Bharathidasan University

Tiruchirappalli – 620 023, Tamil Nadu

6 Yr. Int. **M.Tech. Geological Technology and Geoinformatics**

Course Code : **MTISC0206G**

INTRODUCTION TO GEOTECHNOLOGY

Unit-4 Remote Sensing Based Mapping

ISS, NASA track @ Spot the Station
https://spotthestation.nasa.gov/signup.cfm

Dr. K.Palanivel
Professor, Department of Remote Sensing

Course Objectives

- To know the content and familiarize the courses of this entire programme
- To study the basics and concepts of major disciplines in Geological Technology
- To understand the importance of Geoinformatics and its applications
- To learn the application of Geological Technology and Geoinformatics in natural resources mapping
- To learn the application of Geoinformatics in natural disaster mitigation.

MTISC-0206G - INTRODUCTION TO GEOTECHNOLOGY ---- 3 credits

1. Earth System Processes: 6hrs

Earth Sciences: Definition, Branches of Earth Sciences, Scope and importance of Earth Sciences

Earth System Processes: Origin, interior & age of the Earth – Plate tectonics – Formation of Continents & Oceans – Mountain building activities – origin of rivers – Physiography of the Earth.

2. Lithology, Structure, Geomorphology: 12hrs

Lithology: Rock forming minerals – Igneous, Sedimentary & Metamorphic Rocks – Stratigraphy.

Structure: Folds, faults, geotectonics and their significance.

Geomorphology: Various Geomorphic Processes – Regional Geomorphology of India – Geological Ecosystems.

3. Natural Resources and Disasters: 12hrs

Natural Resources: Mineral Provinces of India and exploration strategies – Hydrocarbon provinces of India and exploration strategies–Water Resources and exploration strategies. Soil, Forest & Biomass and Marine resources.

Natural Disasters: Geodynamic Processes and Natural Disasters (Seismicities – Landslides – Floods – Tsunami – Other Natural Disasters).

4. Remote Sensing Based Mapping: 12hrs

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

5. Geoinformatics: 6hrs

Definition & Concepts – Input Sources (Satellite, Aerial & Ground based) - Computer based Geospatial data base generation – data modeling on Natural Resources, Eco Systems & Natural Disasters – Information Systems.

Course Outcomes

After the successful completion of this course, the students are able to:

- Create subject interest amongst the students joined in this programme and gain knowledge on variety of sub disciplines that they can choose for their future.
- Understand the scope and importance of the Geological Technology and Geoinformatics subjects.
- Provide a brief exposure to the course works of entire 6 year programme.
- Brief exposure to the advanced and computerized tools in Geoinformatics and their applications to Geology, Natural Resources and Natural Disasters.
- Understand the concepts of mapping using Remote Sensing Satellites, Aerial Photography and Digital Image Processing.
- Know the concepts of Geospatial / Geoinformatics Technology based database generation, modeling and information systems.

