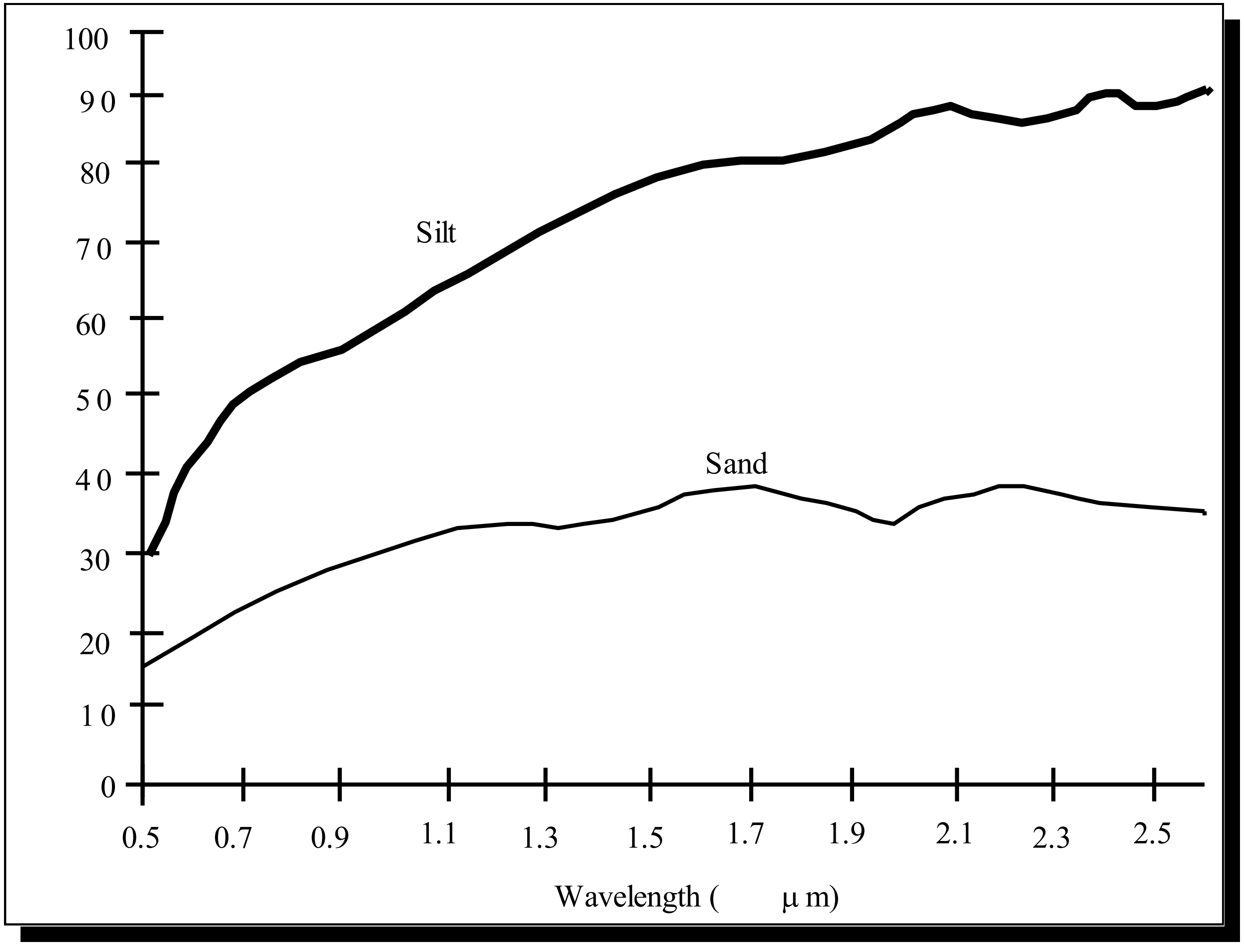
  -Soil moisture content

  -Organic matter content

  -Mineral contents, including iron-oxide and carbonates

  -Surface roughness

Dry soil spectrum

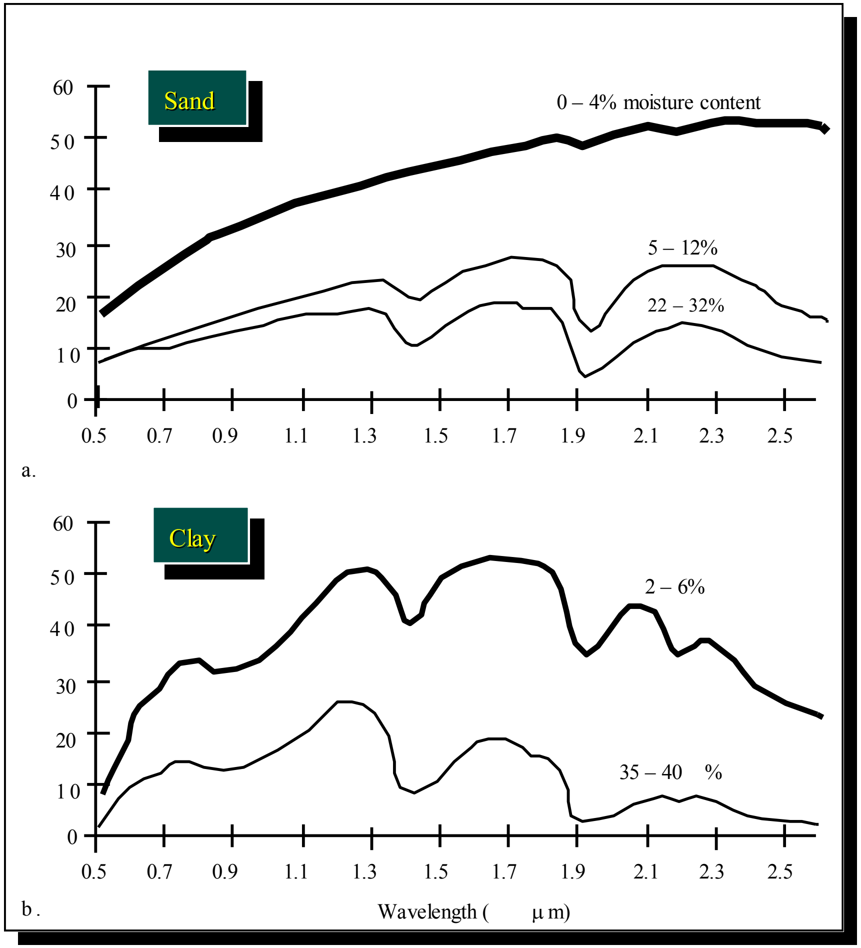


- **Coarse soil (dry) has relatively high reflectance**
- **Increasing reflectance with increasing wavelength through the visible, near and mid infrared portions of the spectrum**

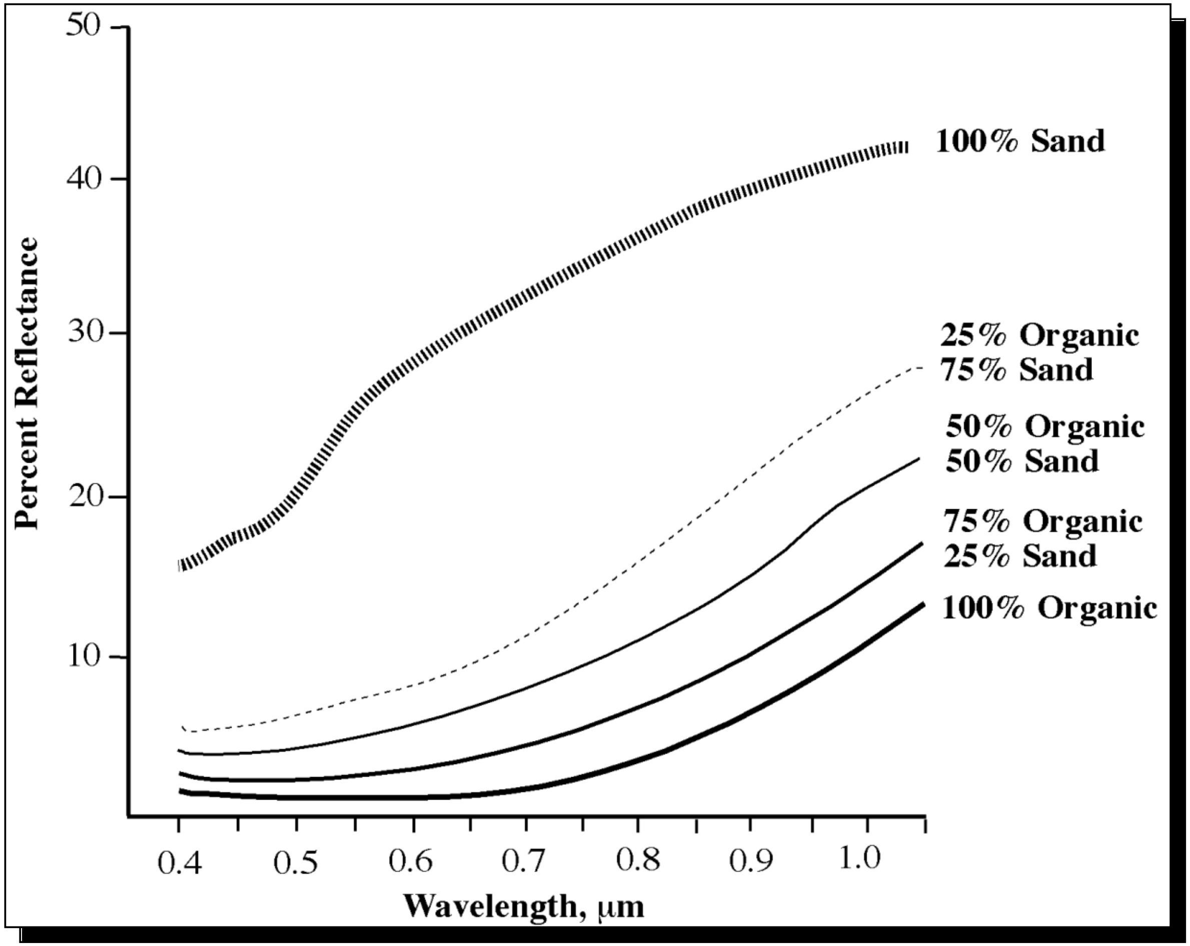
Soil moisture and texture

- Soil moisture decreases reflectance
- Clays hold more water more 'tightly' than sand.
- Thus, clay spectra display more prominent water absorption bands than sand spectra

Soil moisture and texture

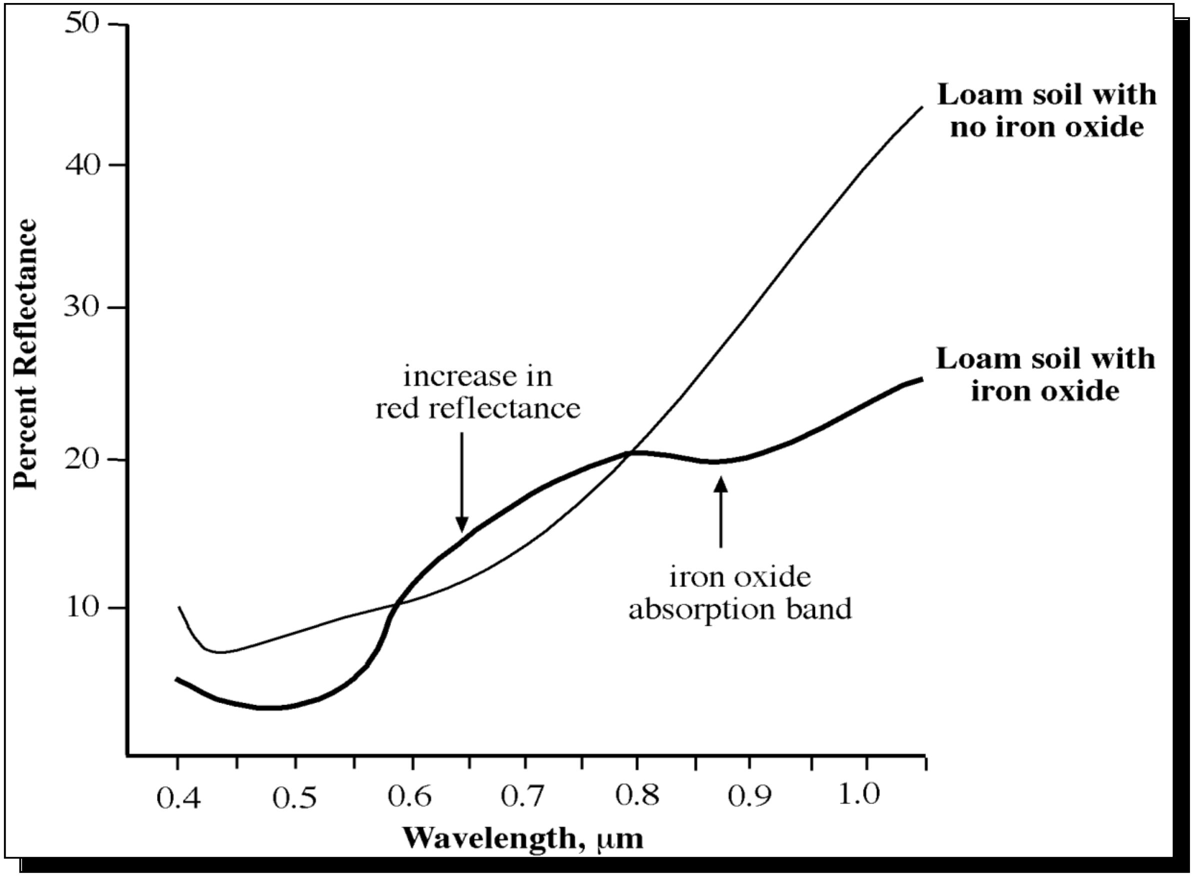


Soil Organic Matter



Organic matter is a strong absorber of EMR, so more organic matter leads to darker soils (lower reflectance curves).

