

Introduction to Geotechnology

Unit – 4 Remote Sensing Based Mapping

**4.Remote Sensing Based Mapping: 12
hrs.**

Aerial Remote Sensing – Satellite Remote Sensing
Principles – Digital Image Processing concepts – GPS
based mobile mapping principles – Image interpretation
principles for Geotechnology.

Remote Sensing

Is the art of sensing an object without
physical contact

1. AERIAL REMOTE SENSING

2. SATELLITE REMOTE SENSING

CAPABILITY OF REMOTE SENSING

- Large aerial coverage
- Regional analysis
- Eliminate surface inaccessibility
- Provides unbiased data sets
- Images are easy to study

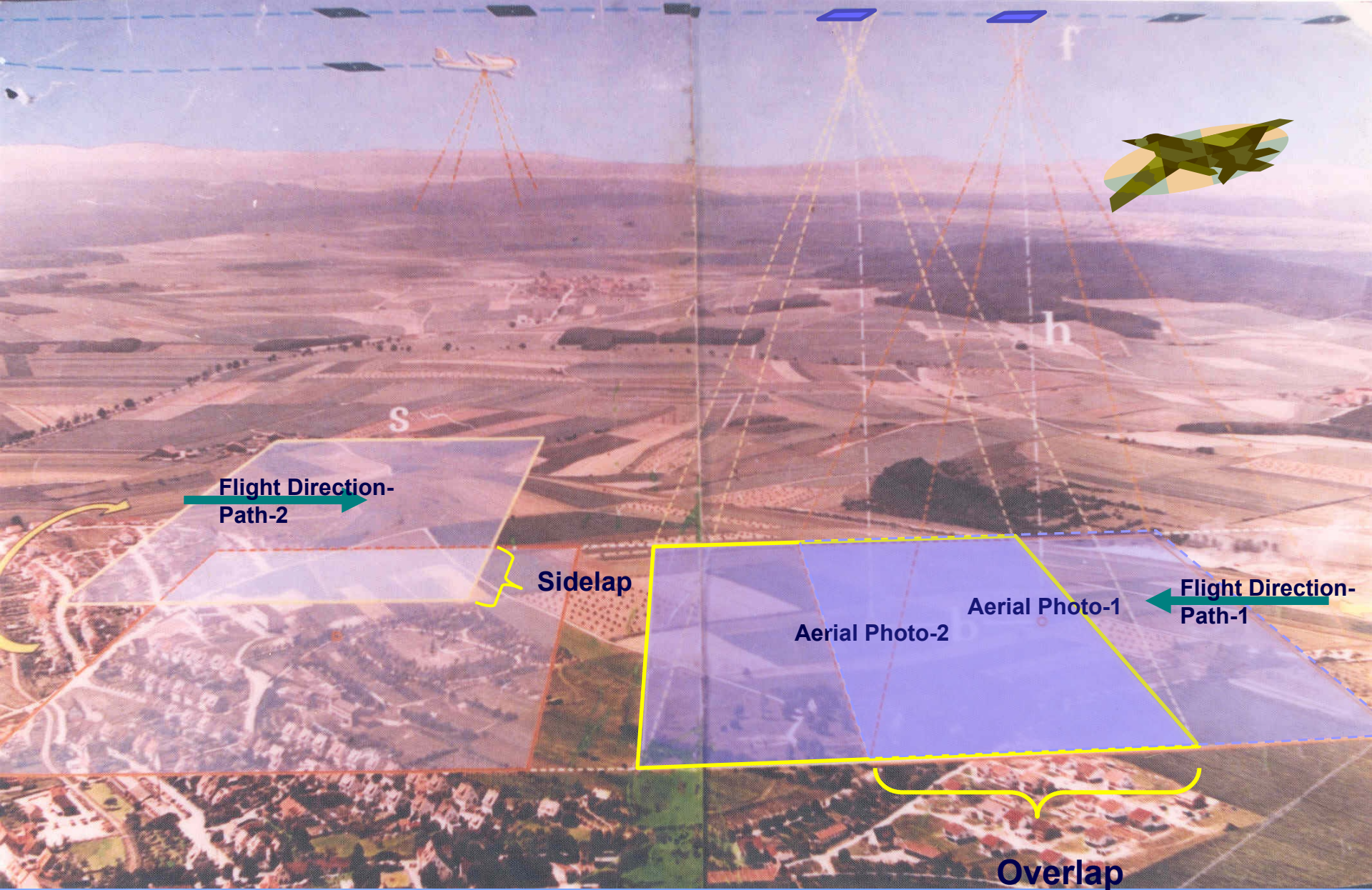
So, comprehensive understanding of the disaster is possible

CREDIBILITY OF REMOTE SENSING

- ➔ **SYNOPTIVITY**
 - ➔ **MULTI SPECTRAL NATURE**
 - ➔ **REPETIVITY**
 - ➔ **ECONOMIC**
 - ➔ **3D (STEREO) DATA CAPTURING**
- etc.**

AERIAL REMOTE SENSING

- PHOTOGRAPHIC FILM IS USED
- **B&W** or **COLOUR** films or IR or Thermal filters are used
- Camera fitted in Air Plane
- Fly over a preplanned paths
- Stereo capability – photo with overlaps/sidelaps
- Interpretation with very large scale is easy



Flight Direction-
Path-2

Sidelap

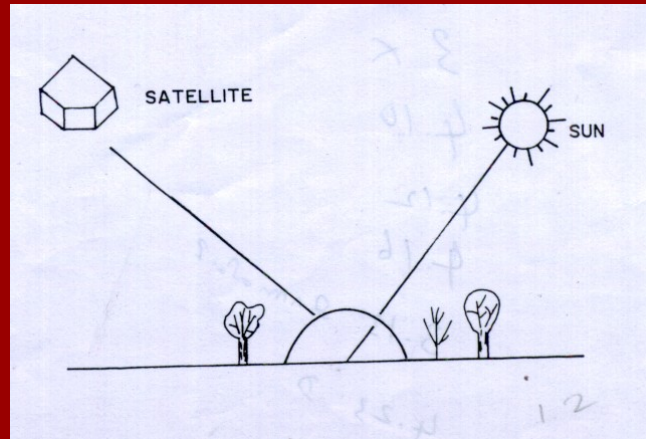
Aerial Photo-2

Aerial Photo-1

Flight Direction-
Path-1

Overlap

Satellite Remote Sensing-PRINCIPLES



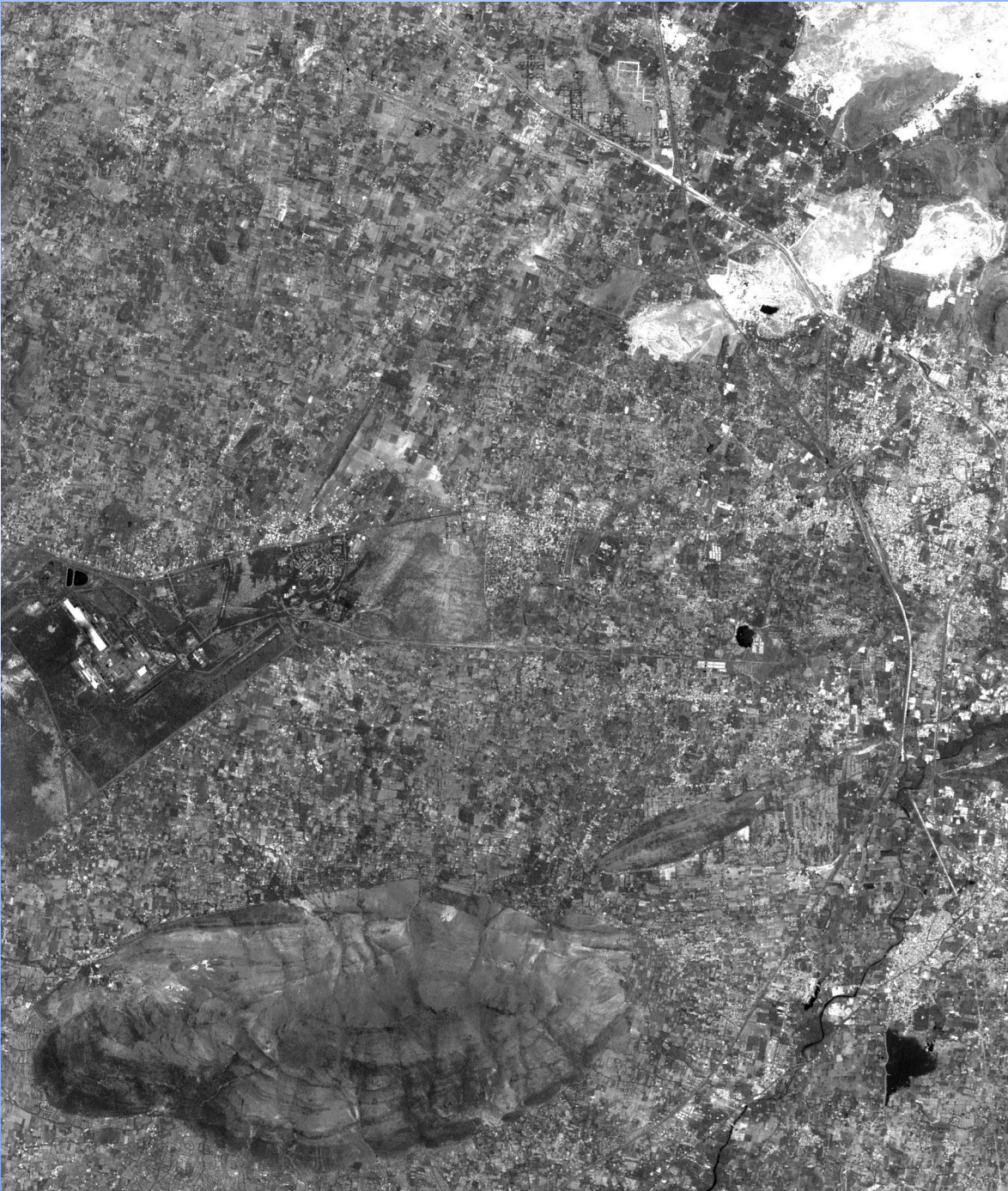
- * The sunlight falling on the terrestrial surface is reflected back to satellite
- * Green, red and infra - red component of reflected energy is captured by the multispectral cameras filtered in satellite
- * Quantum and type of reflected light will depend upon the type of the objects.