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

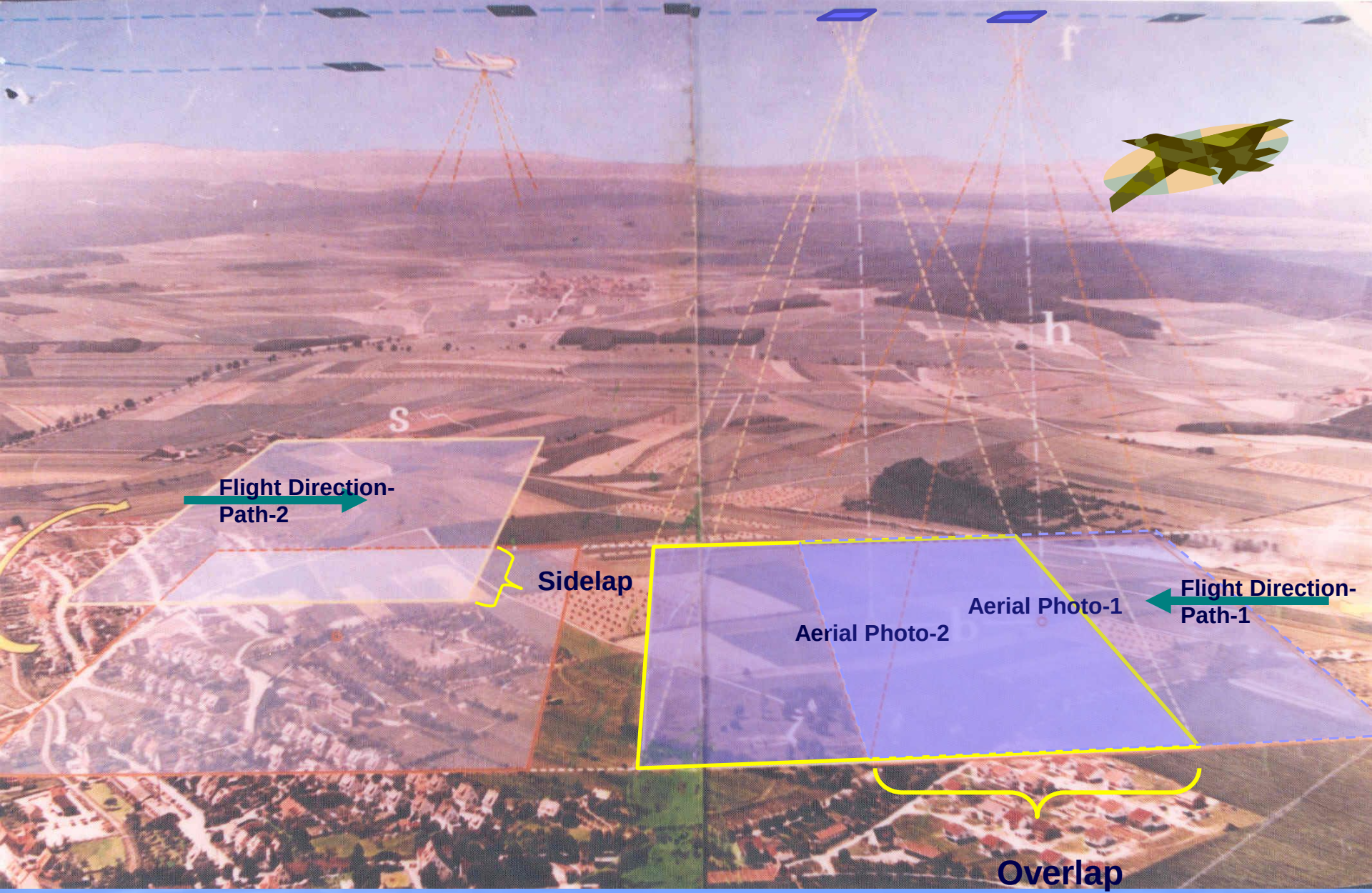
CREDIBILITY OF REMOTE SENSING

- SYNOPTIVITY
- MULTI SPECTRAL NATURE
- REPETIVITY
- ECONOMIC
- 3D (STEREO) DATA CAPTURING

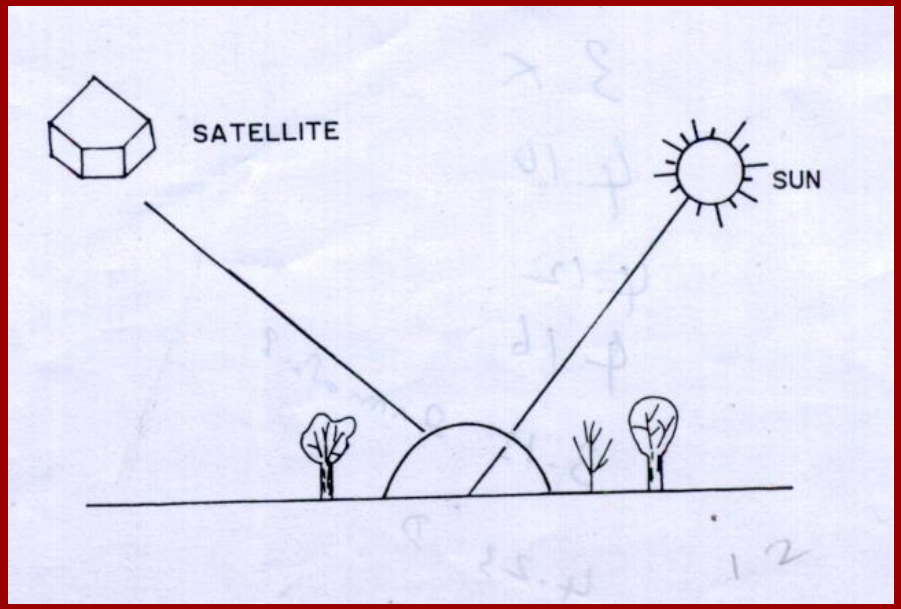
etc.

AERIAL REMOTE SENSING

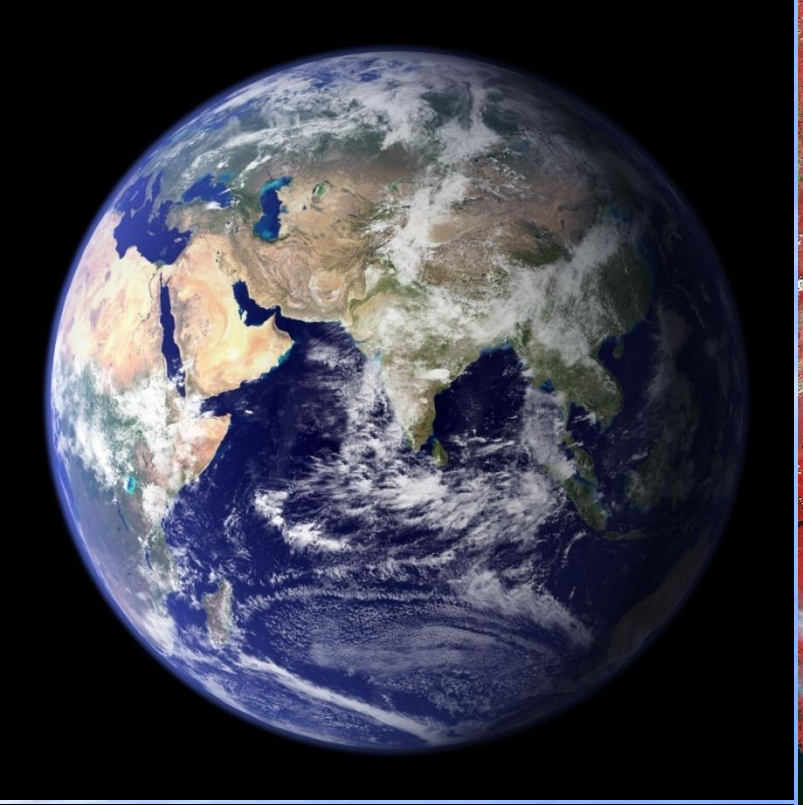
- PHOTOGRAPHIC FILM IS USED
- **B&W** or **COLOUR** films or IR or Thermal filters are used
- Camera fitted in Air Plane
- Fly over a preplanned paths
- Stereo capability – photo with overlaps/sidelaps
- Interpretation with very large scale is easy