Iron Oxide



Recall that iron oxide causes a charge transfer absorption in the UV, blue and green wavelengths, and a crystal field absorption in the NIR (850 to 900 nm). Also, scattering in the red is higher than soils without iron oxide, leading to a red color.

Surface Roughness

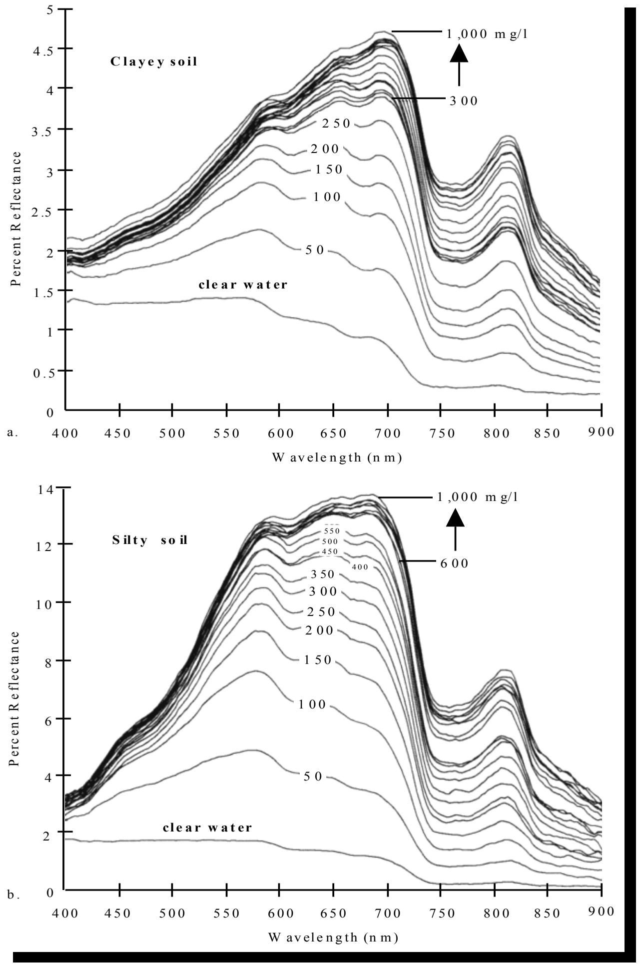
- Smooth surface appears black.
- Smooth soil surfaces tend to be clayey or silty, often are moist and may contain strong absorbers such as organic content and iron oxide.
- Rough surface scatters EMR and thus appears bright.

Spectra of water

- Transmission at visible bands and a strong absorption at NIR bands

- Water surface, suspended material, and bottom of water body can affect the spectral response

Spectra of water



Reflectance peak shifts toward longer wavelengths as more suspended sediment is added

UNIT-3

FUNDAMENTALS OF

GEOGRAPHIC INFORMATION SYSTEMS

Mapping Concepts, Features & Properties

A map represents

- Geographic features or other spatial phenomena by graphically conveying information about locations and attributes.
- Locational information describes the position of particular geographic features on the Earth's surface, as well as the spatial relationship between features,
- Attribute information describes characteristics of the geographic features represented, such as the feature type, its name or number and quantitative information

•Thus the basic objective of mapping is to provide

- descriptions of geographic phenomenon
- spatial and non spatial information

Geomatics, also known as Geoinformatics, is the science and technology of : gathering, analyzing, interpreting, distributing and using geographic information.

Geomatics encompasses a broad range of disciplines including surveying and mapping,, geographic information systems (GIS), and the GPS.

Geographic information systems are among the most exciting and powerful geo matics decision-making tools in the world.

A GIS uses computer technology to integrate, manipulate and display a wide range of information to create a picture of an area's geography, environment and socio-economic characteristics.

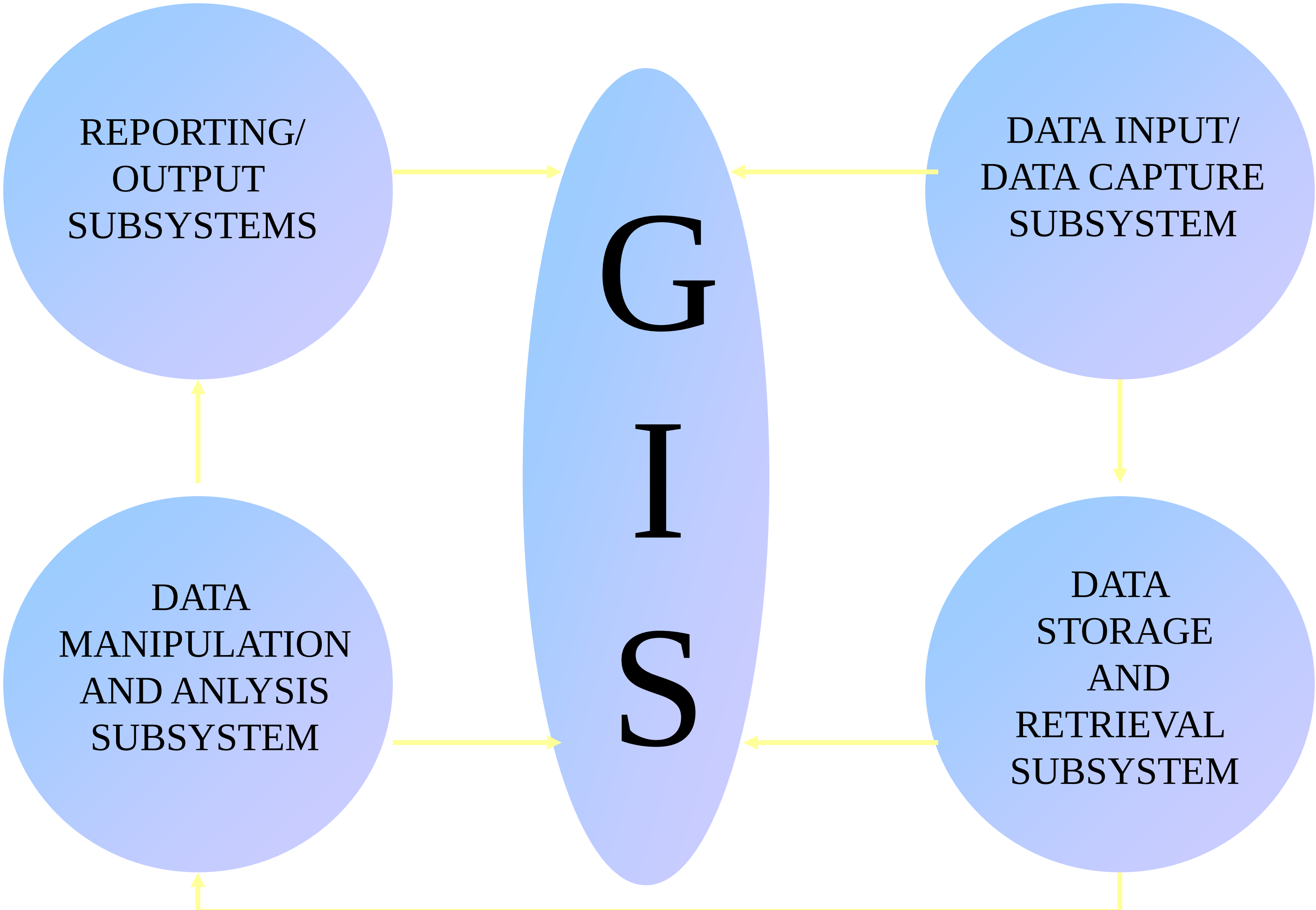
Definition of GIS

An organized collection of computer hardware, software, Geographical data and personnel designed to efficiently capture, store, update, manipulate, analyze & display all forms of Geographically referenced information is called GIS.

Application areas of GIS

- Agricultural applications
- Forestry applications
- Rangeland applications
- Water resources applications
- Urban and regional planning applications
- Wetland mapping
- Land use/ Land cover mapping
- Geologic and soil mapping
- Wildlife ecology applications
- Archaeological applications
- Environmental assessment, monitoring and management

GIS Architecture



DATA INPUT/DATA CAPTURE SUBSYSTEM →

- Key board entry
- Manual Digitizing
- Scanning and automatic digitizing

DATA STORAGE AND RETRIEVAL SUBSYSTEM →

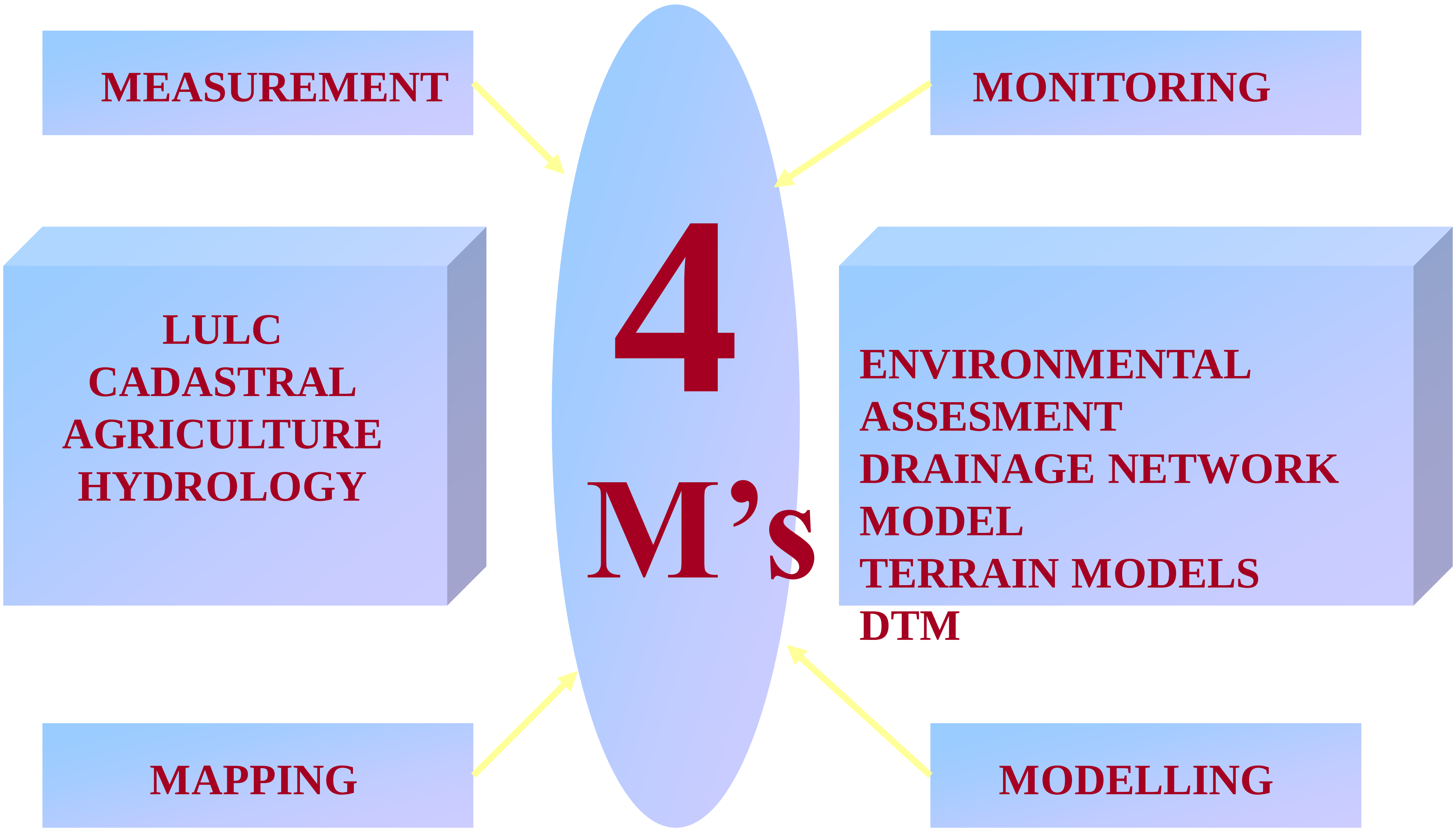
- DBMS

DATA MANIPULATION AND ANLYSIS SUBSYSTEM →

- Format conversion
- Data medium conversion
- Spatial measurements
- Reclassification
- Buffering
- Overlay
- Modelling surfaces