**SATELLITE IMAGES WITH
DIFFERENT SPATIAL RESOLUTIONS**





A high-resolution, black and white aerial photograph of the Salem area. The image shows a dense urban landscape with a grid-like street pattern, interspersed with green spaces and larger open areas. A prominent feature in the lower-left quadrant is a large, dark, irregularly shaped area that appears to be a body of water or a large park. The overall texture is very detailed, showing individual buildings and trees.

IRS P6 PAN –

Panchromatic
image of Salem
area.

Band width

0.45 - 0.82 μm

Spatial resolution

5.8 m



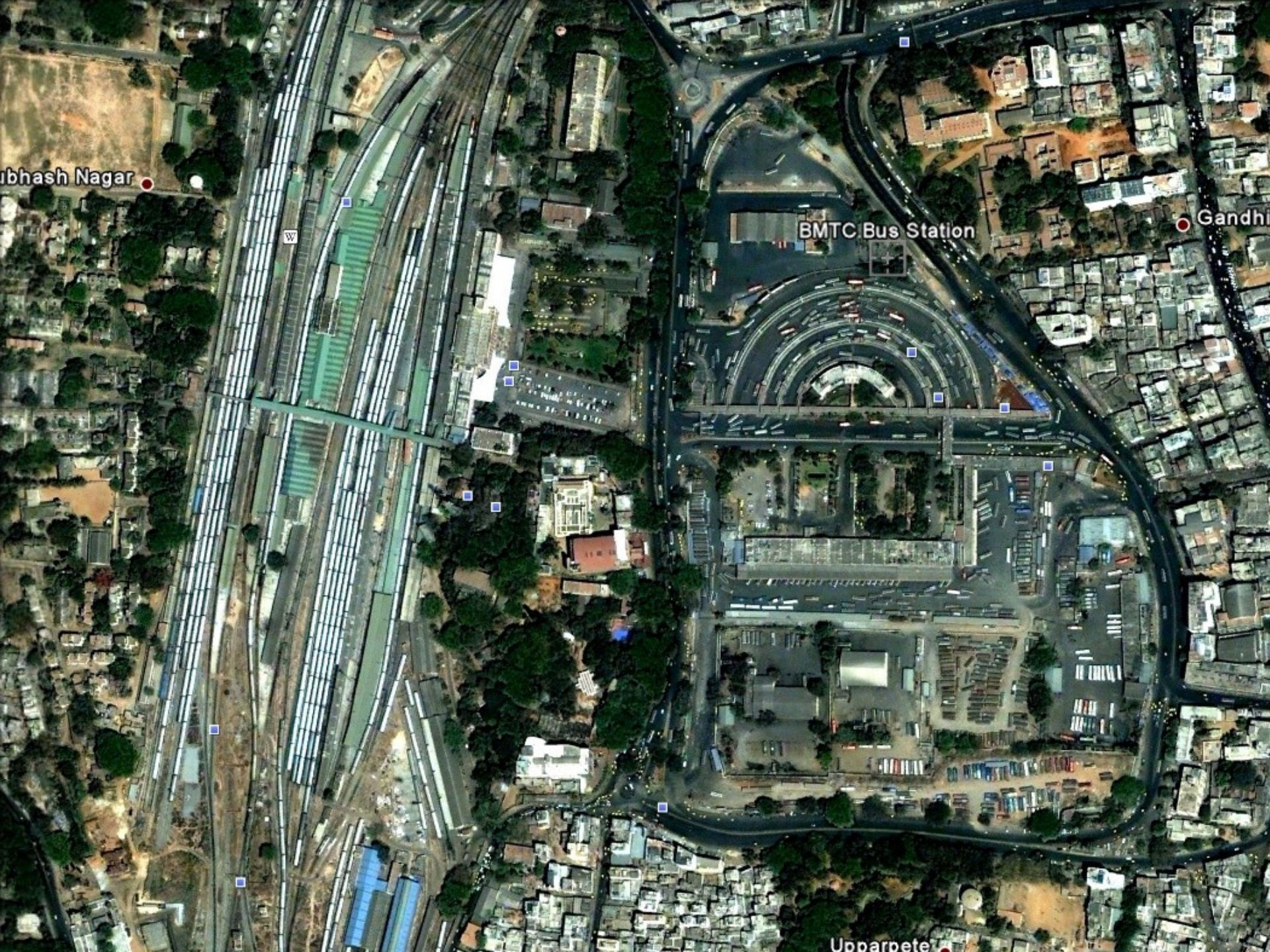


Subhash Nagar

BMTC Bus Station

Gandhi

Upparpete



BMTA Bus Station



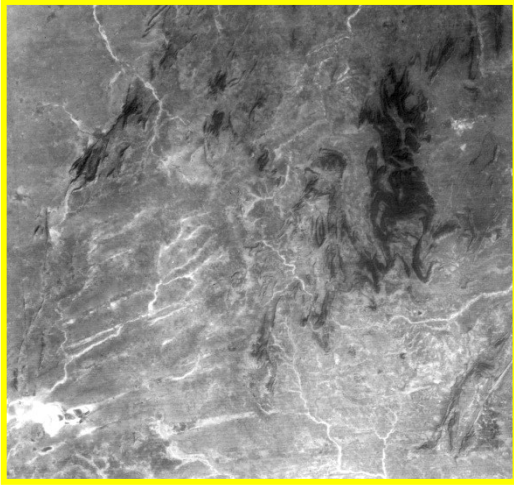


SOUTH INDIA MOSAIC

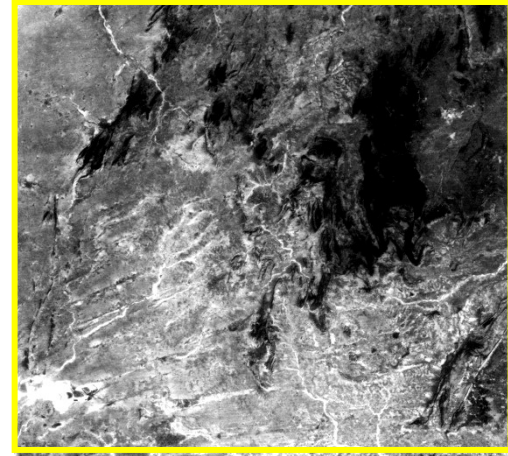


MULTISPECTRAL IMAGE

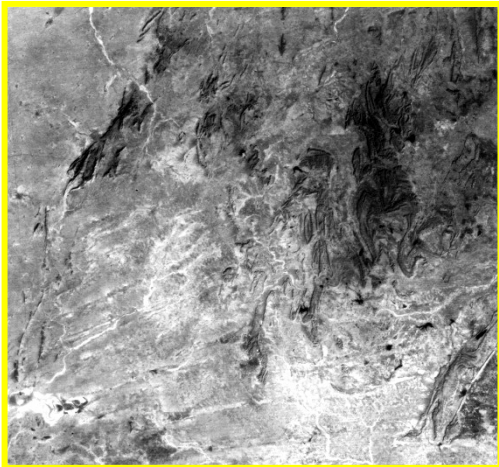
MSS 4



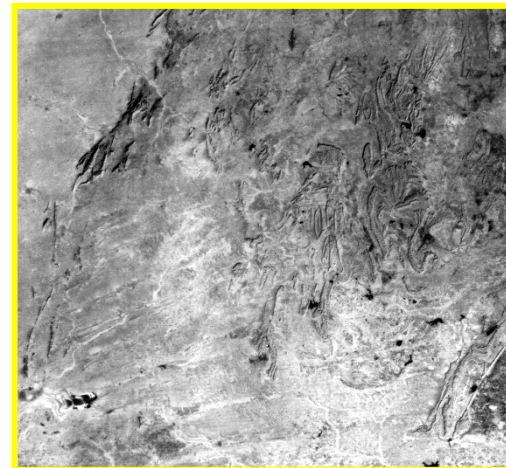
MSS 5



MSS 6



MSS 7



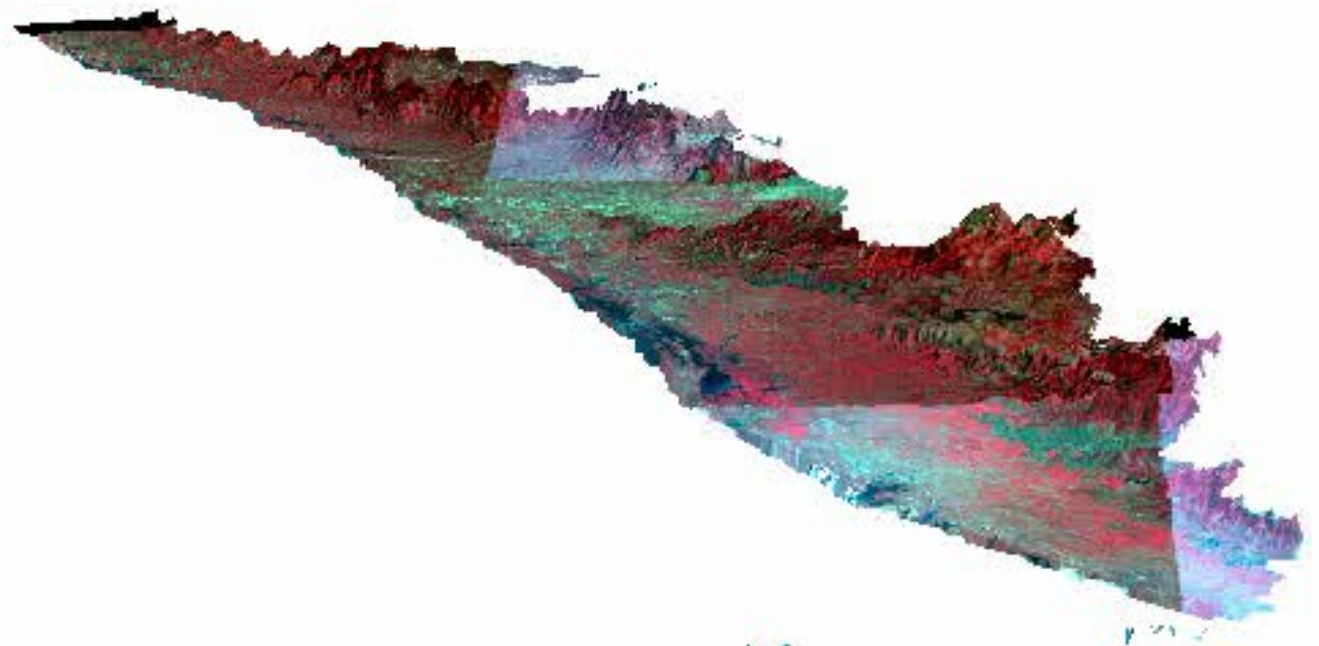
Banda Aceh, Indonesia,
(Temporal data – Repetivity)

23 June 2004



28 December 2004

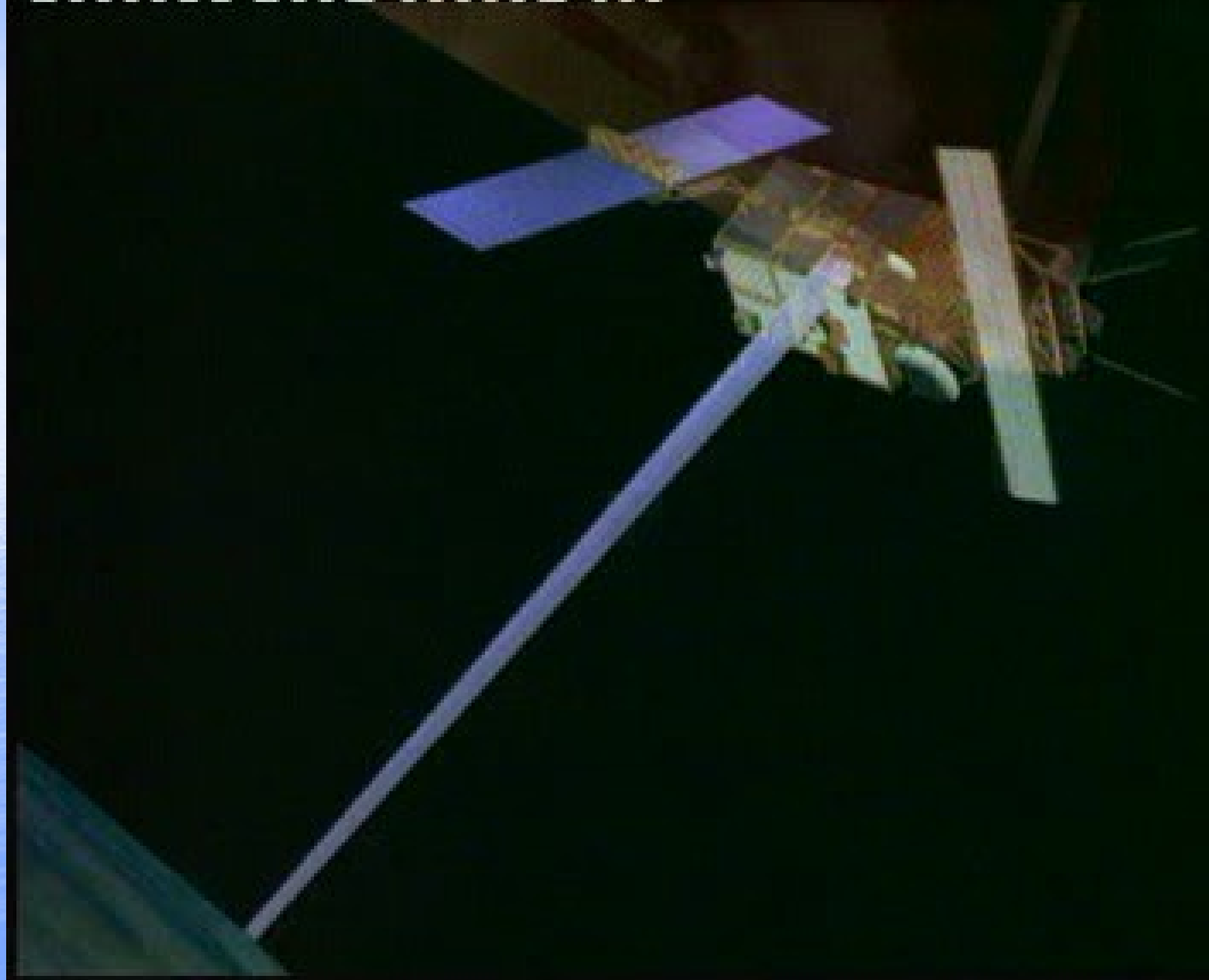