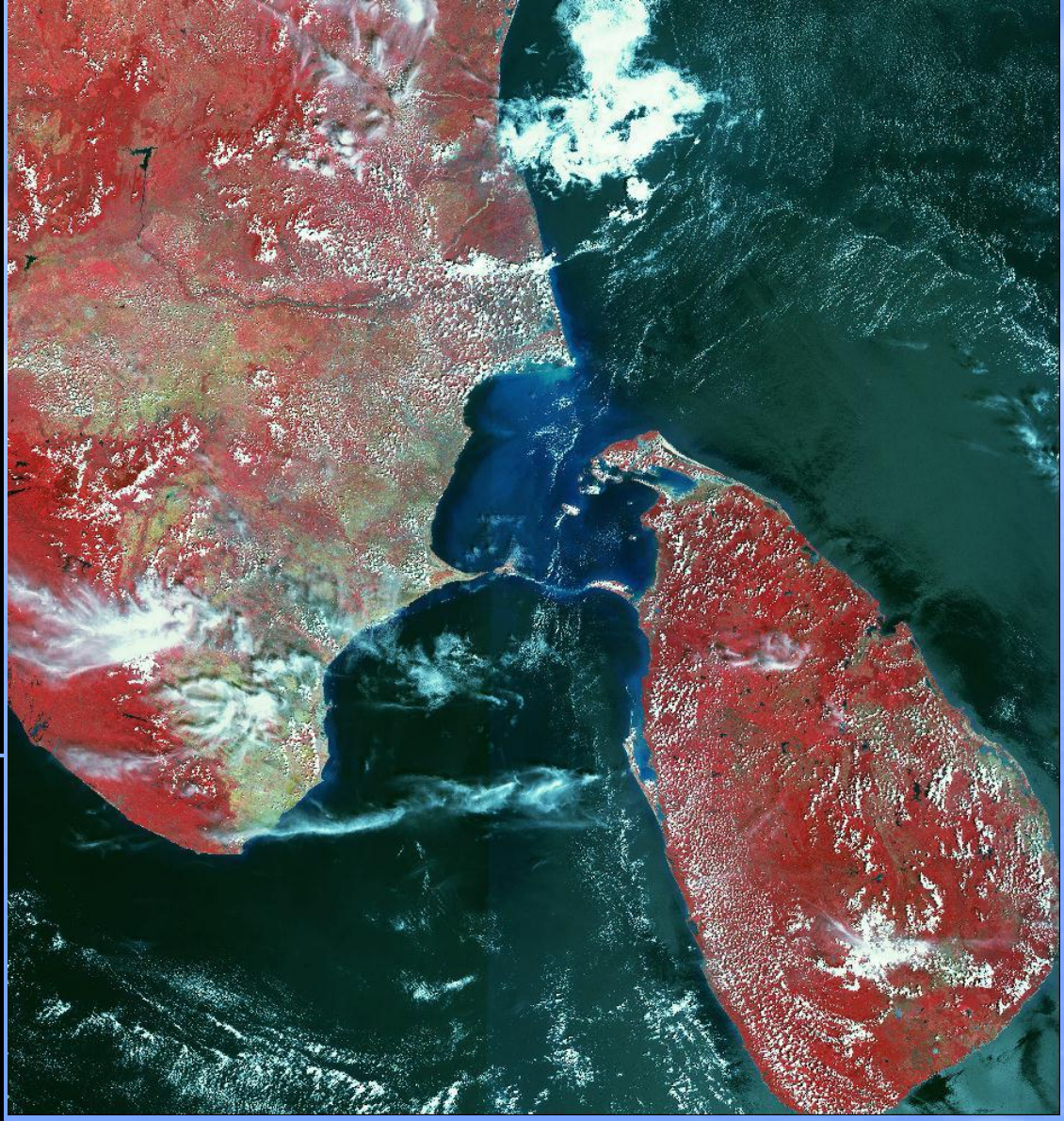

Flight Direction-
Path-2
Sidelap
Aerial Photo-1
Aerial Photo-2
Flight Direction-
Path-1
Overlap

Satellite Remote Sensing-PRINCIPLES

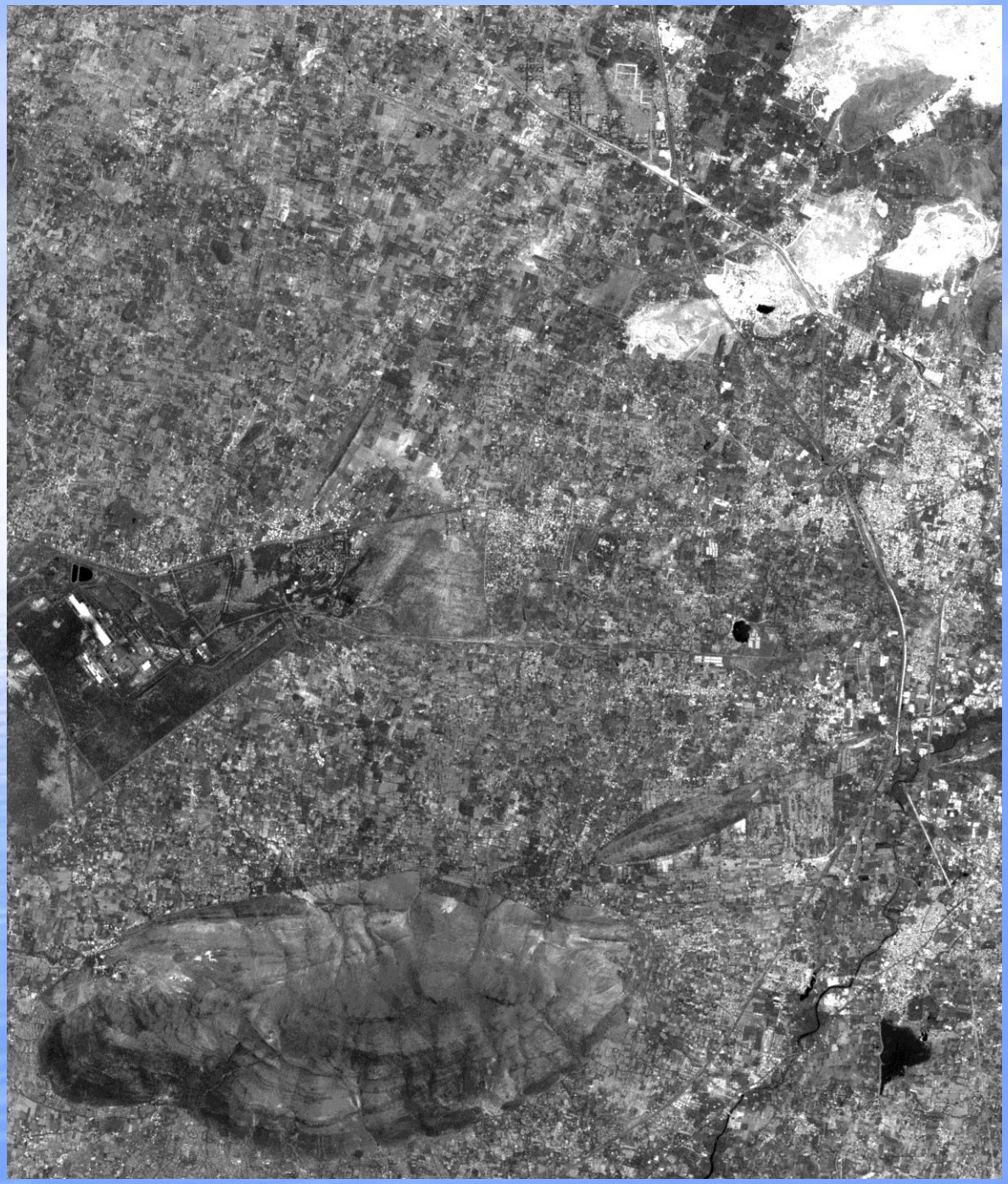


- The sunlight falling on the terrestrial surface is reflected back to satellite
- Green, red and infra - red component of reflected energy is captured by the multispectral sensors fitted in satellite
- Quantum and type of reflected light will depend upon the type of the objects.