REPORTING/ OUTPUT SUBSYSTEMS →

- Maps
- Graphical outputs


MEASUREMENT
MONITORING
LULC
CADASTRAL
AGRICULTURE
HYDROLOGY
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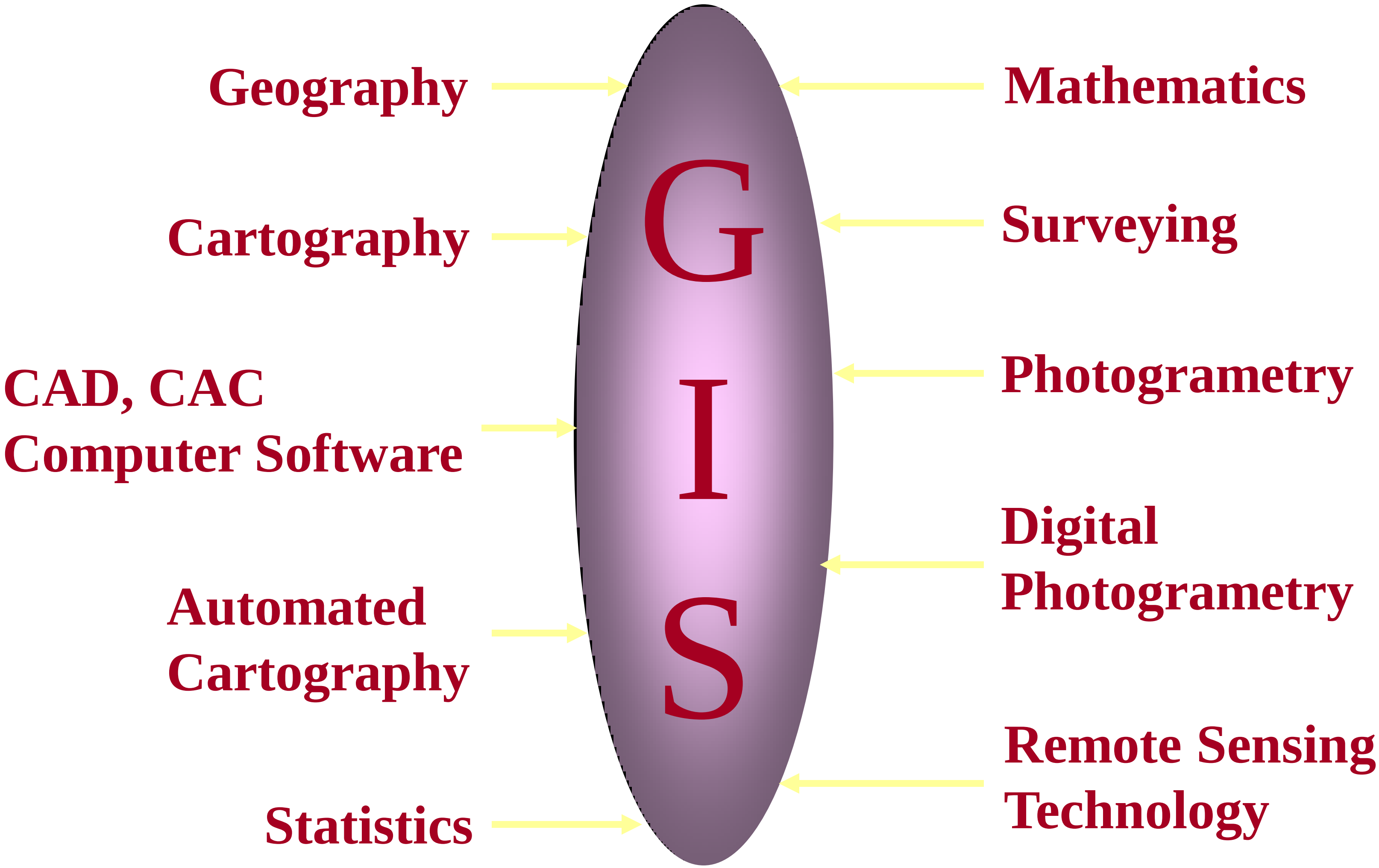
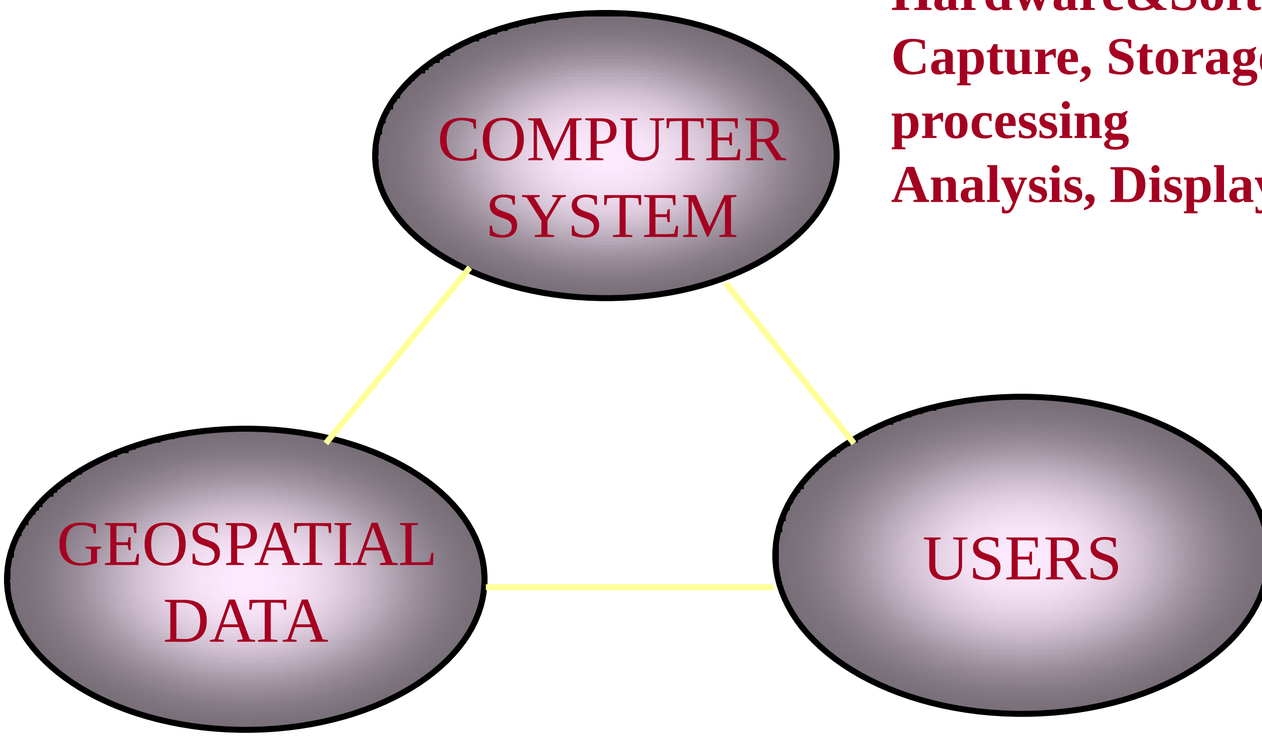
M's
ENVIRONMENTAL
ASSESMENT
DRAINAGE NETWORK
MODEL
TERRAIN MODELS
DTM
MAPPING
MODELLING

Contribution Disciplines



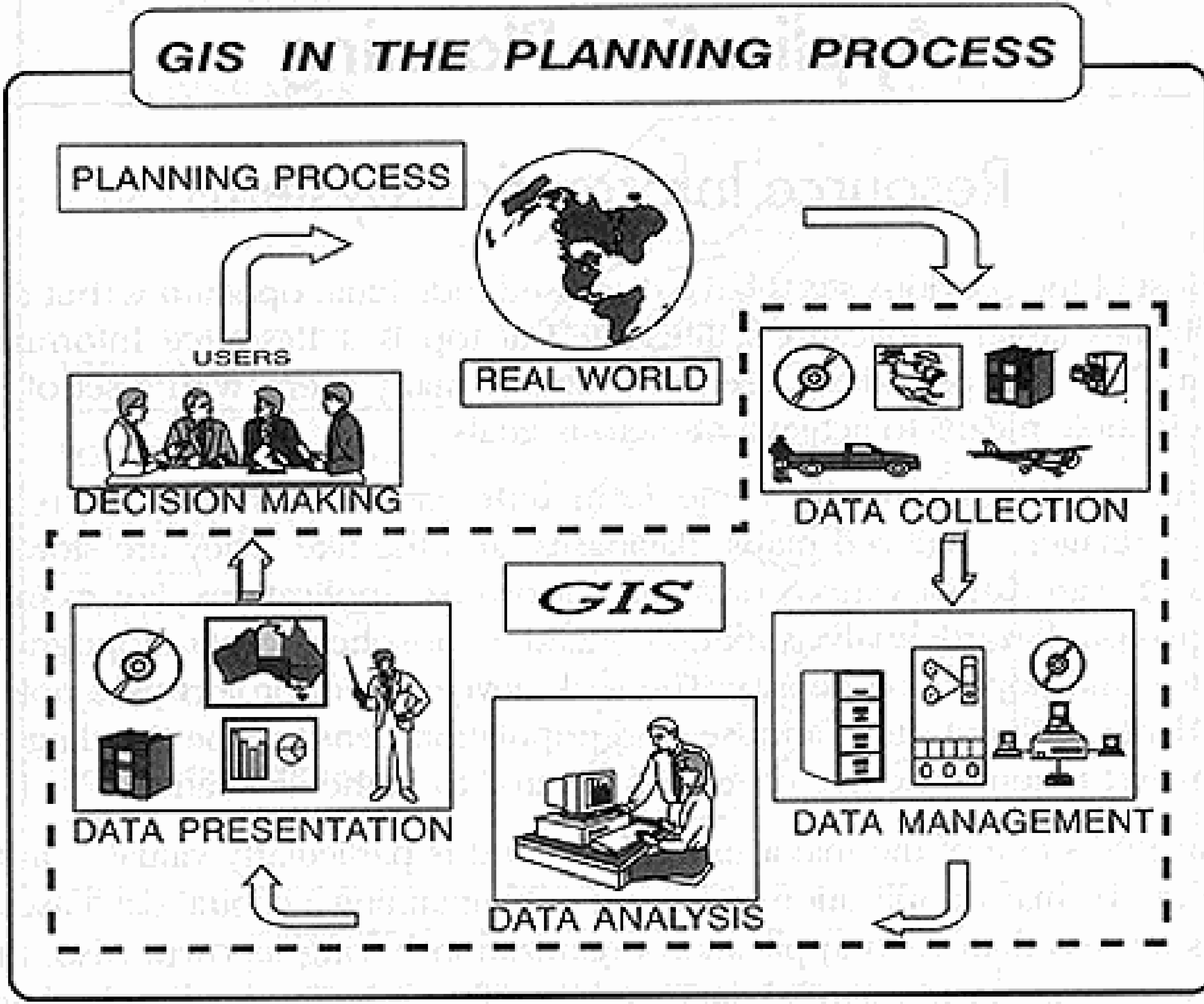
KEY COMPONENTS OF GIS

Hardware&Software
Capture, Storage,
processing
Analysis, Display etc.,

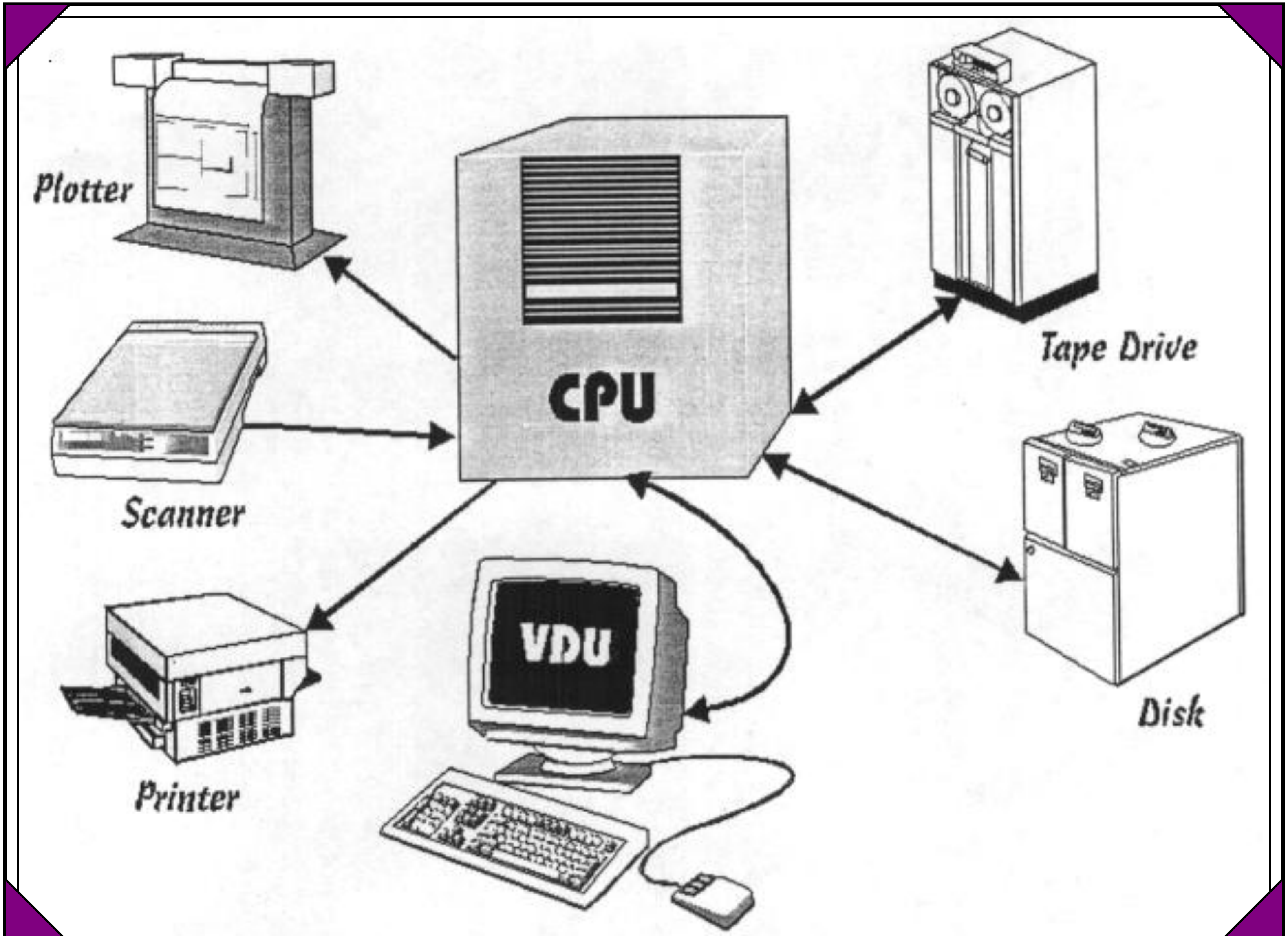


Maps, Aerial photographs, Satellite Images, Statistic Tables etc,

Design of Standards, Updating, Analysis and Implementations


GIS IN THE PLANNING PROCESS
PLANNING PROCESS
REAL WORLD
USERS
DECISION MAKING
DATA COLLECTION
GIS
DATA MANAGEMENT
DATA PRESENTATION
DATA ANALYSIS

HARDWARE COMPONENTS

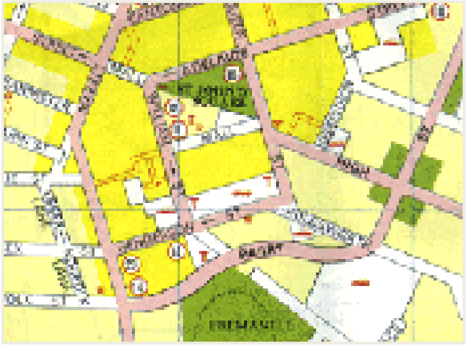


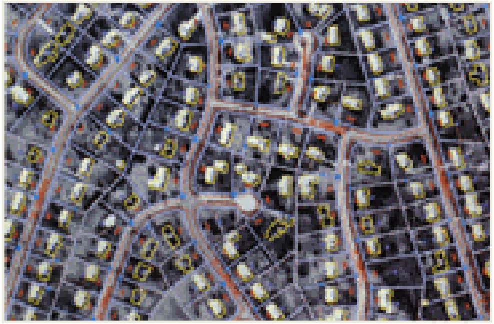
GIS Software...