PRINCIPLES OF IMAGE PROCESSING

DEFINITION

Digital Image Processing is the Manipulation and Interpretation of Digital Images with the aid of computers

HISTORY

- ✦ Began in 1960
- ✦ Widely used from 1972
(after the launch of Landsat – 1)

ADVANTAGES :

- ★ Original Data in Digital Form
- ★ Handling of Large Volume of Data
- ★ Errors – Rectification Possibility
- ★ Analysis of Individual Data Points
- ★ Easy Data Manipulation
- ★ Statistical Analysis Possibilities

- ✧ Utilisation of Full Dynamic Range of Radiometric Resolution
- ✧ Discerning Subtle Differences
- ✧ Quantitative Assessment
- ✧ Repeatability
- ✧ Versatility
- ✧ Preservation of Original Data Precision

DIGITAL IMAGE PROCESSING PROCEDURE

- * One Pixel is fed at a time into the Computer
- * This pixel data is inserted into an equation (or)

series of equations

- * Resulted data of the pixel is stored
- * Out puts

- ◆ Displays
- ◆ Printouts
- ◆ Digital form for further manipulation

DIGITAL ANALYSES

- ⚙ Image Rectification & Restoration
- ⚙ Image Enhancement
- ⚙ Image Classification
- ⚙ Data Merging