SATELLITE IMAGES WITH DIFFERENT SPATIAL RESOLUTIONS



IRS P6 PAN –

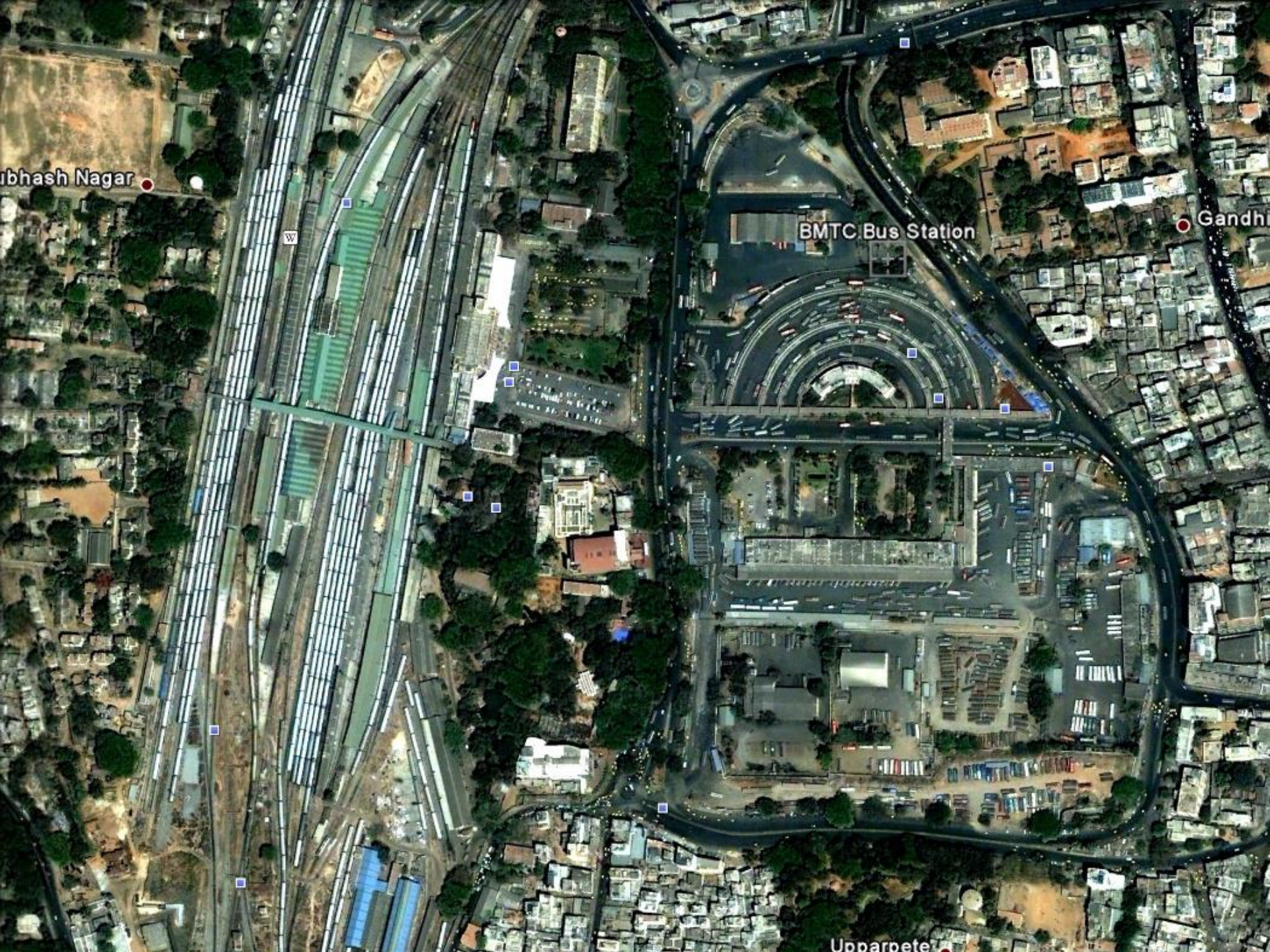
Panchromatic image of Salem area.