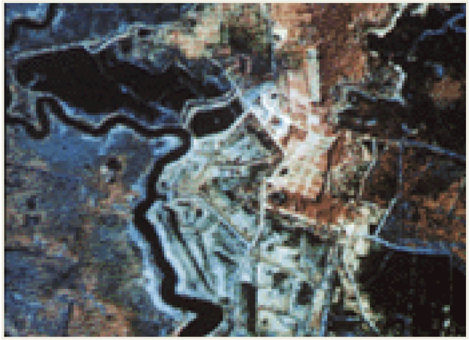
- Arc/Info
- ArcView
- SpansGIS
- PAMAP GIS
- GENA GIS
- INTERGRAPH
- NIC ATLAS

Data Capture Sources

- Digitizing from paper maps
- Scanning
- Traditional surveying techniques
- Paper records & field notes
- Photogrammetry
- Remote sensing
- GPS







UNIT-4

Vector Data Model

Geographic information systems rely on two interrelated types of databases:

•***<u>The Spatial Database</u>***

•**Describes the location and shape of geographic features, and their spatial relationship to other features.**

•**The information contained in the spatial database is held in the form of digital co-ordinates, which describe the spatial features.**

•**These can be points (for example, hospitals), lines (for example, roads), or polygons (for example, administrative districts).**

•***<u>The Attribute Database</u>***

•**The attribute database is of a more conventional type; it contains data describing characteristics or qualities of the spatial features (i.e., descriptive information):**

•GIS links spatial data with geographic information about a particular feature on a map. The information is stored as 'attributes' of the graphically represented feature.

DATA

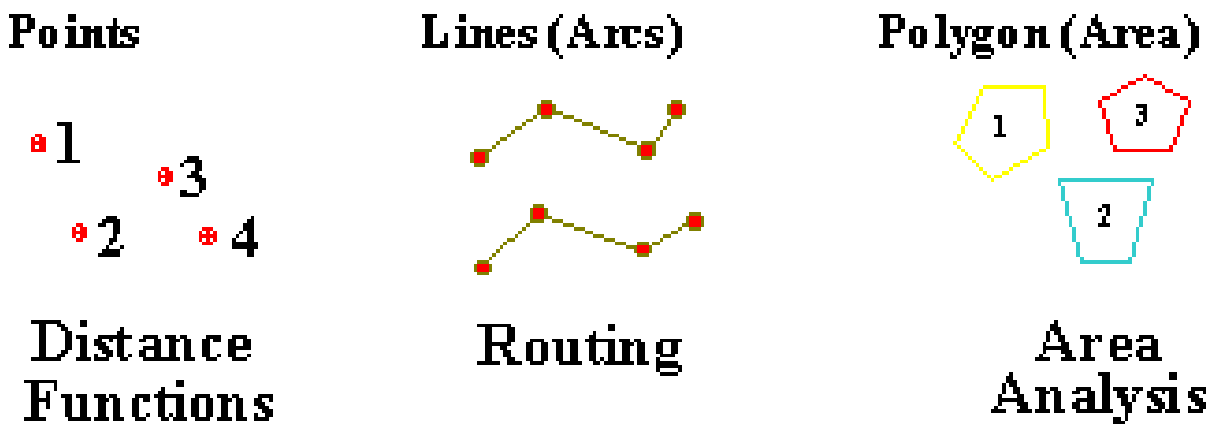
1. SPATIAL DATA

2. ATTRIBUTE DATA


Software
Hardware
GIS
Data
People
Methods


Land Use
Streets
Districts
Parcels
Parks
River
Discharge Point
Sand and Gravel
Sandstone Aquifer
Water Table
Shale

GIS attempts to describe all features in geometric terms.



•**Point:** discrete location represented as a co-ordinate pair (e.g., sampling locations, disease cases, hospitals, and town centroids).

•**Line (Arc):** set of ordered co-ordinates represented by a string of co-ordinates (e.g., streams, power and pipelines, and transportation routes).

•**Polygon (Area):** closed feature whose boundary encloses a homogeneous area represented by a closed string of co-ordinates which encompass an area (e.g., land use, lakes, census tracts, hospital catchment area, and town boundaries).

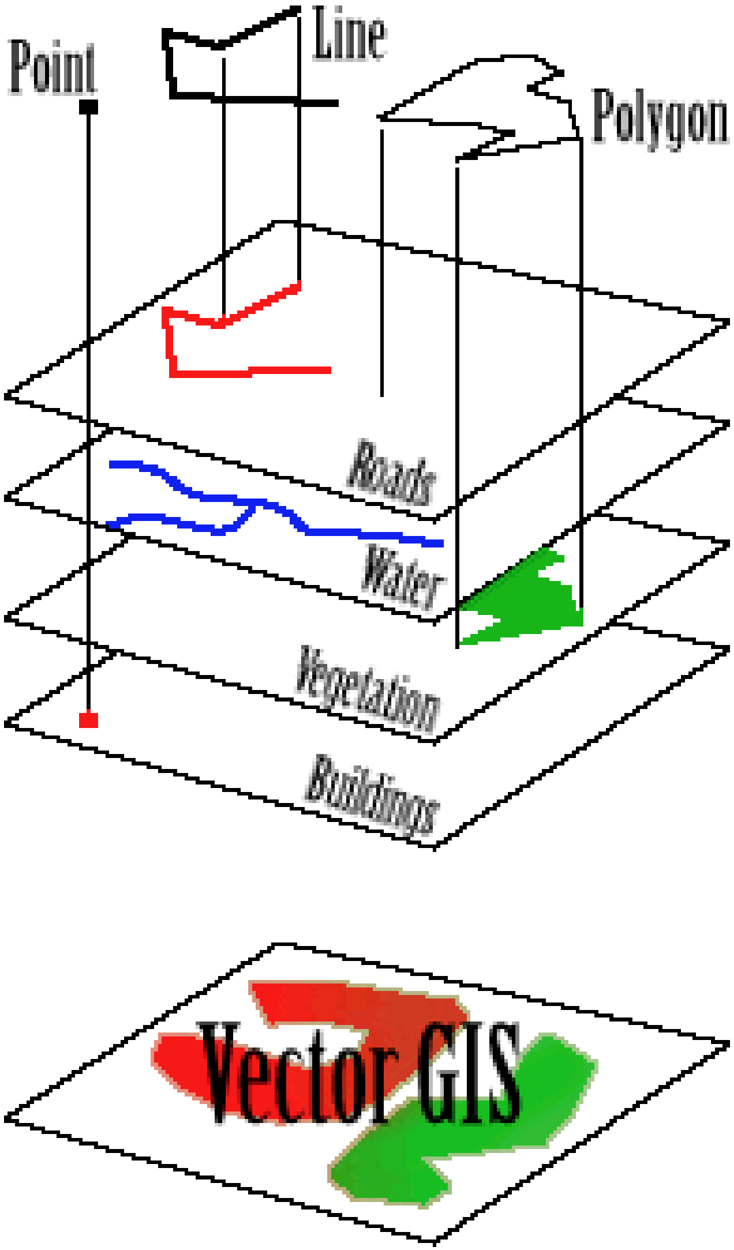
ATTRIBUTE DATA

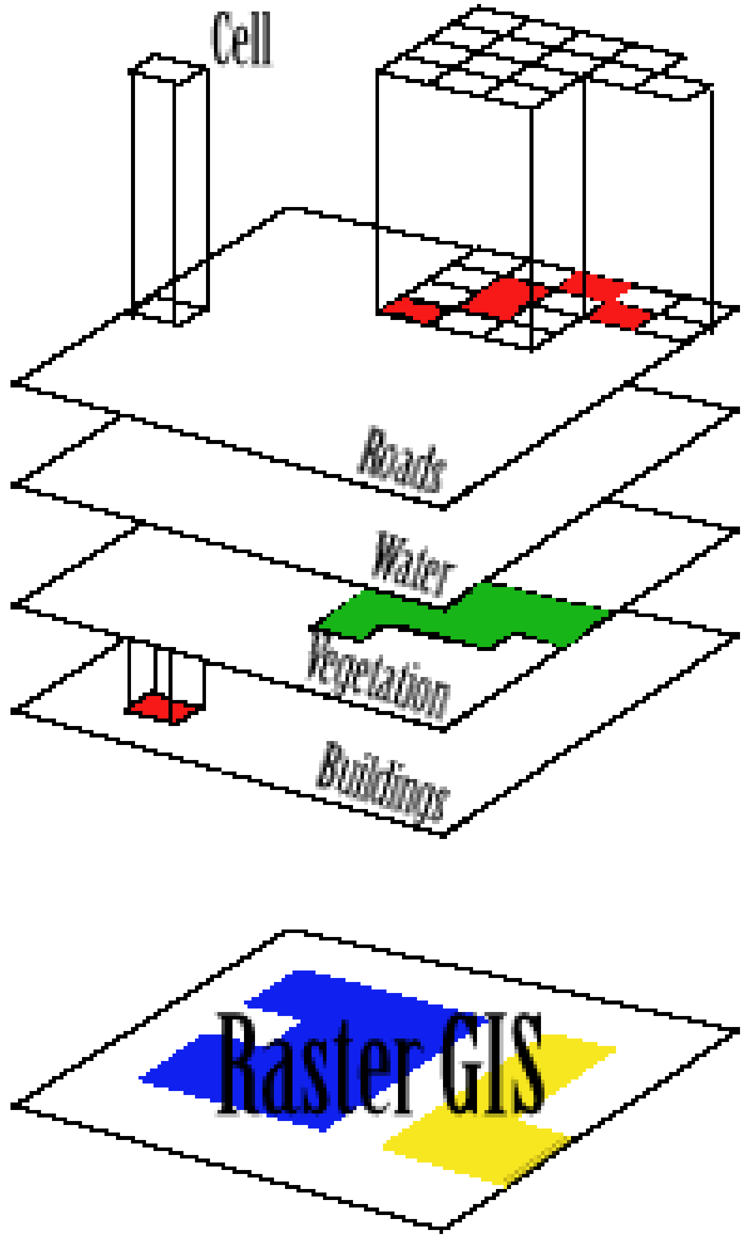
<u>Attributes</u> can be numeric or alphaanumeric data that is assigned to a point, line or area spatial features

Example Attributes…

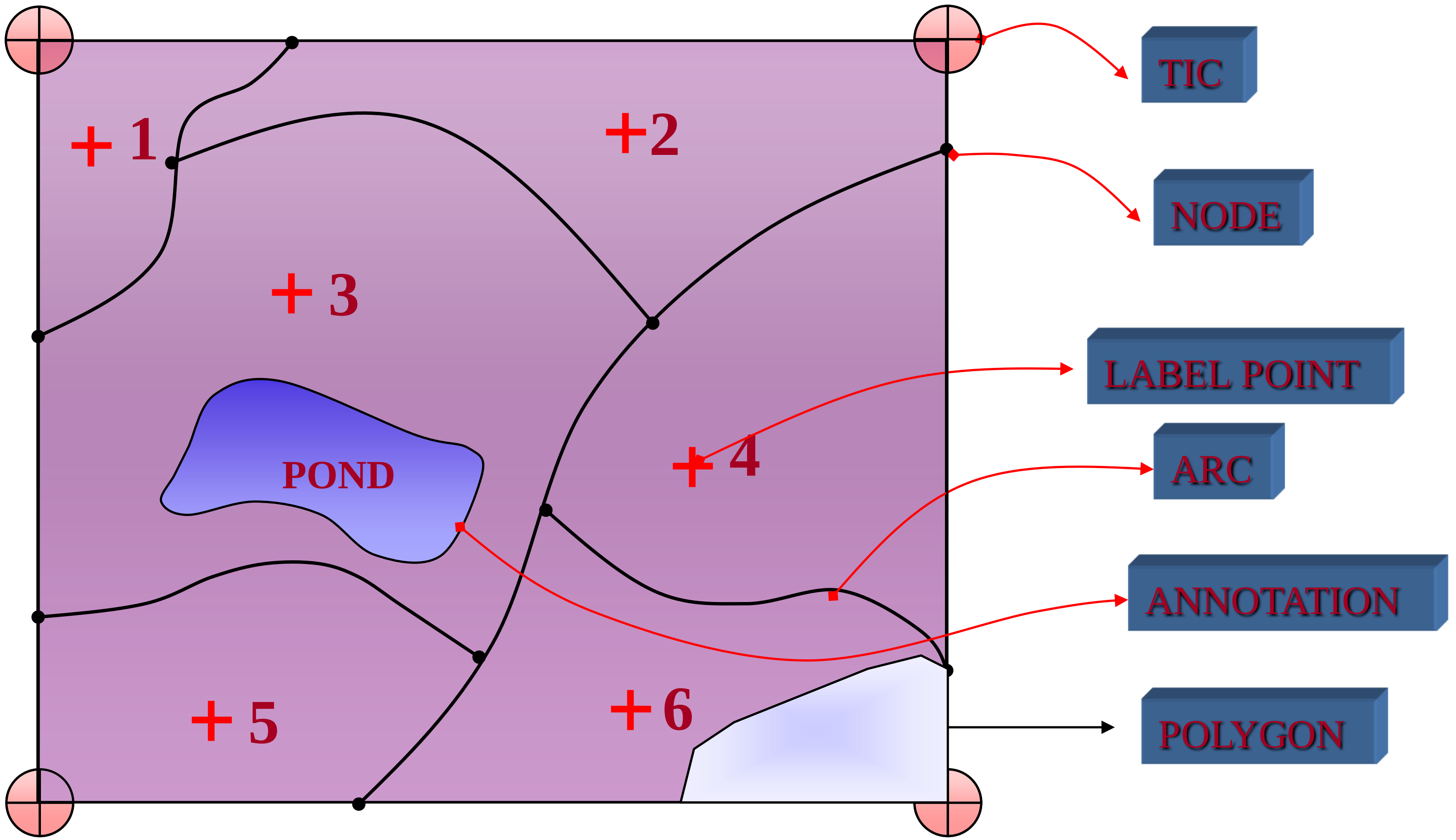
Stand ID, Compartment no, Vegetation type, Name of the Forest Block, Type of road, VSS code etc.,