IMAGE RECTIFICATION & RESTORATION

This is to correct the image data for Distortions or for Degradations Introduced During Image Acquisition Process

- ➡ Geometric Correction
- ➡ Radiometric Correction
- ➡ Noise Removal

GEOMETRIC CORRECTION

- ★ Variation in Altitude, Attitude & Velocity of Sensor
- ★ Scan Skew
- ★ Scan Mirror - Scanning Velocity
- ★ Earth Rotation

RADIOMETRIC CORRECTION

- ★ Change in Scene Illuminations
- ★ Atmospheric Condition
- ★ Viewing Geometry
- ★ Instruments Response Characteristics

NOISE REMOVAL

Noise in an Image is due to the Malfunction of the Sensor

Systematic Noise

- ❖ 6th Line Banding
- ❖ 6th Line Dropout

Non Systematic Noise

- ❖ Bit or random Error

IMAGE ENHANCEMENT

This Process Enhances the Feature for better Identification & Interpretation

-  Contrast Manipulation
-  Spatial Feature Manipulation
-  Multi Image Manipulation

- Supervised Classification
- Unsupervised Classification
- Post Classification Smoothing
- Classification Accuracy Assessment

DATA MERGING

- ★ Multiple Temporal Data Merging
- ★ Change Detection Procedure
- ★ Multi Sensor Image merging
- ★ Merging of Data with Ancillary Information

IMAGE ENHANCEMENT

IMAGE ENHANCEMENT

- To improve visual interpretability
- Operations applied only after the preprocessing techniques (Noise get enhanced)

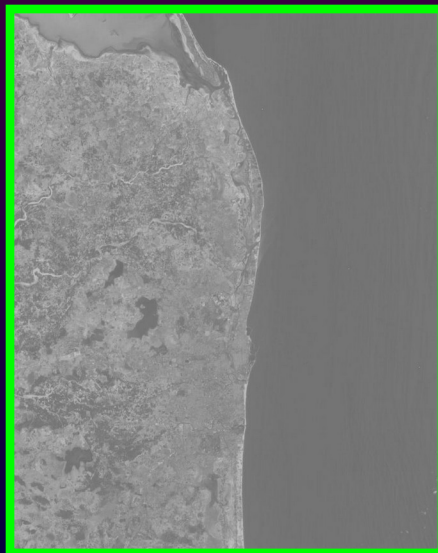
Techniques

- ◆ Point operation (Single pixel independently)
- ◆ Local operation (Each pixel in relation to neighboring values)

BAND I



BAND II



BAND III



FCC



CATEGORIES

CONTRAST MANIPULATION

- ✱ Grey level thresholding
- ✱ Level slicing
- ✱ Contrast stretching

SPATIAL MANIPULATION

- ✂ Spatial filtering
- ✂ Edge enhancement
- ✂ Fourier analysis

MULTI-IMAGE MANIPULATION

- ⊕ Band rationing & differencing
- ⊕ Principle component analysis
- ⊕ Canonical component analysis
- ⊕ Vegetation component analysis
- ⊕ Intensity-Hue-Saturation
- ⊕ Colour space transformation

GREY LEVEL THERSHOLDING

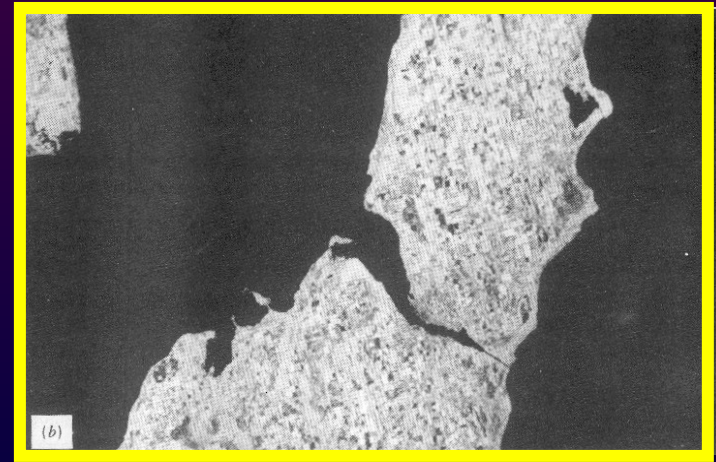
- ❖ Grey values -divided into two groups as below
and above threshold – “*BINARY MASK*”.
- ❖ Additional processing for each class independently.

Eg. Water and land class to show brightness variation in these two groups.

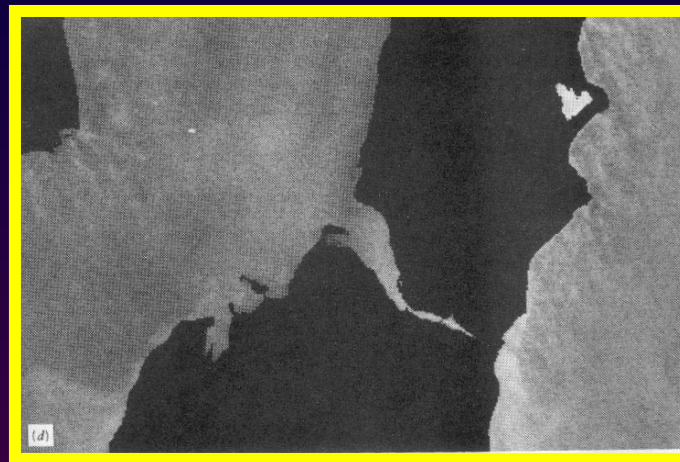
RAW



BINARY MASK



BINARY MASK



LEVEL SLICING

- ✘ Grey values are divided into classes of analyst intervals
- ✘ Each class given single colour – so the image will have 5 to 6 variations
- ✘ Can be applied to binary mask images
- ✘ Extensively used in TIR data images

RAW



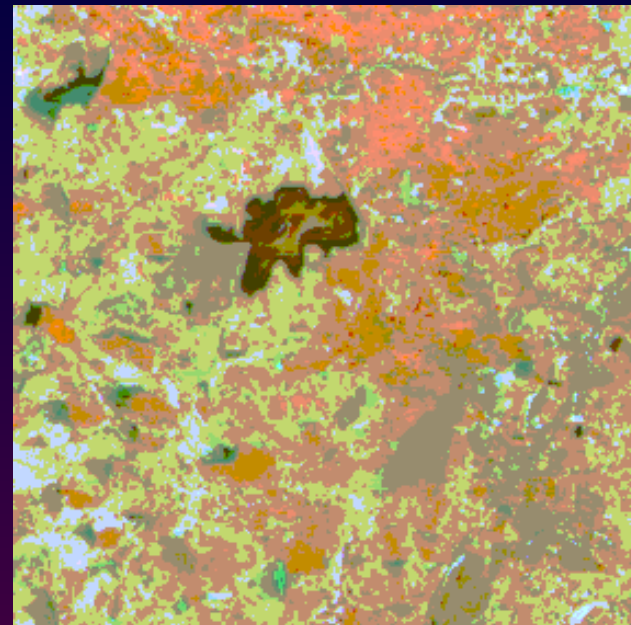
LEVEL SLICING



RAW



LEVEL SLICING

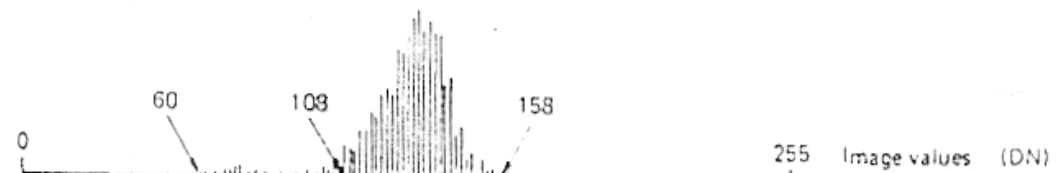


CONTRAST STRECTCHING

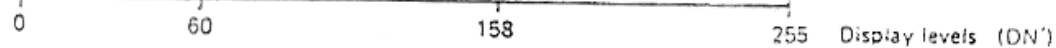
- ❖ Recording & display devices operates over 128/256 grey level ranges
- ❖ Intention is to expand the narrow range of display level
- ❖ Output accentuates the contrast