Band width

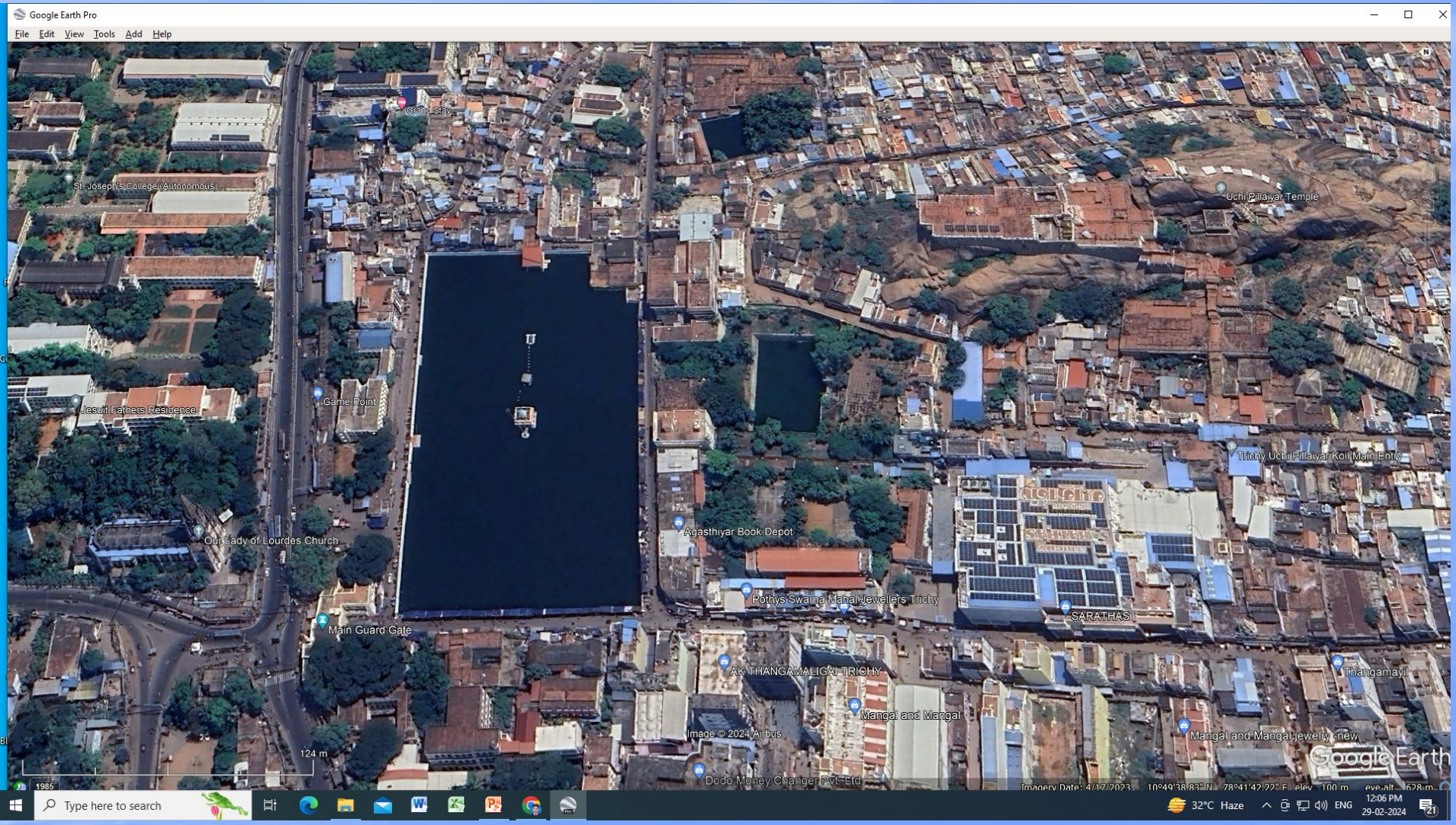
0.45 - 0.82 µm

Spatial resolution

5.8 m


ubhash Nagar
BMTC Bus Station
Gandhi
Upparpete


BMTC Bus Station



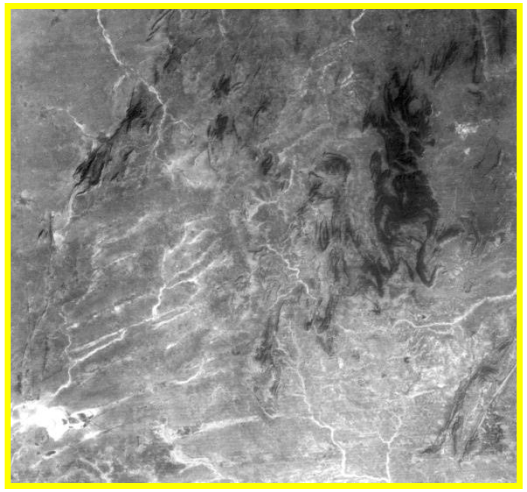
Recently acquired (17.4.2023 dated) AIRBUS (30cm High **Spatial Resolution**) satellite image wrapped over DEM in GIS, providing a 3D Terrain oblique view of Main Guard Gate area of Tiruchirappalli Town, as if viewed from a height of 628m above surface.

– Screenshot from Google Earth

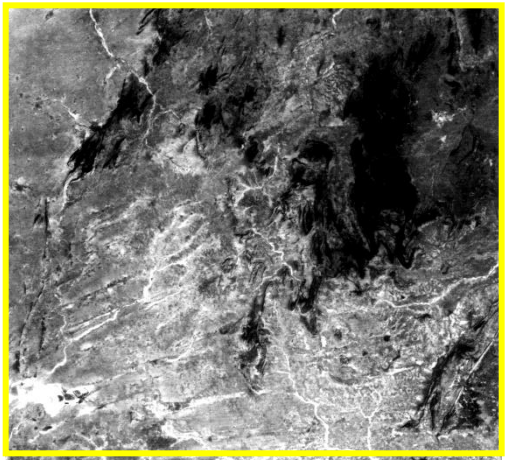
SOUTH INDIA MOSAIC

LANDSAT MULTISPECTRAL SCANNER IMAGES

MSS 4

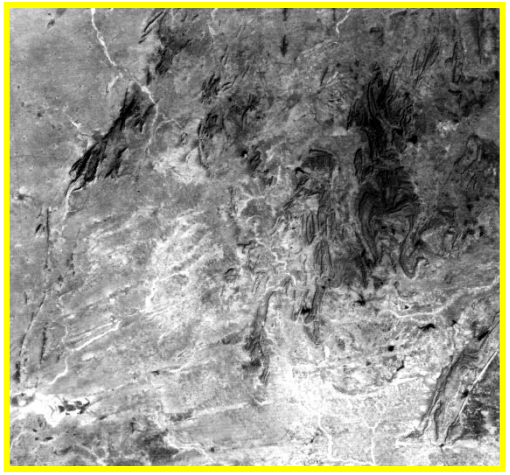


MSS 5

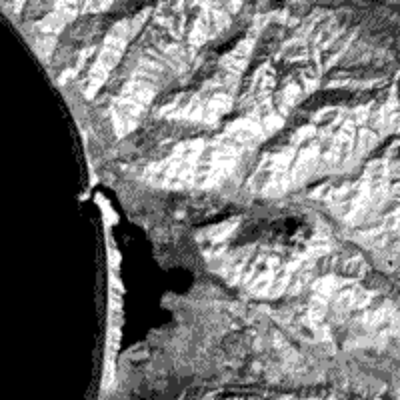


Spectral Resolution

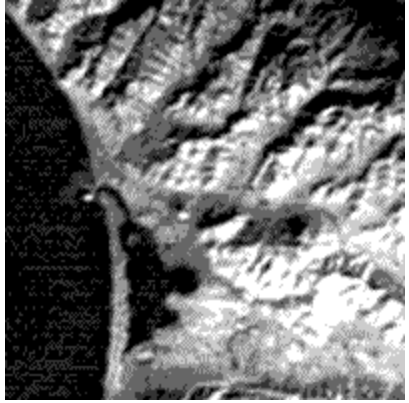
MSS 6



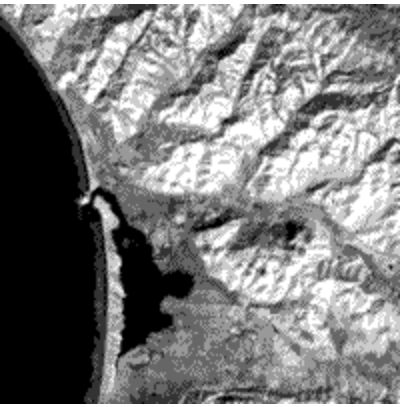
MSS 7



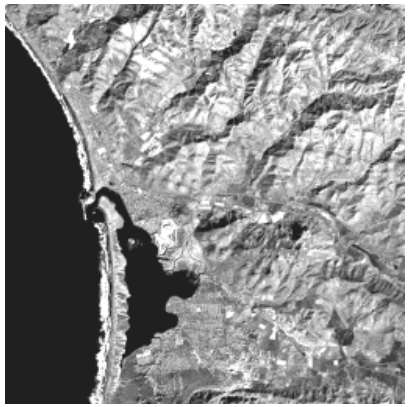
Band 1



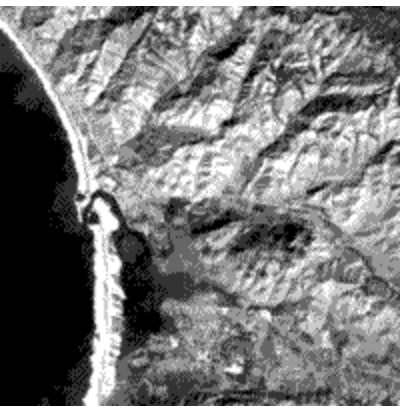
Band 2



Band 3



Band 4



Band 5

Band 6

Standard FCC derived using Multispectral image

STANDARD FALSE COLOUR COMPOSITE
(Standard FCC)