Vector and Raster





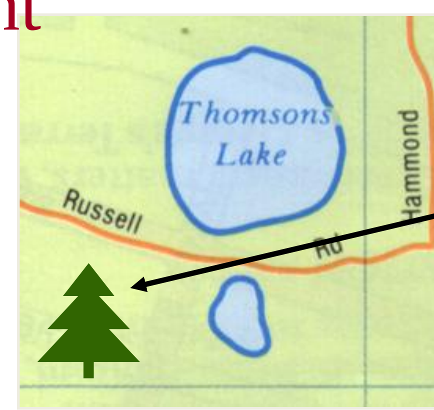
FEATURES OF A COVERAGE

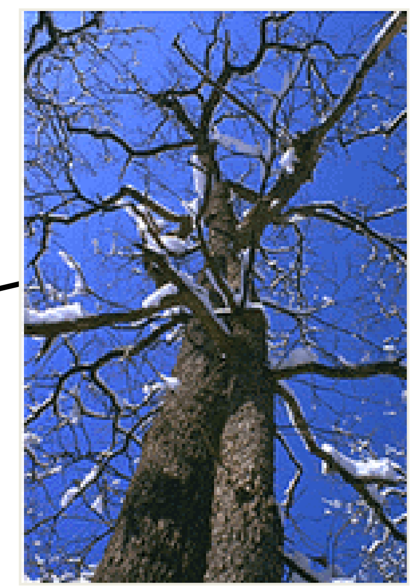


Point Features

Spatially distributed entities, activities or events

- Points have a single geographic coordinate such as:
  - Tree
  - Traffic accident
  - Lamp post

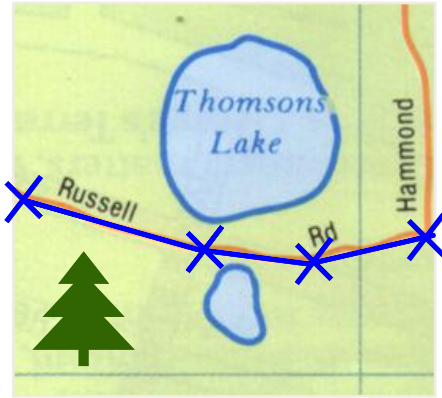




Line Features

Spatially distributed entities, activities or events

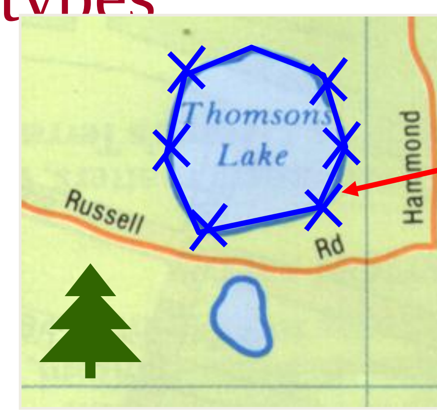
- Lines (Arcs) are a series of geographic coordinates joined to form a line such as:
  - Road
  - Stream
  - Railway



Area Features

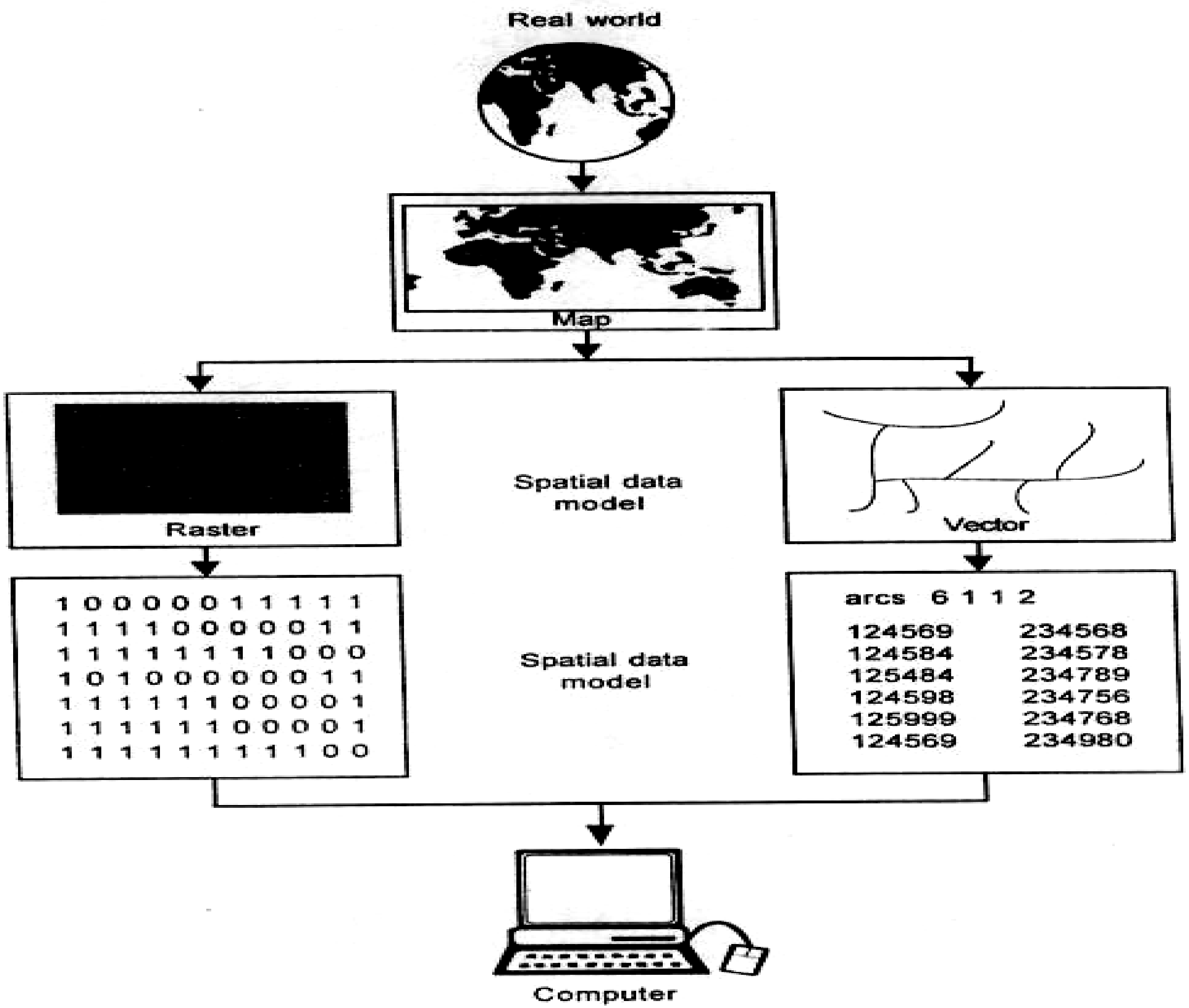
Spatially distributed entities, activities or events

- Areas (Polygons) are a series of geographic coordinates joined together to form a boundary such as:
  - Lake
  - Soil types



GIS DATA STRUCTURES

Stages in creating a GIS data model

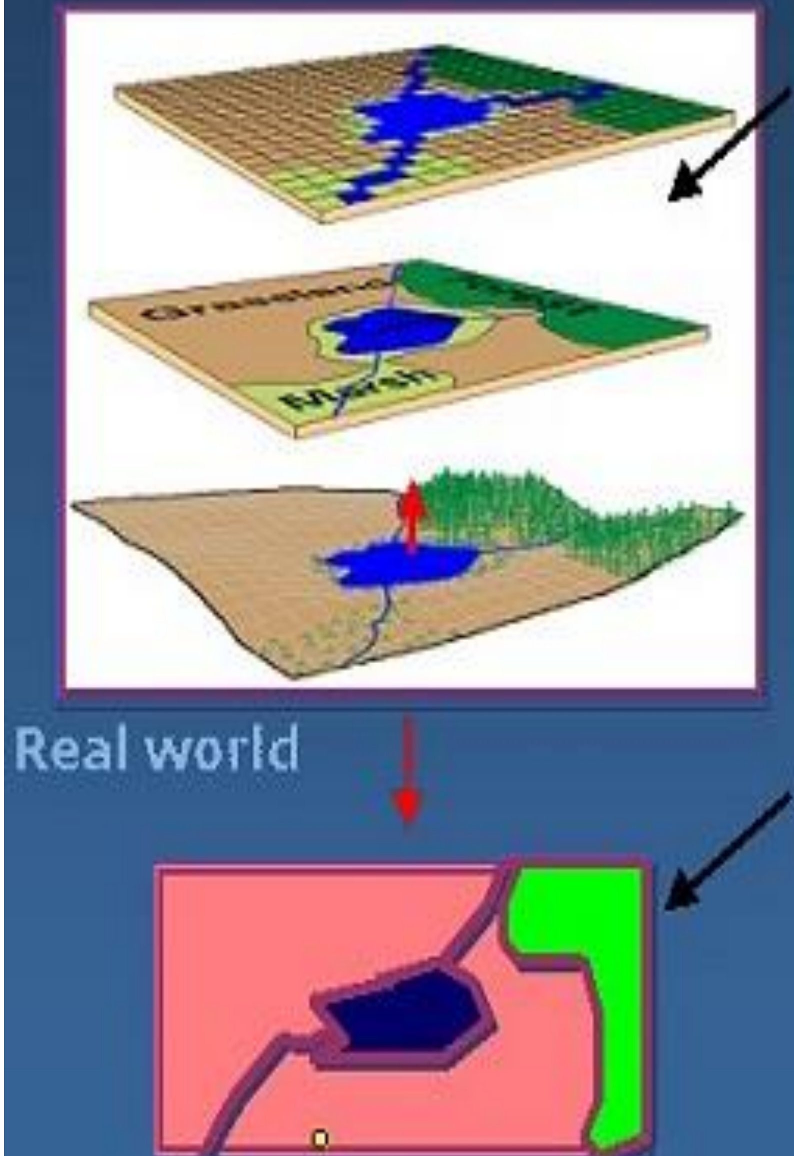


GIS Data and Structures

- SPATIAL DATA
  - RASTER DATA
  - VECTOR DATA
- NONSPATIAL DATA / ATTRIBUTE DATA
- THE RELATIONSHIP BETWEEN SPATIAL DATA AND NON-SPATIAL DATA IS TOPOLOGY

UNIT-5

Raster Data Model



- **Raster – *Grid***
  - "pixels"
  - a location and value
  - Satellite images and aerial photos are already in this format
- **Vector – *Linear***
  - Points, lines & polygons
  - "Features" (house, lake, etc.)
    - Attributes
      - size, type, length, etc.

- Raster Geographic Information Systems, which store map features in raster or grid format,
- generalise the location of features to a regular matrix of cells.

- Raster GIS data structures are preferred for digital elevation modelling

- In raster-based analysis, the areas of analysis are divided into squares of uniform size (cells).

- Each cell characterises the feature of interest within this area with a single value.

- Digital image data, including aerial photos and satellite imagery, are stored in raster format (as pixels).

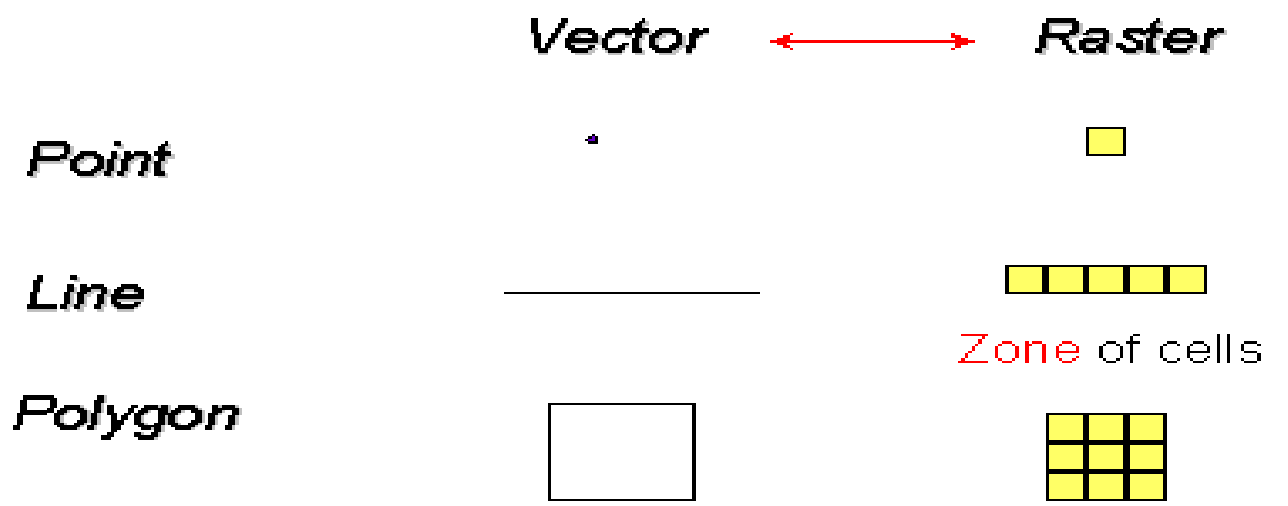
- GRID cell-based modelling uses the raster format to determine routing patterns and terrain.