- ✧ LINEAR STRETCH
- ✧ HISTOGRAM EQUATION
- ✧ SPECIAL STRETCH

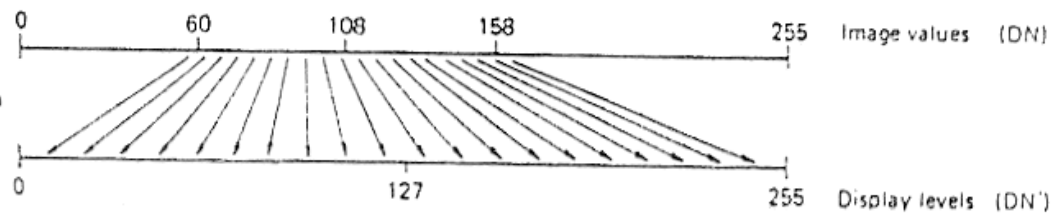
(a) Histogram



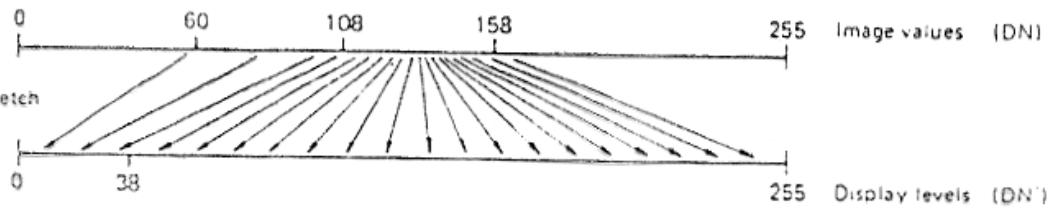
(b) No stretch



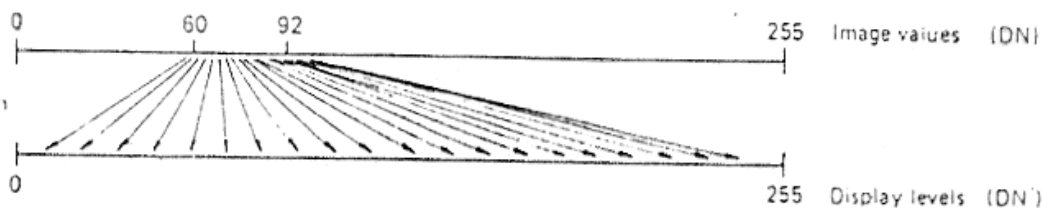
(c) Linear stretch



(d) Histogram stretch



(e) Special stretch



Principle of contrast stretch enhancement.

RAW



LINEAR



HISTOGRAM



SPECIAL



SPATIAL FEATURE MANIPULATION SPATIAL FILTERING: (Local operation)

- ⊕ Emphasize or deemphasize image data of various spatial frequencies (“Roughness” – tonal variation)
- ↻ High spatial frequency (Rough) – Roads, field borders
Grey level changes abruptly over relationally small number of pixels
- ↻ Low spatial frequency (Smooth) – Water bodies, Agriculture bodies
Grey level changes are little over a large number of pixels

VARIOUS FILTERS

Low pass filter $\Rightarrow$ Low pass filtering – (3x3 window average)

High pass filter $\Rightarrow$ High pass filtering – (original DN – Low pass filter value)

SOBEL filter $\Rightarrow$ Diagonal, Horizontal, Vertical

DIFFERENCING

Directional first differencing

- ◆ Edges normal to the particular direction will get enhanced
- ◆ The differences may be +ve and -ve
- ◆ For normalisation add 127 constant for 8 bit data
- ◆ Then contrast stretch

Cross diagonal first differencing

- ◆ It enhances all edges $= (A-D)+(H-V)$

LOW PASS



HIGH PASS



EDGE ENHANCE



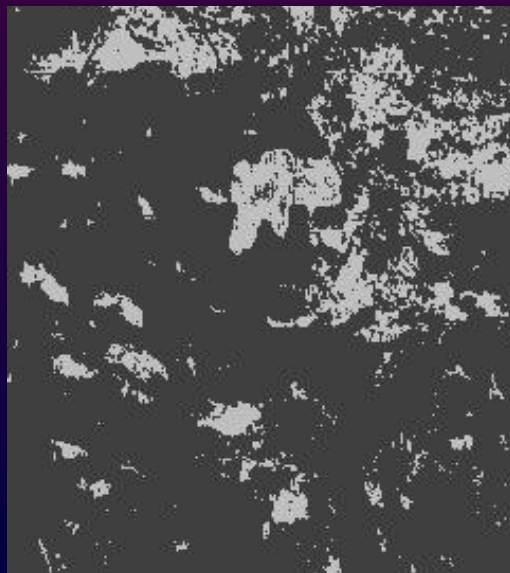
EDGE DEDECETED



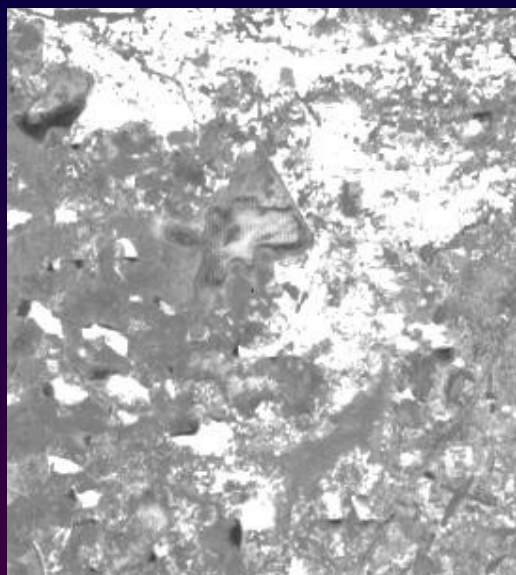
RAW



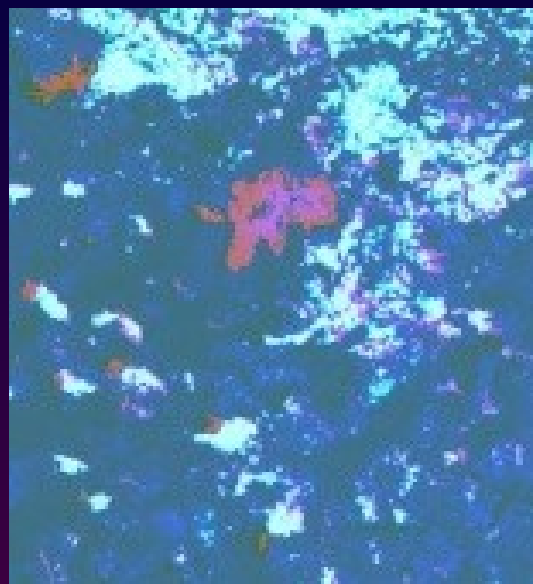
RATIO 2/3

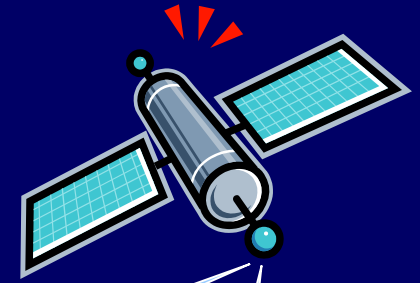
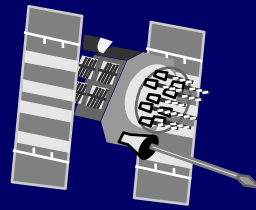


RATIO 4/3

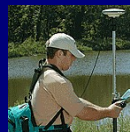
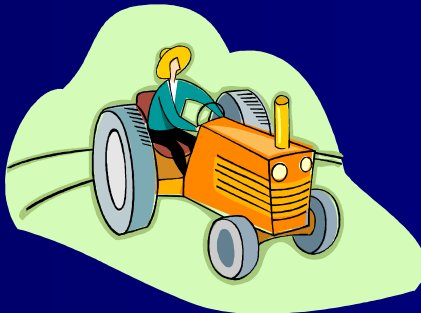
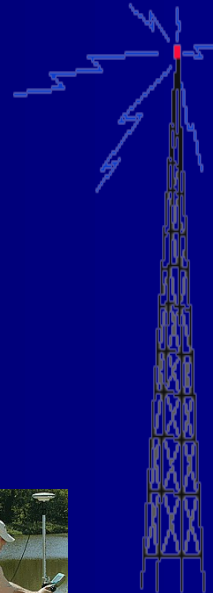


RATIO STACKED





GLOBAL POSITIONING SYSTEM



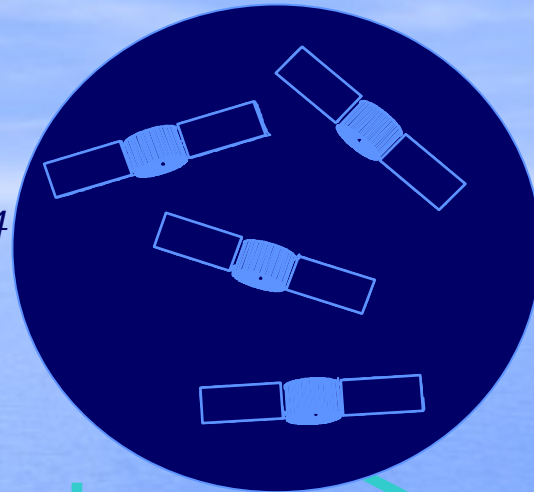
Basics of GPS

- *The GPS NAVSTAR (Navigation Satellite timing and Ranging Global Positioning System)*
- *Satellite-based navigation, timing and positioning system*
- *Three-dimensional positioning 24 hrs a day throughout the world*
- *Well-defined coordinate system, usually by three coordinate values.*