View B2, B3 & B4, bands combined

Green + Red + InfraRed bands

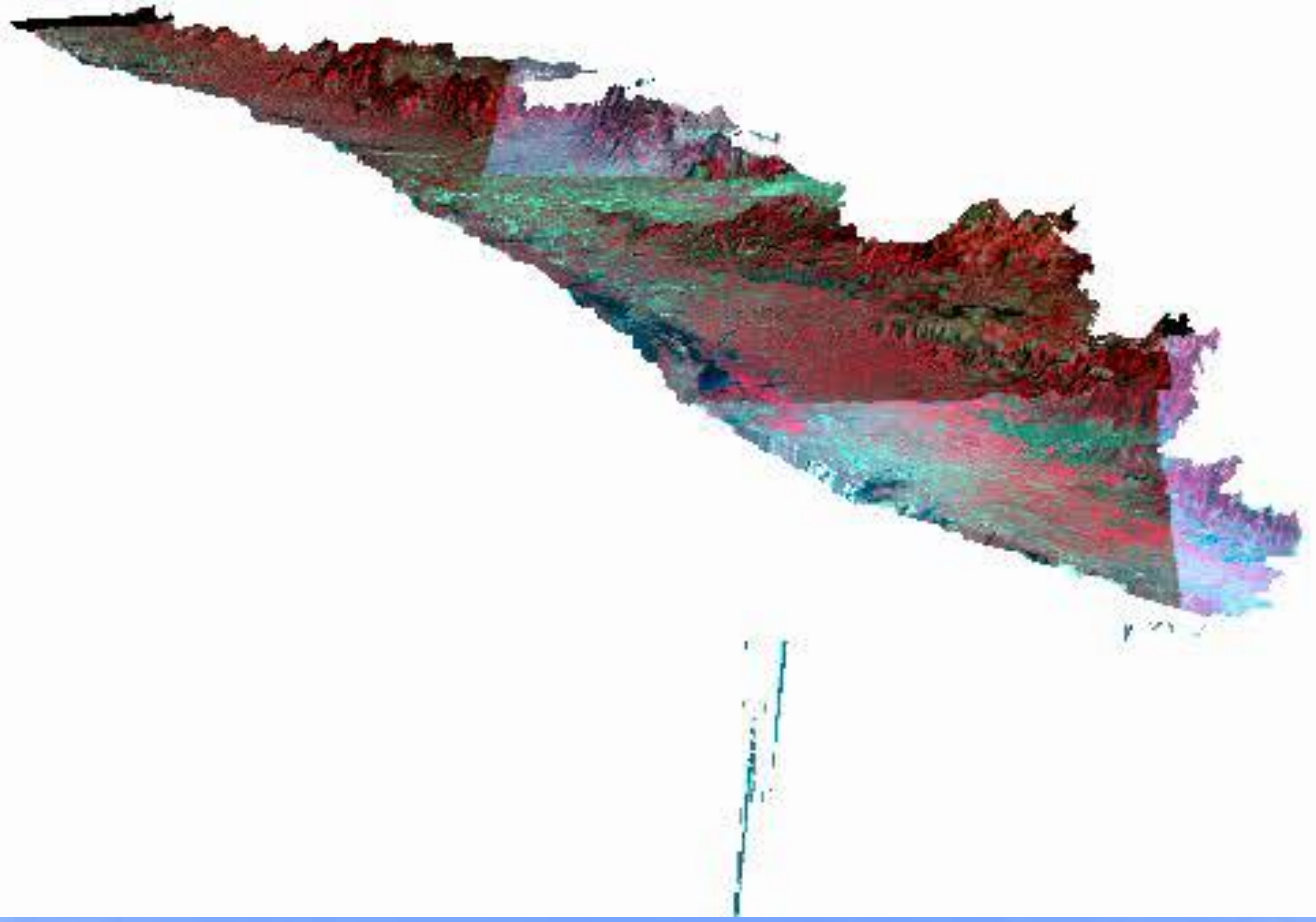
with Filters = **Blue** **Green** **Red**