Vector data on the other hand, are coordinate-based data structures commonly used to represent linear features (polygons can be formed by closed strings of co-ordinates).

Each feature in this format is represented as a list of ordered x,y co-ordinates.

Raster and Vector Data

Raster data are described by a cell grid, one value per cell



Data Layers in the Database

- Organize by feature type
  - point
  - line
  - polygon
- Organize by thematic grouping
  - roads (lines)
  - land use (polygons)
  - soils (polygons)
  - wells (points)

TOPOLOGY

- ***Topology*** **- mathematical representation of geographic features(arcs, nodes, polygons and points)**
- **When topology is built, it creates spatial relationship among the features**
- **Topology can be very important for certain types of analysis.**

Topology

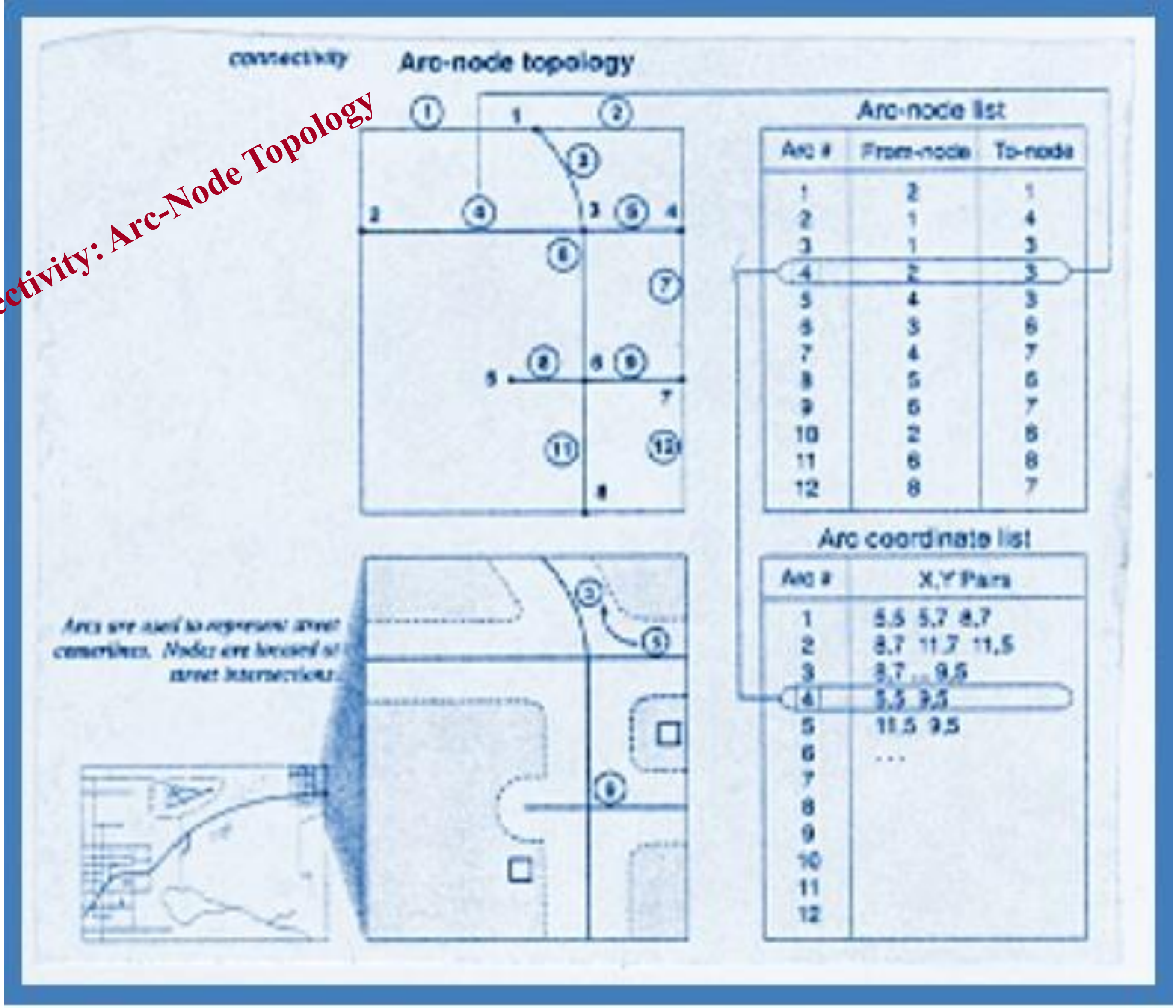
❖**Topology is a mathematical procedure for explicitly defining** *spatial relationships*.

❖Arcs connect to each other at nodes (*connectivity*),

❖Arcs that connect to surround an area define a polygon (*area definition*), and

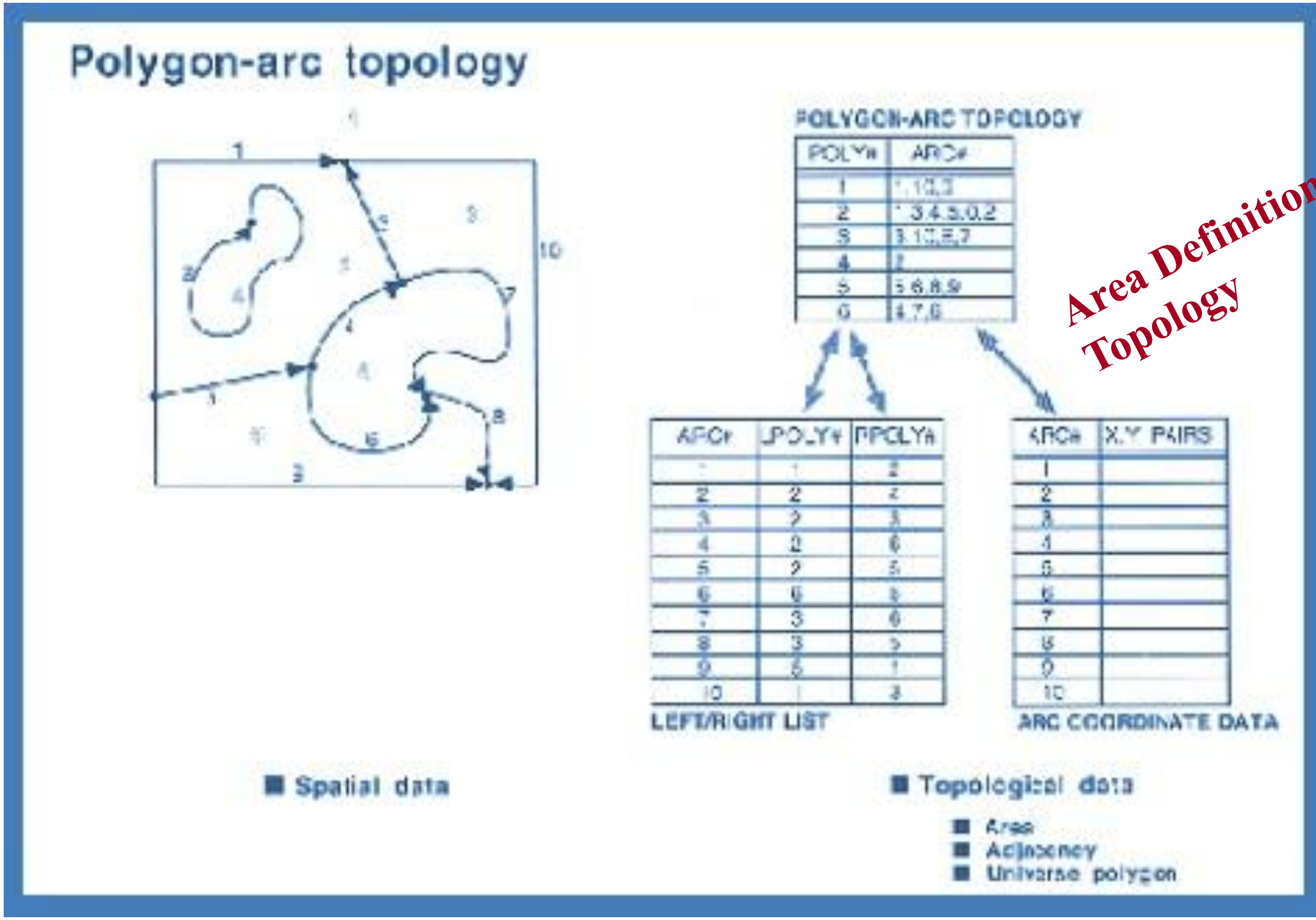
❖Arcs have direction and right and left sides (*contiguity*).

Connectivity: Arc-Node Topology



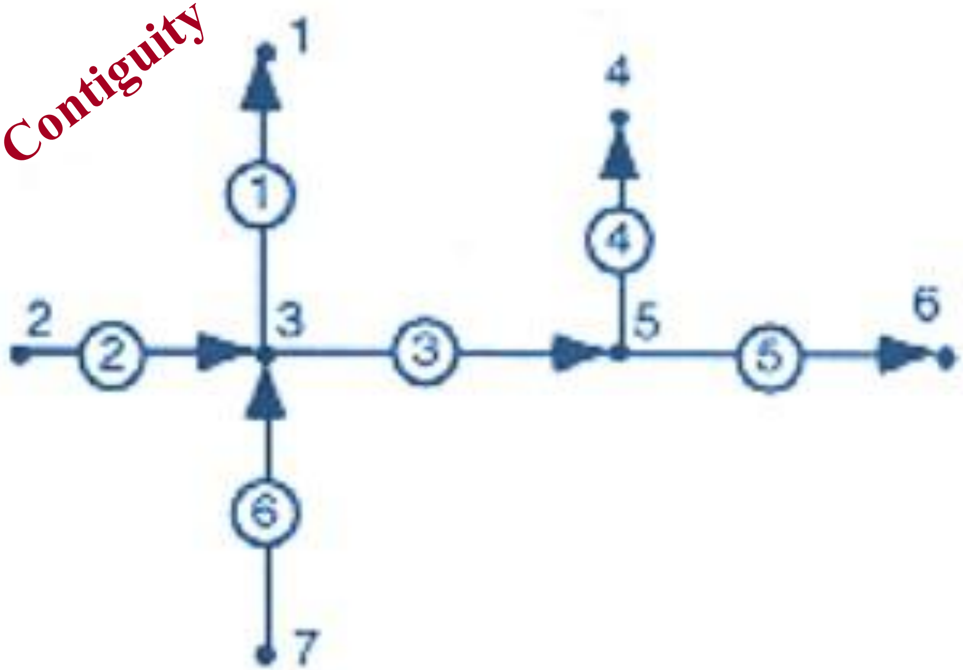
- Points along the arc that define its shape are called ***vertices***.
- Endpoints of arcs are called ***nodes***.
- Arcs join ***only at nodes***.

Area Definition: Polygon-Arc Topology



Polygons are represented as a series of x,y co-ordinates that connect to define an area.
The GIS also stores the list of arcs that make up the polygon.