Segments

SPACE-SEGMENT

*6 orbital planes x 4 sat. = 24
some spare satellites
GPS satellites*

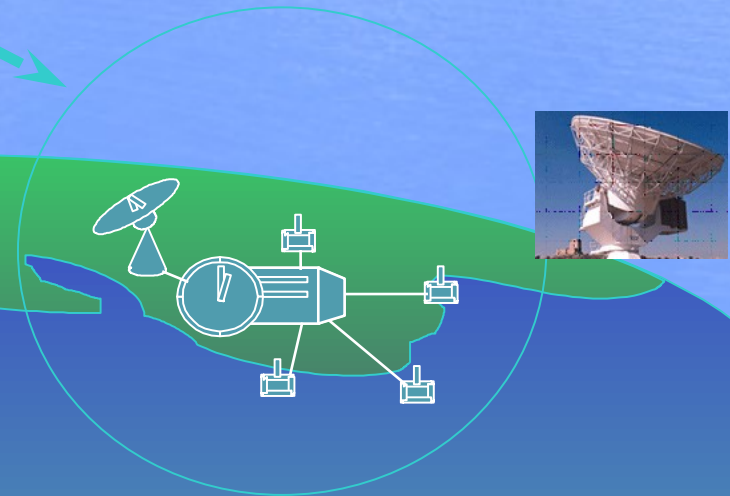


*Locations of
CONTROL-SEGMENTS*



USER-SEGMENT

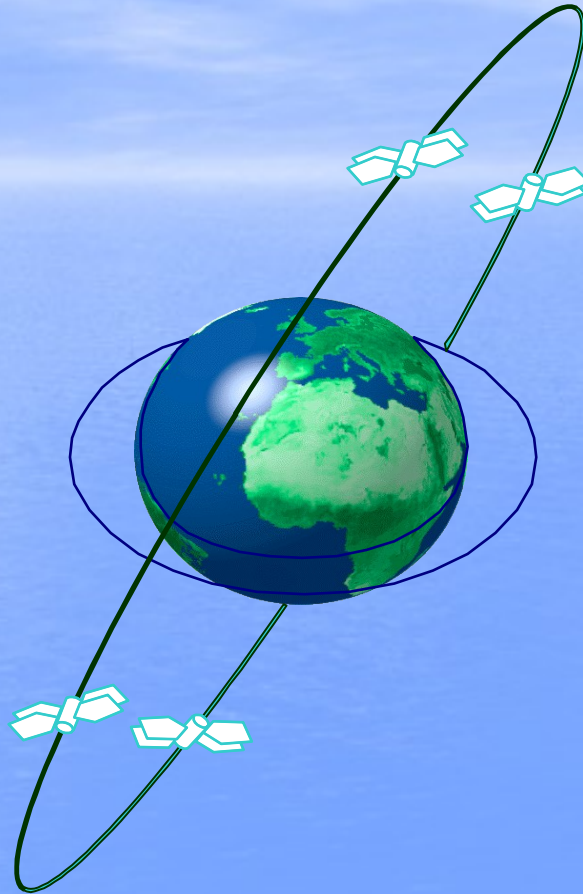
Receive Satellite Signal



CONTROL-SEGMENT

*Central
Time Synchronisation
Tracking Stations*

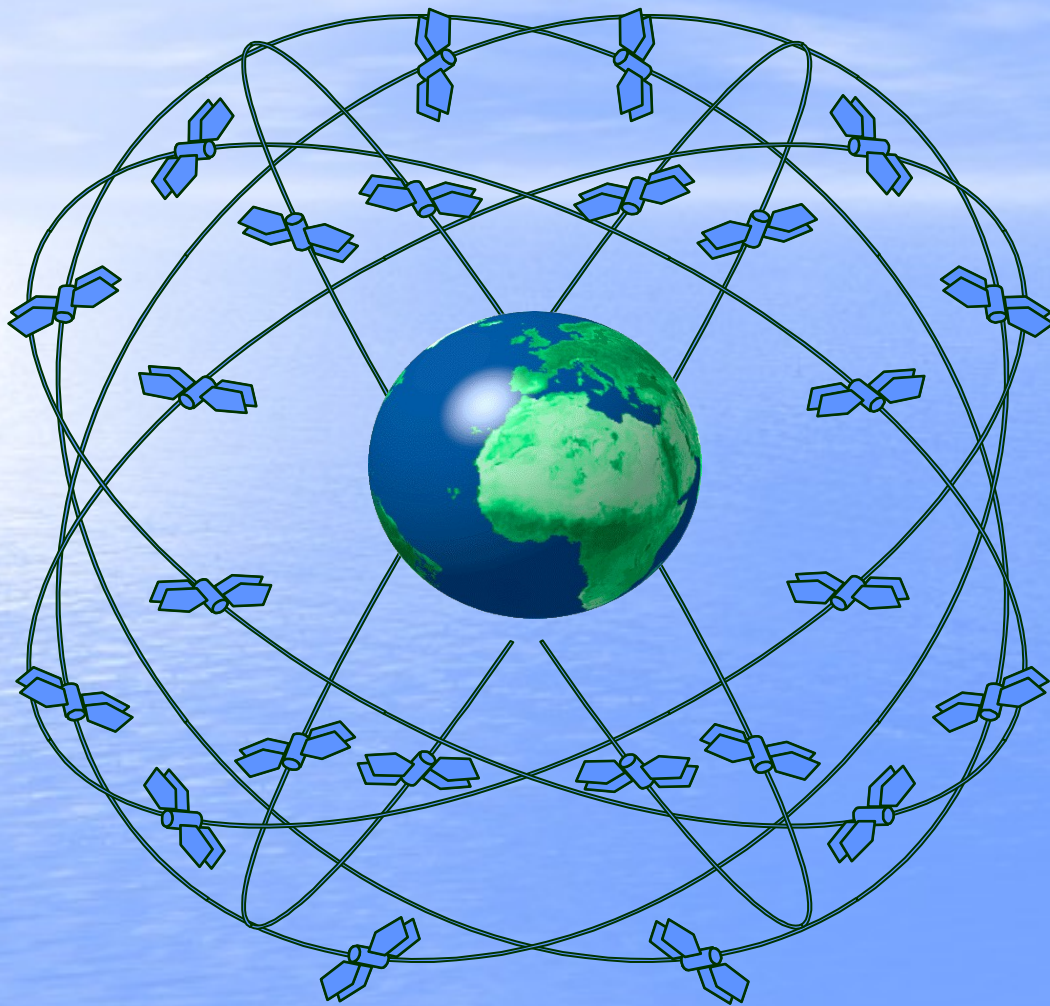
Satellite Constellation



4 Satellites per
orbital plane

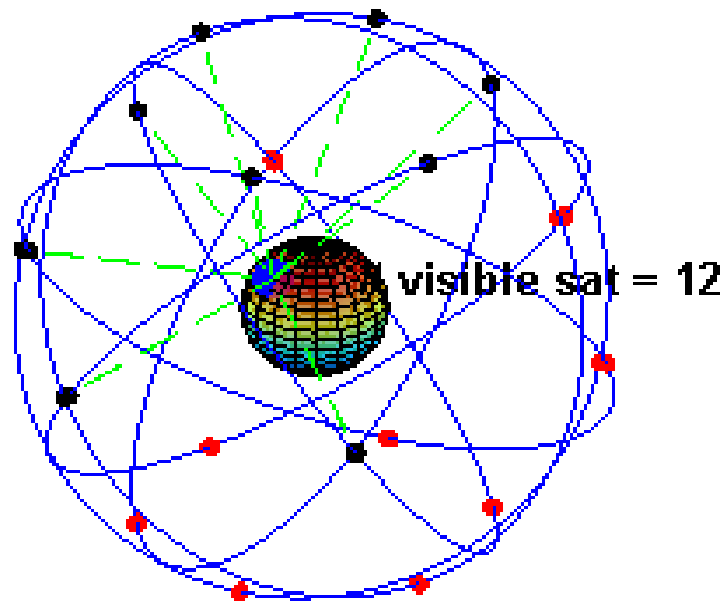
55° Inclination to the Equator
20,200 km above Earth
12 hour orbits

Satellite Constellation



24 Satellites
6 Orbital Planes

55° Inclination to the Equator
20,200 km above Earth
12 hour orbits



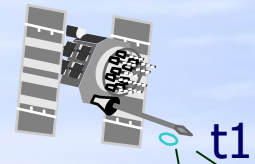
Triangulation Principal



Where is Thiruchirapalli?