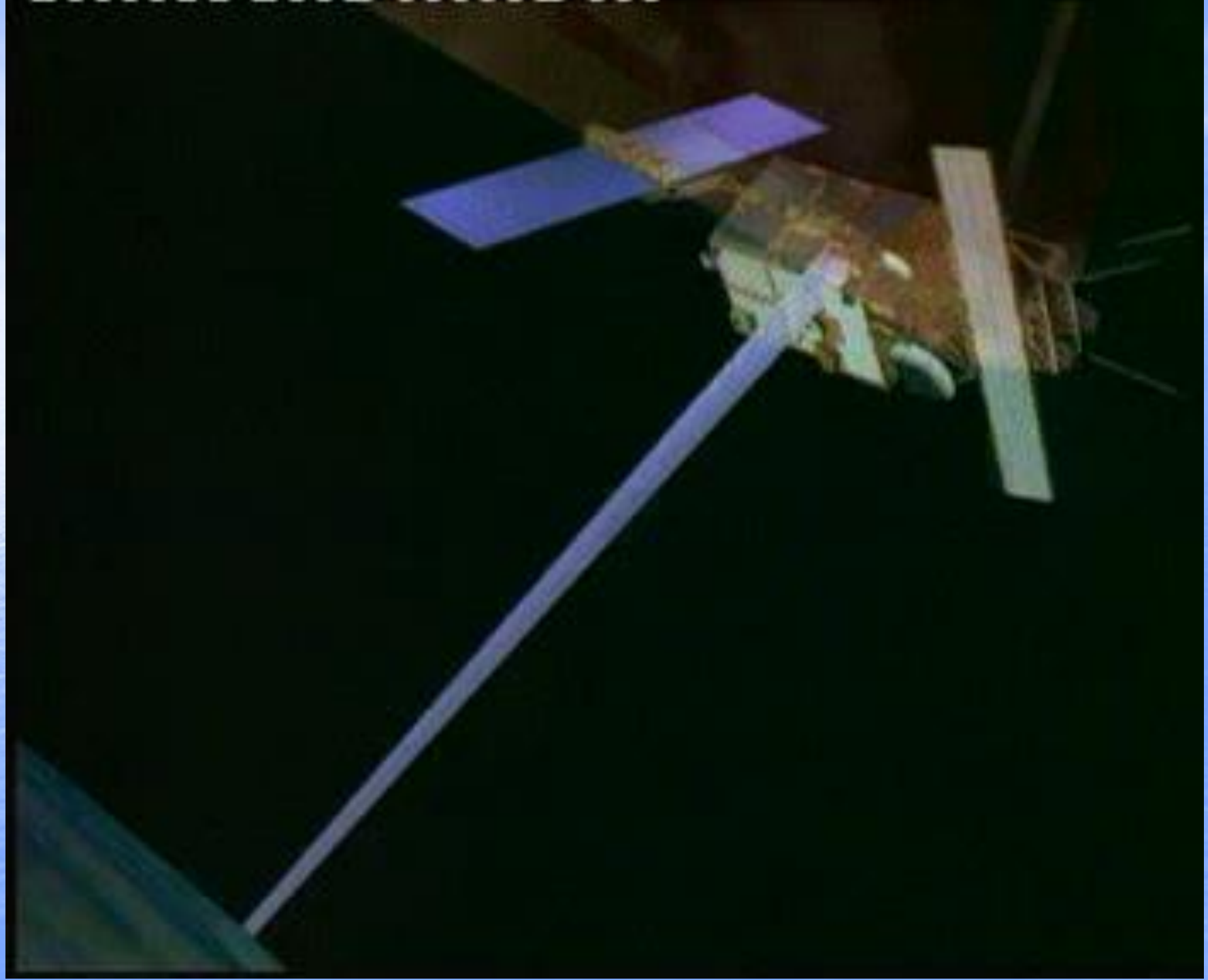
Banda Aceh, Indonesia,

(Temporal data – Repetivity)

23 June 2004

28 December 2004





PRINCIPLES OF IMAGE PROCESSING

DEFINITION

Digital Image Processing is the Manipulation, Enhancement 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 in the Computer
- This pixel data is inserted into an equation (or) series of equations
- Resulted data of the pixel is stored in a separate file as outputs
- Outputs are in the forms of:
  - Displays in LCD monitors / projectors / other screens
  - Printouts – hard copies
  - Digital form in several formats for further manipulation &
  - Compressed / Exported digital file formats for quick transfer through internet / archives.

DIGITAL ANALYSES

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

IMAGE ENHANCEMENT

as an Example:

Aim of image enhancement technique is:

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

IE Techniques are of two types based on the method of handling of data

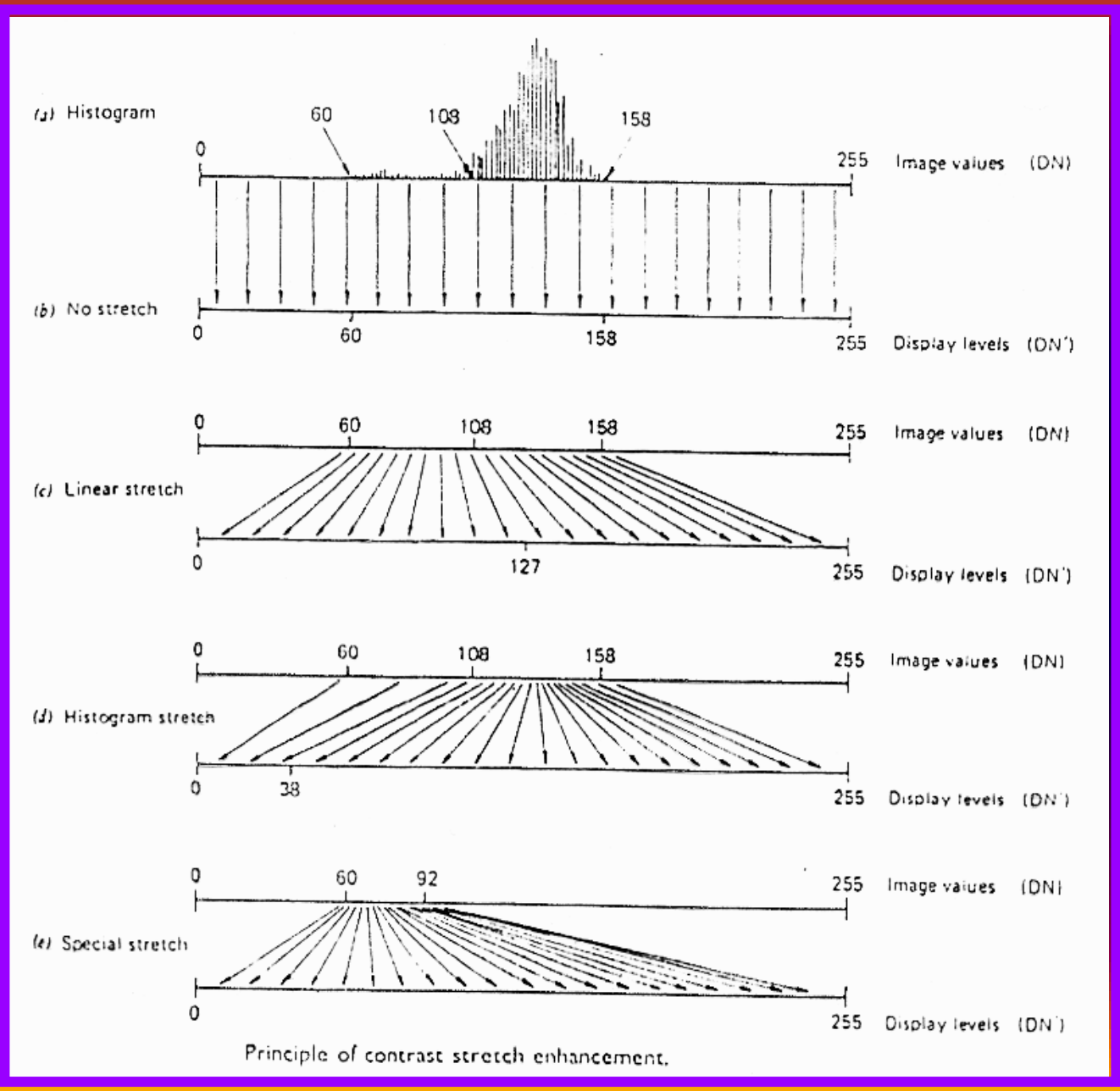
- Point operation (Single pixel independently)
- Local operation (Each pixel in relation to neighboring values)

CONTRAST STRECTCHING

is one of the IE Techniques:

- Recording & display devices operates over 128/256 grey level ranges
- Intention is to expand the narrow range of display level
- Output accentuates the contrast
- Types of **contrast stretching** are:
  - LINEAR STRETCH
  - HISTOGRAM EQUATION &
  - SPECIAL STRETCH

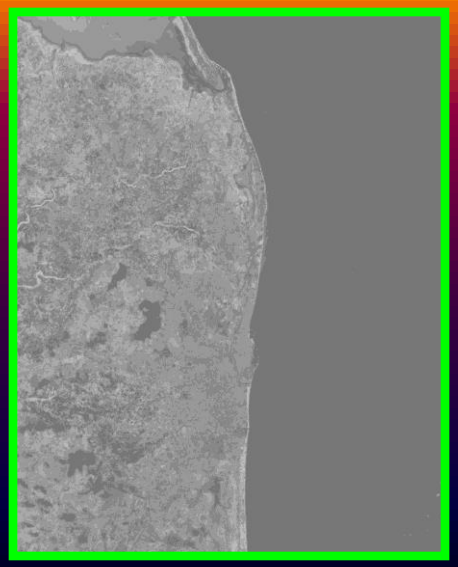
The intensity of reflected EMR spectra are dealt in DIP as Digital Numbers / DN values for every pixel in an image. Stretching will be done based on DN range:



Principle of contrast stretch enhancement.