Contiguity



Arc	From node	To node
1		
2		
3		
4		
5		
6		

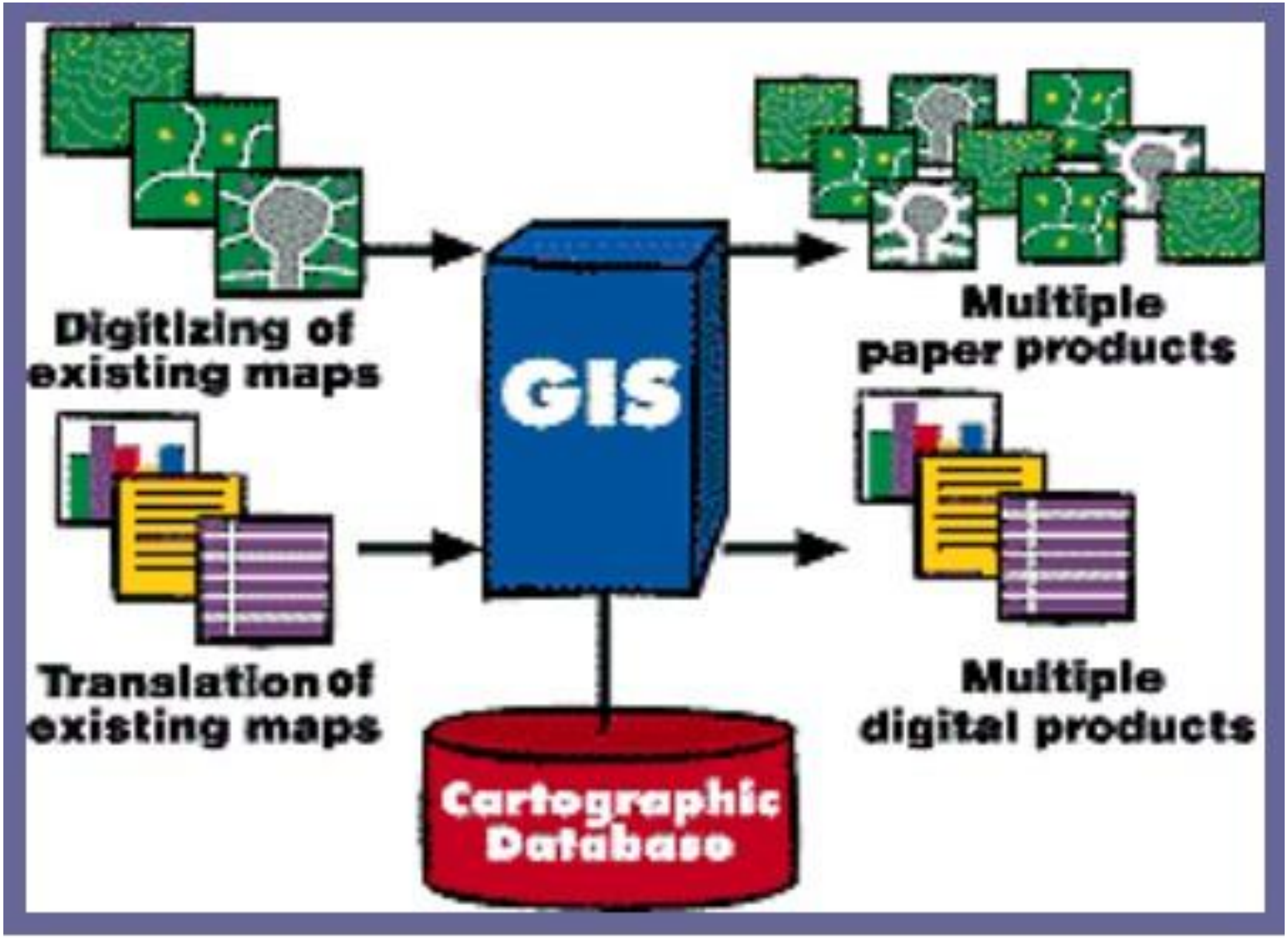
Path from Node 6 to Node 1

Arc #	5				
Direction	–				

Every arc has a direction.
The GIS maintains a list of polygons on the left and right side of each arc.

The computer uses this information to determine which features are next to one another.

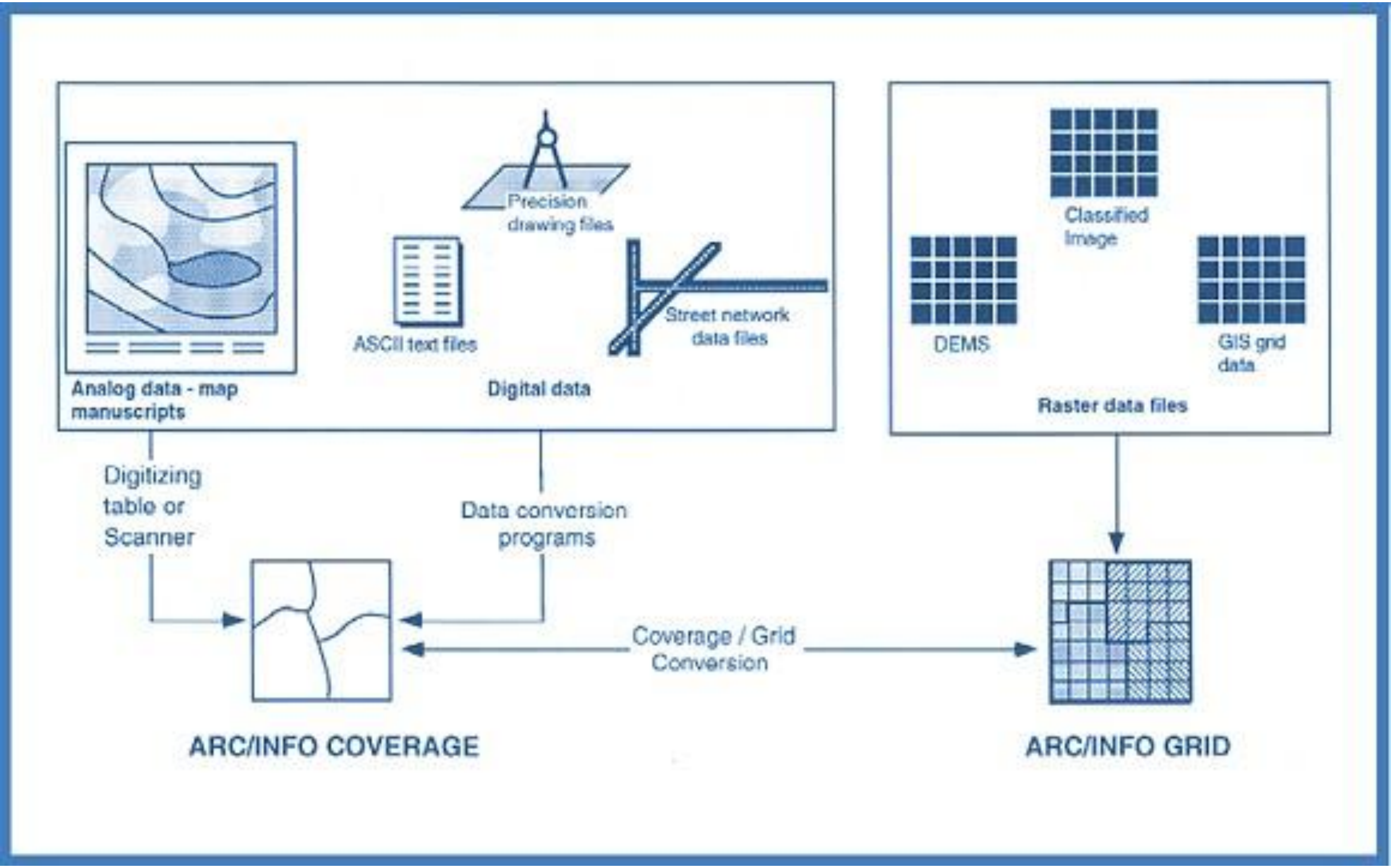
Getting Data into a GIS – Sources of Electronic Data Files


Digitizing of existing maps
GIS
Multiple paper products
Translation of existing maps
Multiple digital products
Cartographic Database

This can be done by:

- **Digitising hard copy maps**
- **Keyboard entry of co-ordinate data (co-ordinates are added as a series of numbers defining the location of a point, the shape of a line, or**
- **Electronic entry using a data file;**
- **Scanning a map manuscript; and**
- **Converting or reformatting existing data.**

Electronic data files are the easiest way to get data into a GIS. Ready-to-use data sources.


Precision
drawing files
ASCII text files
Street network
data files
Analog data - map
manuscripts
Digital data
Classified
Image
DEMS
GIS grid
data
Raster data files
Digitizing
table or
Scanner
Data conversion
programs
Coverage / Grid
Conversion
ARC/INFO COVERAGE
ARC/INFO GRID

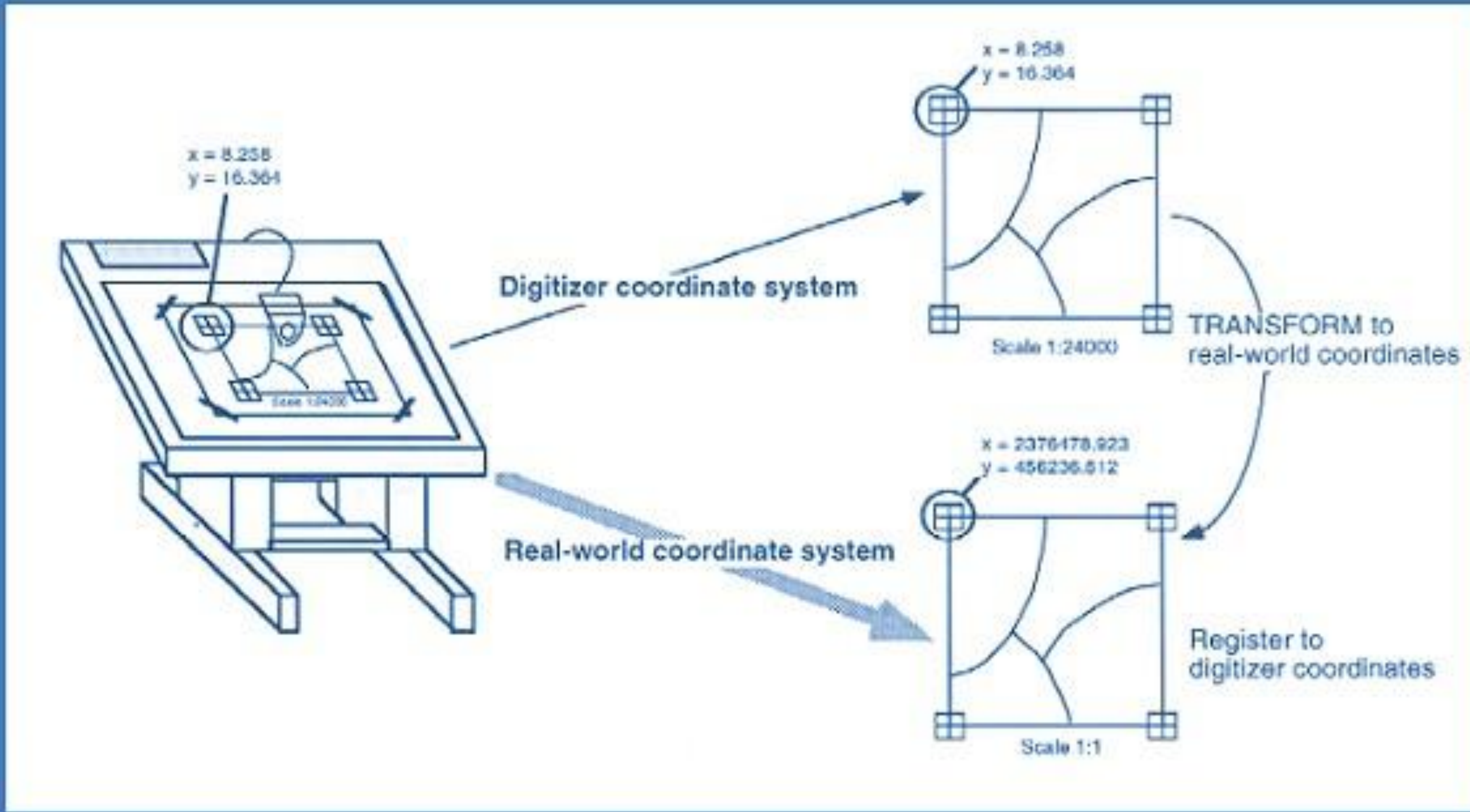
Digitisers

- A digitiser converts spatial features on a hard copy map into digital format.
- Point, line and area features are converted into x,y co-ordinates.
- The process involves manually tracing all features of interest using an electronic stylus.

Good base maps must be used.

After digitising, a procedure known as *transformation* converts digitiser units to a real-world co-ordinate system.

Tics are used to provide the relationship between the two co-ordinate systems.



x = 8.258
y = 16.364
x = 8.258
y = 16.364
Digitizer coordinate system
Scale 1:24000
TRANSFORM to
real-world coordinates
x = 2376478.923
y = 456236.612
Real-world coordinate system
Register to
digitizer coordinates
Scale 1:1

Techniques For Spatial Representation

•feature data (point feature, linear feature, homogenous polygon)
•areal units (boundaries, areal polygon)

•network topology (node, link, polygon)
•sampling records (stations, lines, plots)

•surface data (elevations, contours, proximal polygons)

•label/text data (place names, linear feature names, polygon labeling)

•graphic/symbol data (point symbols, line type, polygon shading)

Topological Relationships

- basic point: node
- basic line: node, line, node
- basic polygon: node1, line, node2, line, node3, line, node4, line, node1
- *topological relationships can be linked to a geographic reference system*

Processing of Geographic Data

- removal of duplicates
- arc to polygon conversion
- edge-matching
- editing of x,y coordinates for entry errors
- base file creation & update
- file management
- basic search & retrieval
- query of selected attributes

Data Retrieval

- browsing
- windowing (zoom-in & zoom-out)
- query window generation (retrieval of certain, selected features)
- multiple map sheet observation
- Boolean logic functions (meeting specific rules)

Map Generalization

- line coordinate thinning of nodes
- polygon coordinate thinning of nodes
- drop lines
- edge-matching

Map Abstraction

•calculation of centroids

•visual editing & checking

•automatic contouring from randomly spaced points

•generation of Thiessen/proximity polygons

•reclassification of polygons

•raster to vector/vector to raster conversion

Map Sheet Manipulation

•changing scales

•distortion removal/rectification

•changing projections

•rotation of coordinates/registration

Buffer Generation

- generation of zones around certain objects

Polygon Enhancement Techniques

- polygon overlay
- polygon dissolve

Measurements

- points - total number or number within an area
- lines - distance along a straight or curvilinear line
- polygons - area or perimeter
- volumes - measure cross-sections or differences between overlays

Raster/Grid Analysis

- grid cell overlay
- area calculation
- search radius
- distance calculations
- optimum corridor selection

Digital Terrain Analysis

- slope/aspect analysis
- watershed calculation
- contour generation

Graphical Manipulation Techniques

- variable symbols
- variable text fonts
- variable line thickness
- variable colors

GIS Output Formats

- hard copy maps
- tabular outputs
- visual display
- data tapes/CDs

Several Approaches To GIS Development

- process-orientated approach
- application approach
- toolbox approach
- database approach
- Computer-Aided Design (CAD) approach

Several Approaches To GIS Development

Process-Orientated Approach

- GIS converts geographic data into useful information
- the system should include: inputs, storage, retrieval, analysis, output

❑Application Approach

- GIS designed to meet the standards of the data
- each application will need a unique GIS