- 1) Thiruchirapalli is 190 KMs from Coimbatore.
- 2) Thiruchirapalli is 116 KMs from Madurai.
- 3) Thiruchirapalli is 302 KMs from Chennai.

Distance calculation from Satellite

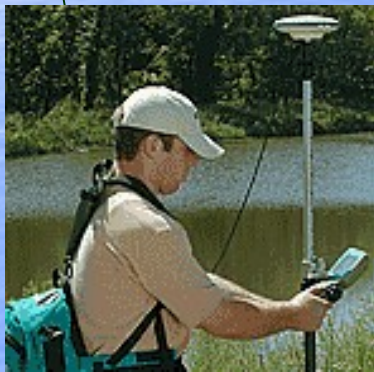


Signal containing:

- Time stamp...
- Satellite ID #
- Exact position of satellite

- $\text{Velocity} = \frac{\text{Distance Traveled}}{\text{Time Taken}}$
- $\text{Distance Traveled} = \text{Speed of light} * (t1 - t2)$

t2



t2



Types of GPS surveys:

**Static, Semi-kinematic(stop & go),
Kinematic, DGPS surveys**

Current Applications of GPS

- Public Safety
- Environmental resource agents
- Aviation
- Military
- Local planning
- Surveying
- Recreation
- Business

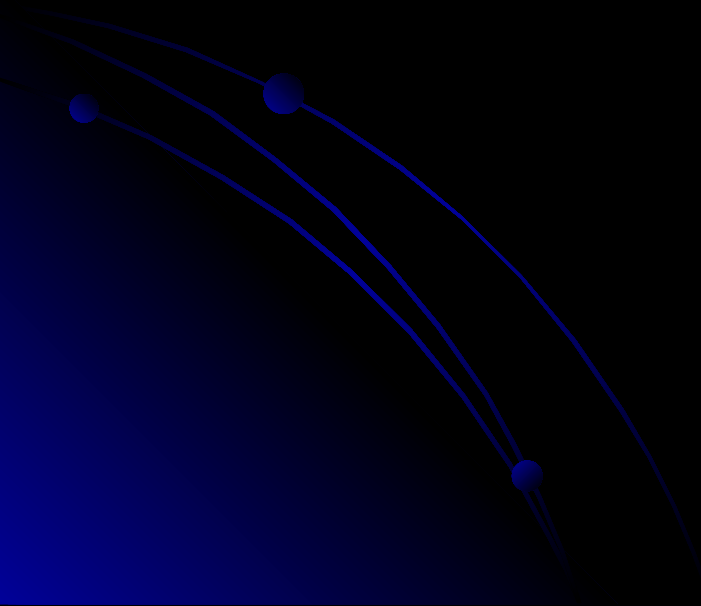


IMAGE INTERPRETATION PRINCIPLES FOR GEOTECHNOLOGY



What is image interpretation?

- Act of examining images or photographs for the purpose of identifying objects and judging their significance.



Fundamentals of image interpretation

- An image is any pictorial representation, irrespective of the wavelength of the imaging device used to produce it.

Platforms

1. Aircrafts
2. Satellites

Fundamentals of Photo Interpretation

- Aerial photographs are representations of the landscape containing a detailed record of features and patterns on the ground at the time of film exposure.
- The pattern is composed of elements -- indicators of conditions and events which reflect the physical, biological and cultural components of the landscape.

Cont.....

- **Applications:** resource inventory, mapping, and monitoring.
 - Crop and forest inventory
 - Soil survey
 - Habitat mapping
 - Geological mapping
 - Urban land use
 - Change detection and analysis

Conti....

- A photo interpreter systematically examines the photos in conjunction with maps, field observations and other information, and makes an interpretation of the physical nature of features and phenomena appearing on the photographs.
- Interpretation may be at a varying degrees of complexity, from simple recognition of objects to derivation of detailed information

- The success of photo interpretation depends on
 - **training and experience of the interpreter**
 - **nature of the objects or phenomena being interpreted**
 - **quality of the photographs**
- The most skilled interpreters generally have keen powers of observation, coupled with an ability to assimilate and analyze information.
- Knowledge of the subject, the geographic region and the sensor are critical

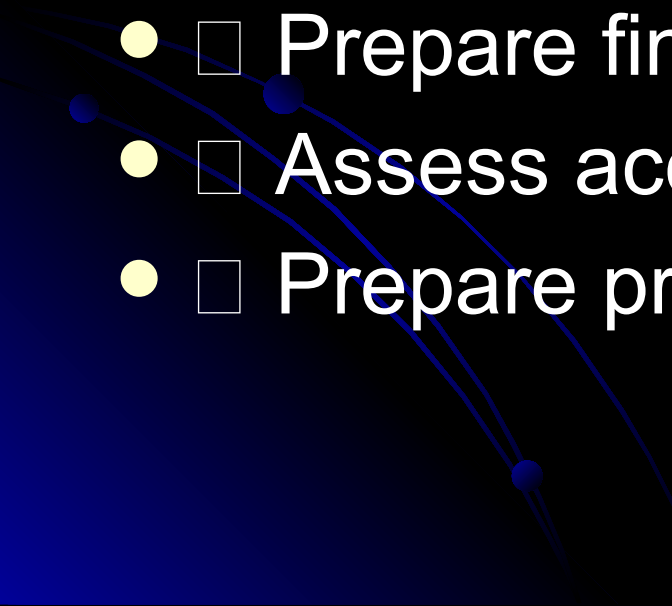
Steps in interpretation

- Collect background information
- Label & index photos & maps
- Identify the effective area
 - 1. Detection**- determine the presence & absence of features
 - 2. Recognitions**- a higher level of knowledge about a feature or object
 - 3. Delineation**- separation of specific aerial unit
 - 4. Measurement**- to measure the distance, height and extension – area, by values

Steps in an Air photo Interpretation Project

- ☐ Review literature
- ☐ Define objectives, classification system,
- ☐ Minimum mapping unit
- ☐ Specify and acquire aerial photography
- ☐ Acquire equipment and materials
- ☐ Train photo interpreters
- ☐ Field reconnaissance

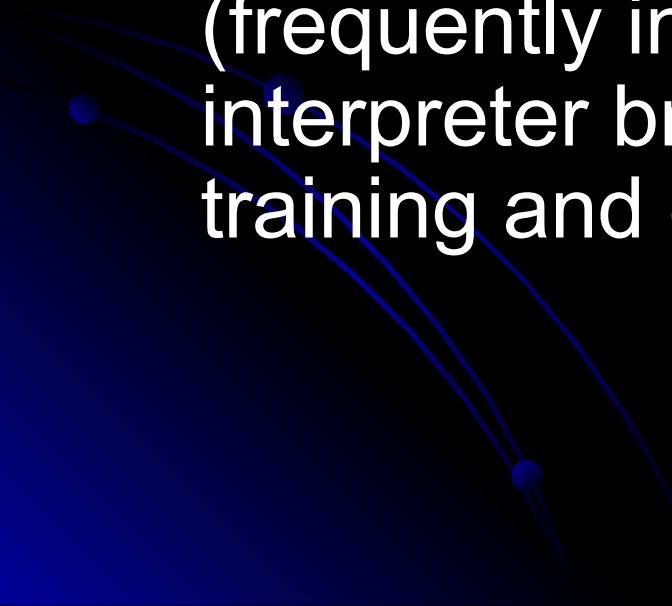
Project Steps, cont..

- ☐ Initial interpretation
 - ☐ Develop preliminary map
 - ☐ Field check
 - ☐ Final interpretation
 - ☐ Prepare final map
 - ☐ Assess accuracy
 - ☐ Prepare project report
- 

- Be familiar with the geographic – ecological setting and land cover types.
- Keep in mind the imagery you are interpreting -- film type, date, scale, etc.
- Systematically consider all the elements of interpretation and evidence – deductive process.