❑Toolbox Approach

- a set of procedures and algorithms run together
- unique bundling must be present to be considered a GIS

- Database Approach
  - a DBMS that allows unique spatial queries into its databases
  - retrieval, analysis, and display should be part of the system
- CAD Approach
  - electronically drafting tools with spatial referencing
  - needs to have graphical output

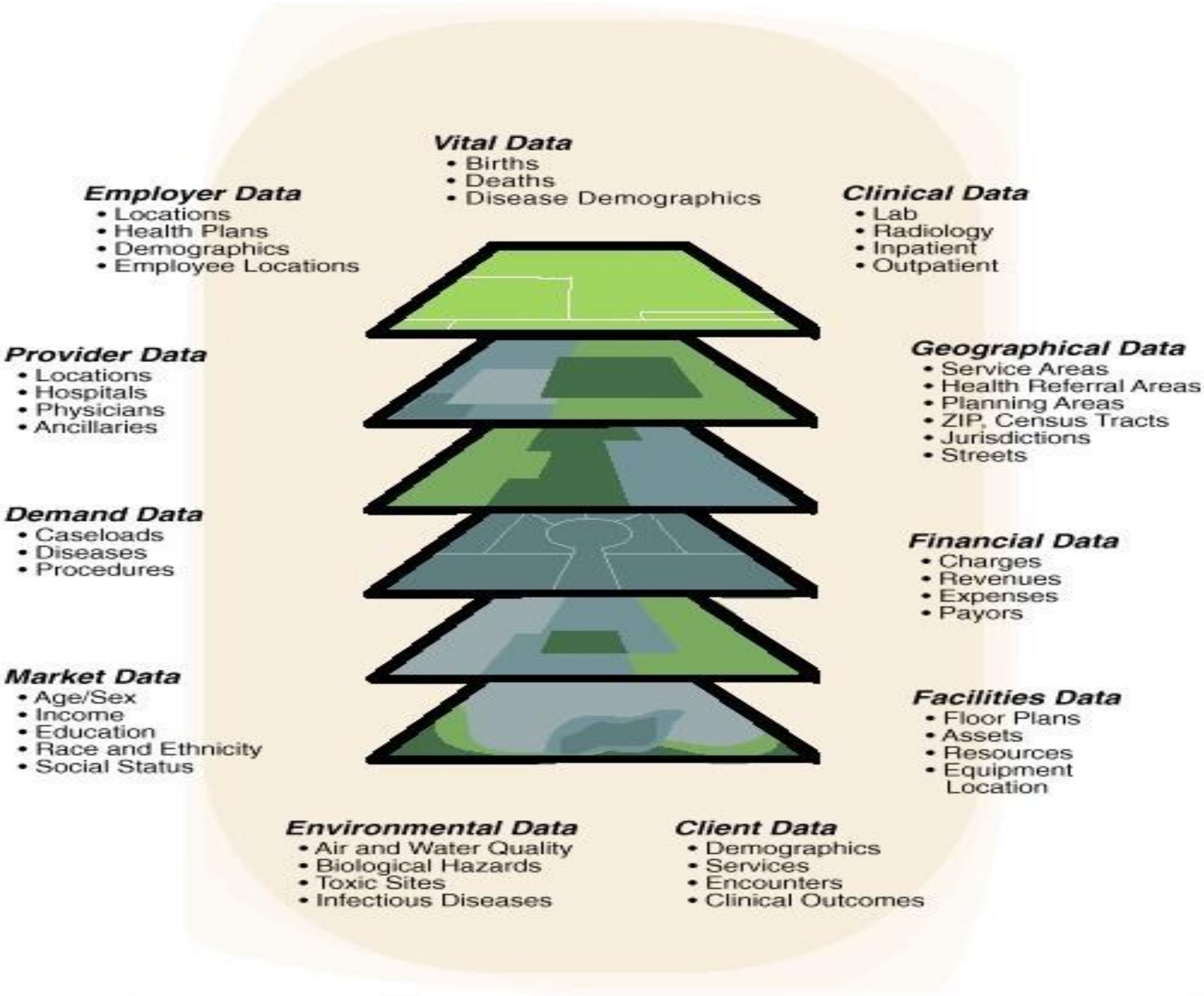
Four Main Types of Maps/Data Exist:

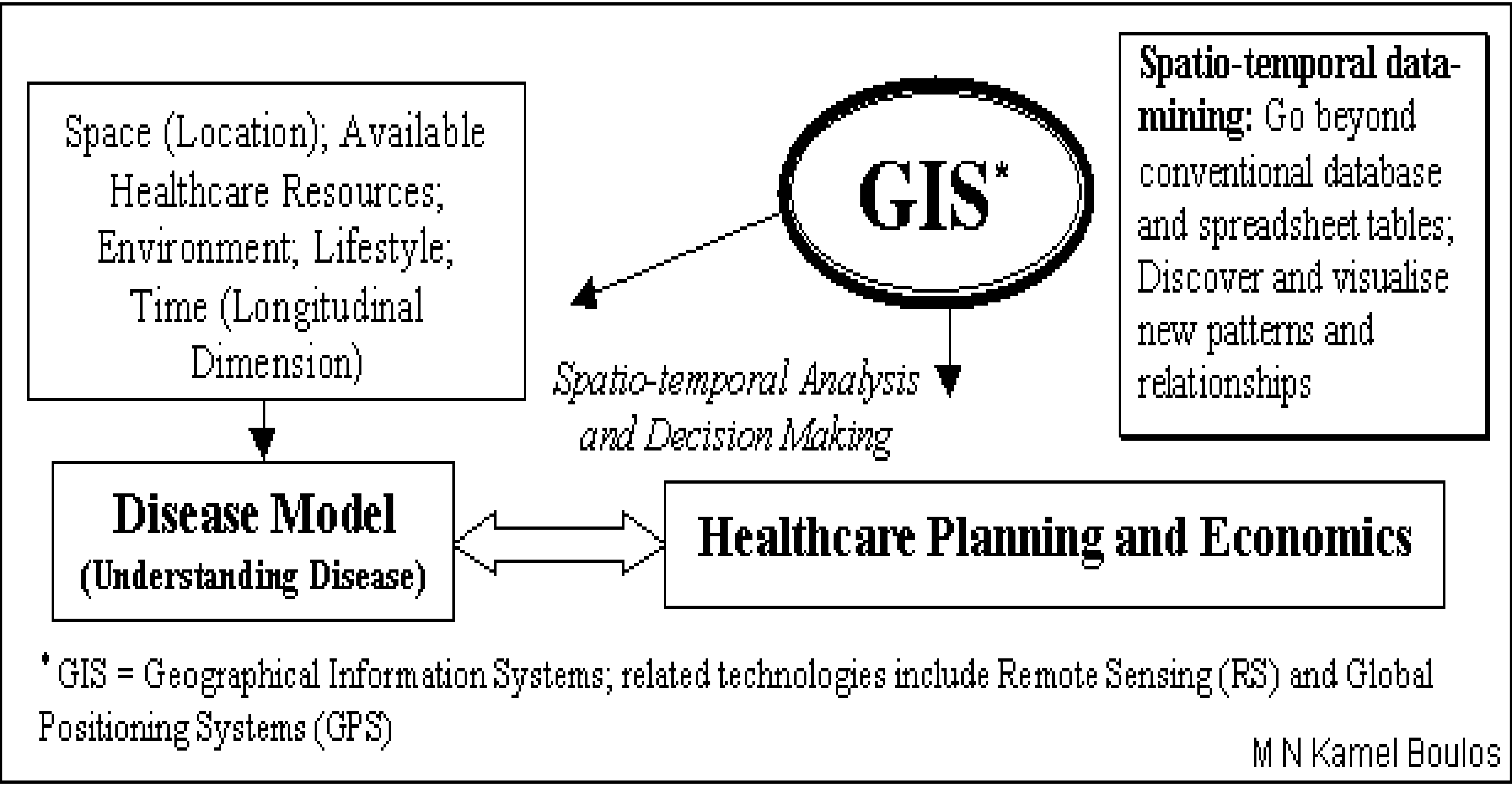
Base Maps: include streets and highways; boundaries for census, postal, and political areas; rivers and lakes; parks and landmarks; place names;

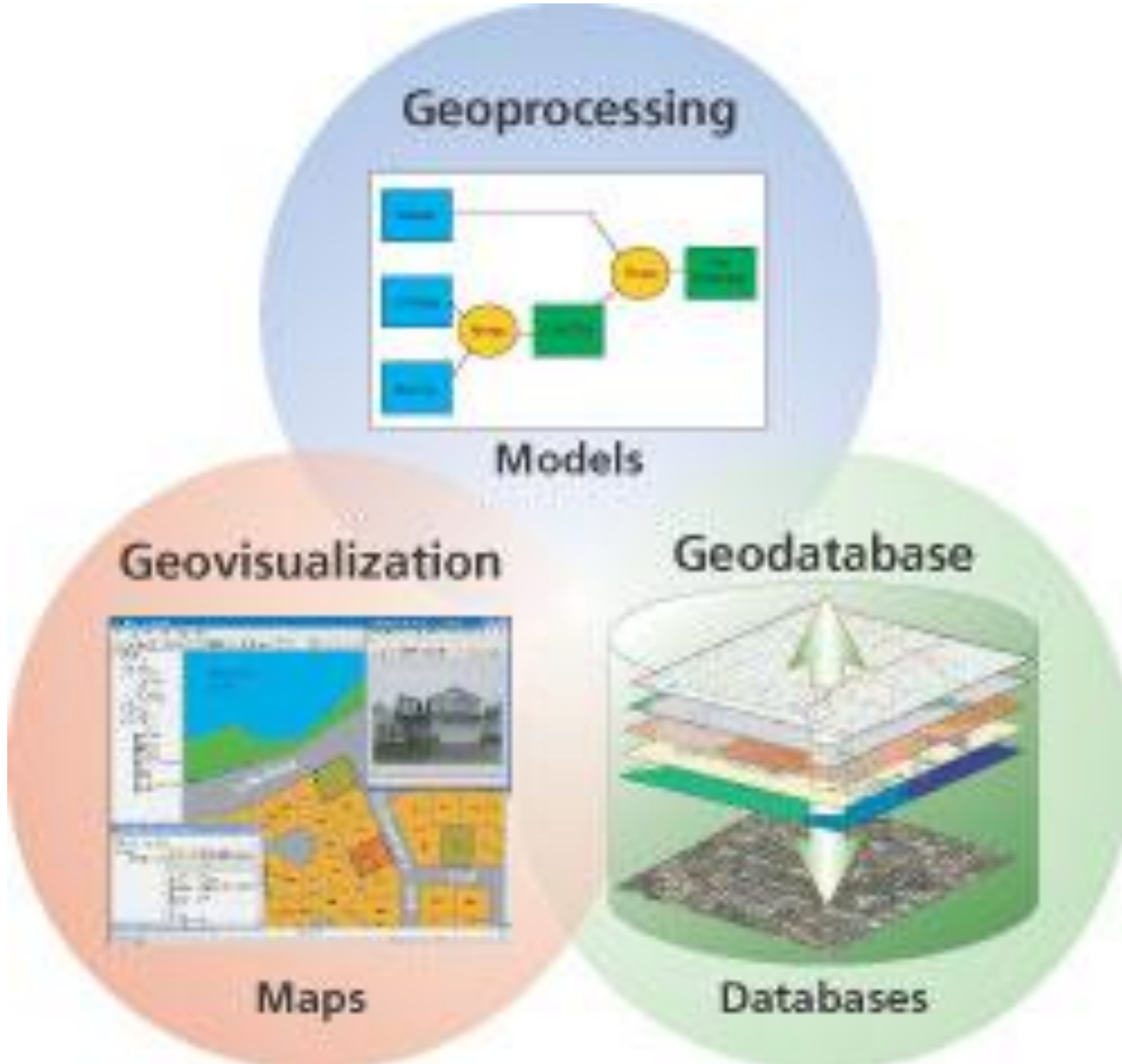
Business Maps and Data: include data related to census/demography, consumer products, financial services, healthcare, real estate, telecommunications, emergency preparedness, crime, advertising, business establishments, and transportation.

Environmental Maps and Data: include data related to the environment, weather, environmental risk, satellite imagery, topography, and natural resources.

General Reference Maps: world and country maps and data that can be a foundation for a GIS database.


Vital Data
• Births
• Deaths
• Disease Demographics
Employer Data
• Locations
• Health Plans
• Demographics
• Employee Locations
Clinical Data
• Lab
• Radiology
• Inpatient
• Outpatient
Provider Data
• Locations
• Hospitals
• Physicians
• Ancillaries
Geographical Data
• Service Areas
• Health Referral Areas
• Planning Areas
• ZIP, Census Tracts
• Jurisdictions
• Streets
Demand Data
• Caseloads
• Diseases
• Procedures
Financial Data
• Charges
• Revenues
• Expenses
• Payors
Market Data
• Age/Sex
• Income
• Education
• Race and Ethnicity
• Social Status
Facilities Data
• Floor Plans
• Assets
• Resources
• Equipment Location
Environmental Data
• Air and Water Quality
• Biological Hazards
• Toxic Sites
• Infectious Diseases
Client Data
• Demographics
• Services
• Encounters
• Clinical Outcomes


Space (Location); Available Healthcare Resources; Environment; Lifestyle; Time (Longitudinal Dimension)
GIS*
Spatio-temporal data-mining: Go beyond conventional database and spreadsheet tables; Discover and visualise new patterns and relationships
Spatio-temporal Analysis and Decision Making
Disease Model (Understanding Disease)
Healthcare Planning and Economics
* GIS = Geographical Information Systems; related technologies include Remote Sensing (RS) and Global Positioning Systems (GPS)
M N Kamel Boulos


Geoprocessing
Models
Geovisualization
Maps
Geodatabase
Databases