- **General to Specific**

● Collateral Information

- ☐ Ancillary, non-image information used in interpretation.
 - ☐ Can come from books, maps, or field observations.
 - ☐ But often includes the implicit (frequently intuitive) knowledge that the interpreter brings to the task in the form of training and experience.
- 

Interpretation strategies

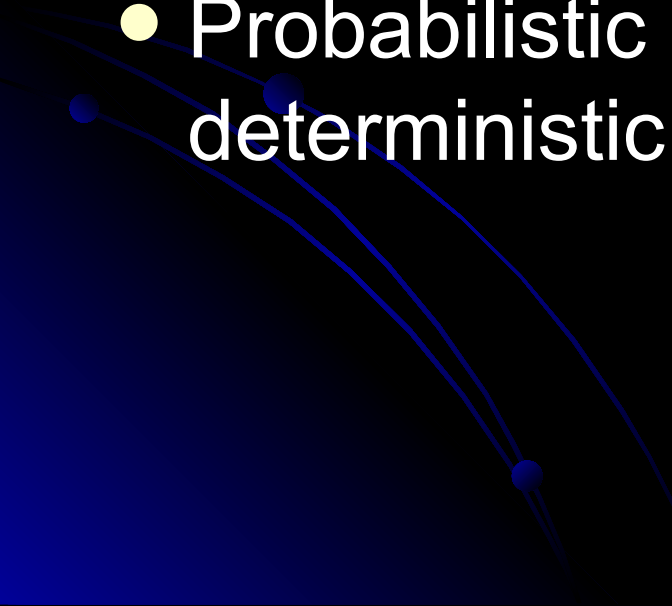
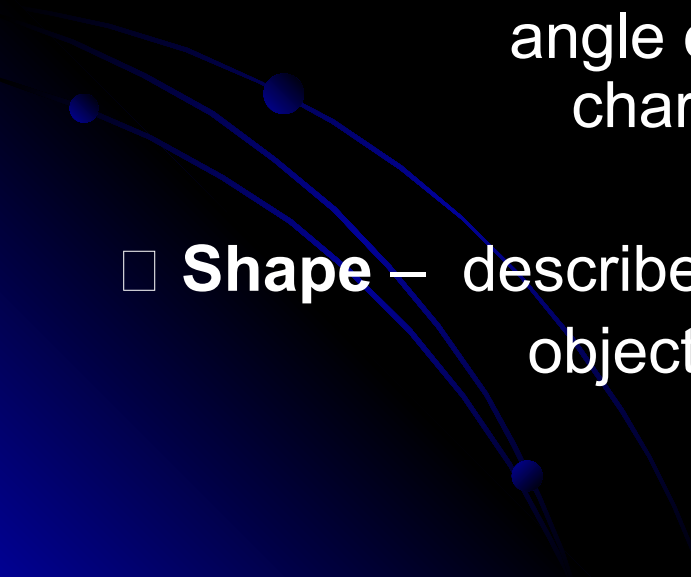
- Field observations (ground truth)
 - Direct recognitions
 - Interpret by inference (soil by vegetation and land cover)
 - Probabilistic interpretation and deterministic interpretation.
- 

Image Elements Used in Photo Interpretation

- **Tone or Color** – relates to the spectral reflectance characteristics of objects
 - **Texture** –frequency of tonal or color change which determines apparent roughness vs. smoothness of an image region; depends on angle of illumination and surface characteristics.
 - **Shape** – describes the form or configuration of an object
- 

Conti....

Size – measure of surface dimensions of objects, including height, length-width, slope

Shadow – may reveal details about size and shape not apparent from overhead view

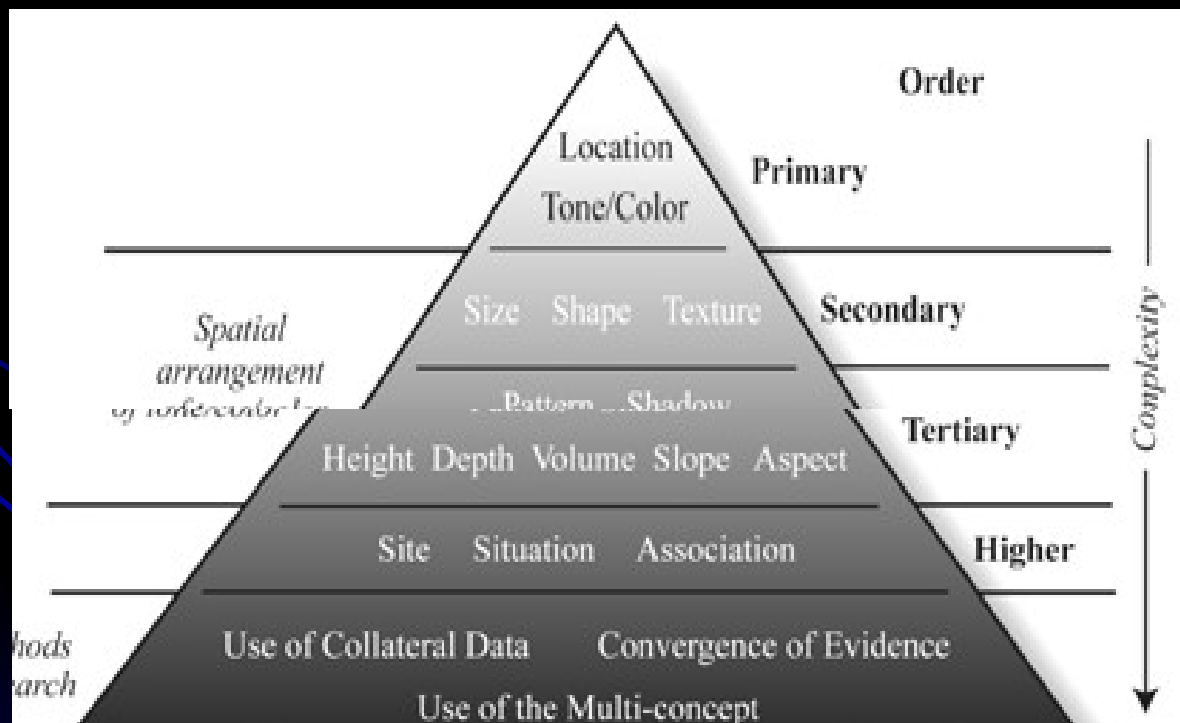
Site – location of object in relation to its geographic or topographic setting

Association – occurrence of certain features in relation to others

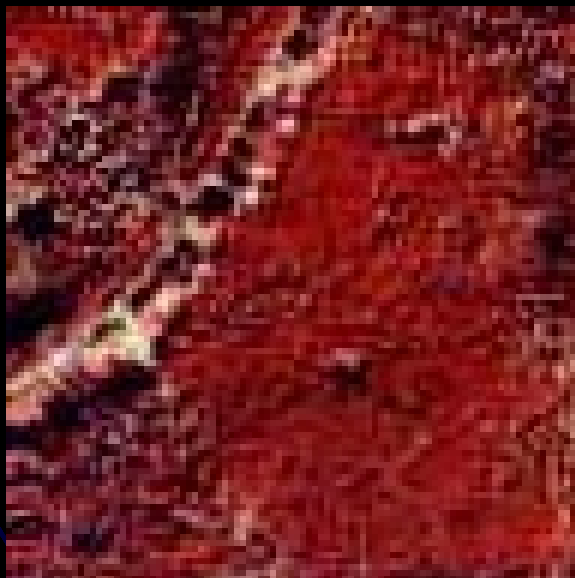
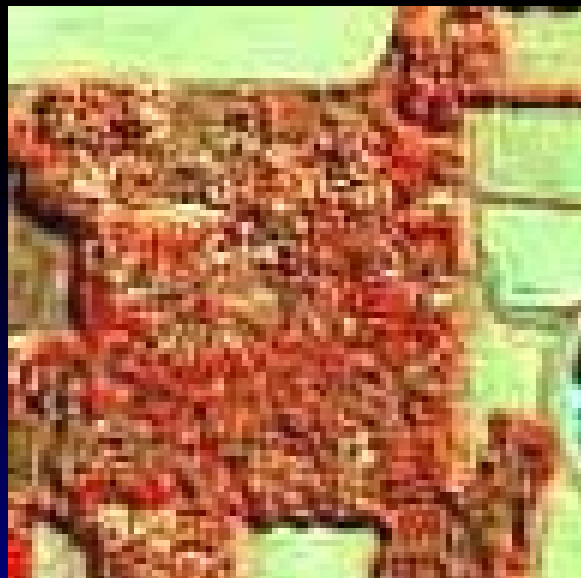
Pattern – spatial arrangement of individual objects into distinctive, recurring forms.

★ Convergence of evidence

- Elements of Image Interpretation: Order and Methods of Search







- **Example Dichotomous Key**
- ☐ **Texture - Smooth.....CROPLAND**
- ☐ **Color - Bluish green.....BARE SOIL**
- ☐ **Color - Red.....CORN OR SOYBEAN**
- ☐ **Texture - Rough.....FOREST**
- ☐ **Color - Red or magenta.....HARDWOODS**
- ☐ **Color - Very dark redCONIFER**
- ☐ **Site - Upland.....Jack Pine**
- ☐ **Site - Lowland.....Black Spruce**

Types of keys

- ☐ **Selective keys** – typical illustrations and descriptions of objects. Interpreter selects the key example that most nearly coincides with the object to be identified
- ☐ **Elimination keys** – user follows a step-by-step procedure working from the general to the specific
- ☐ **Dichotomous keys**
Interpretation makes a series of choices between two alternatives and progressively elements.

Geotechnical Elements

- To study the features on the earth surface such as:

1. Land form
2. Drainage
3. Vegetation
4. Land use and
5. Soil

Significant information on lithology, structure, mineral occurrences and subsurface geology.