BAND I

BAND II



BAND III

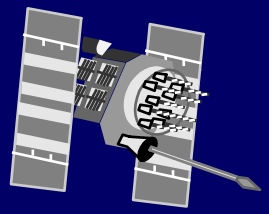
FCC

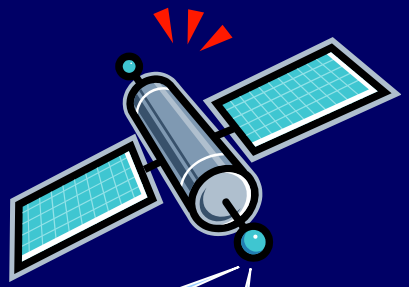
RAW

LINEAR

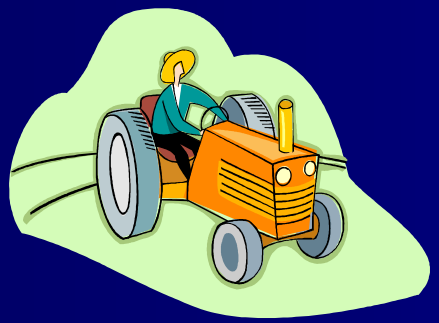
HISTOGRAM

SPECIAL





GLOBAL POSITIONING SYSTEM



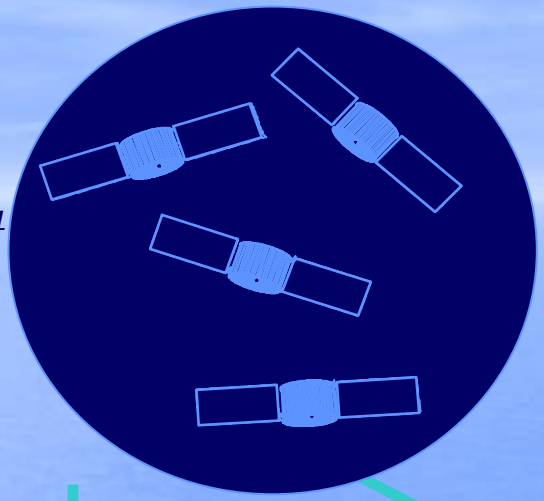
Basics of GPS

- ***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 values (nadir points) of GPS satellites are stamped with nano second time of despatch & satellite ID, i.e., modulated over the bundles of microwaves and sent towards the users – our Earth continuously.***
- ***The nano second time of receipt of such three satellite signals (minimum) by the receiver are used to find out the Receiver's / user's Location.***

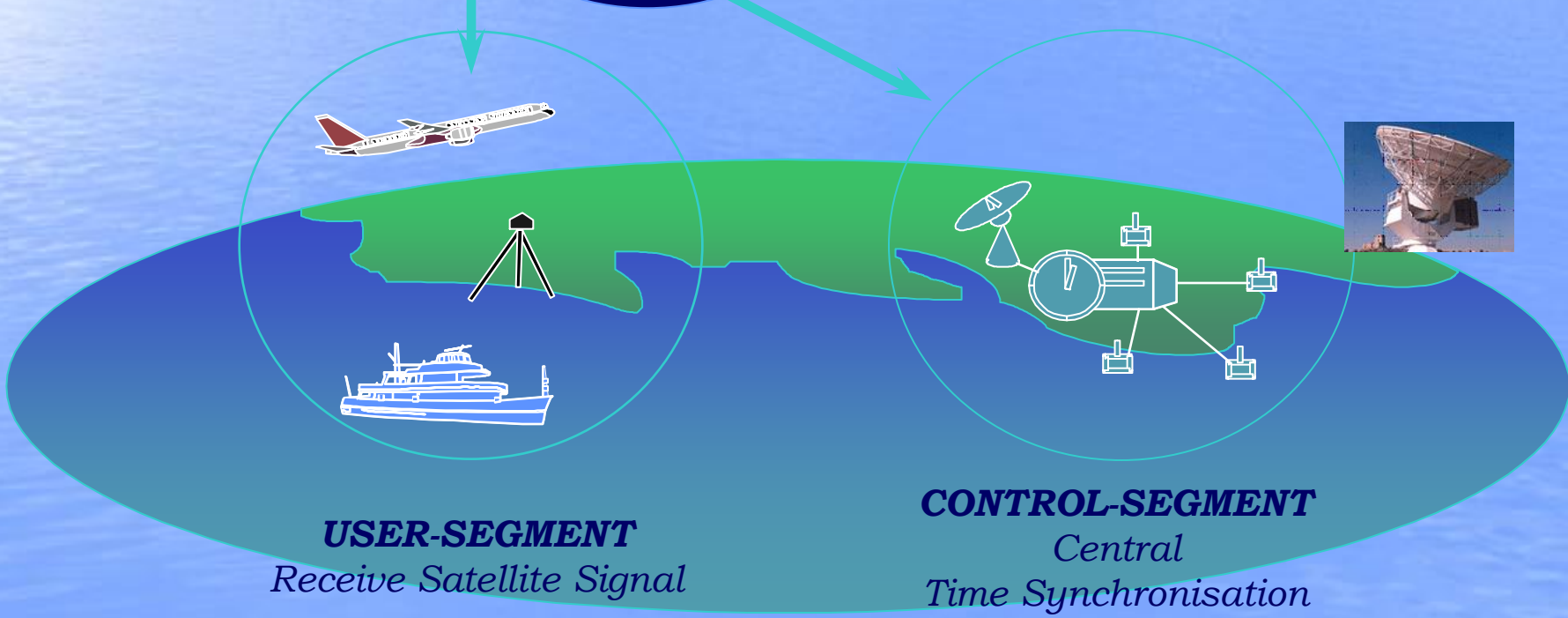
Segments

SPACE-SEGMENT

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



Locations of
CONTROL-SEGMENTS



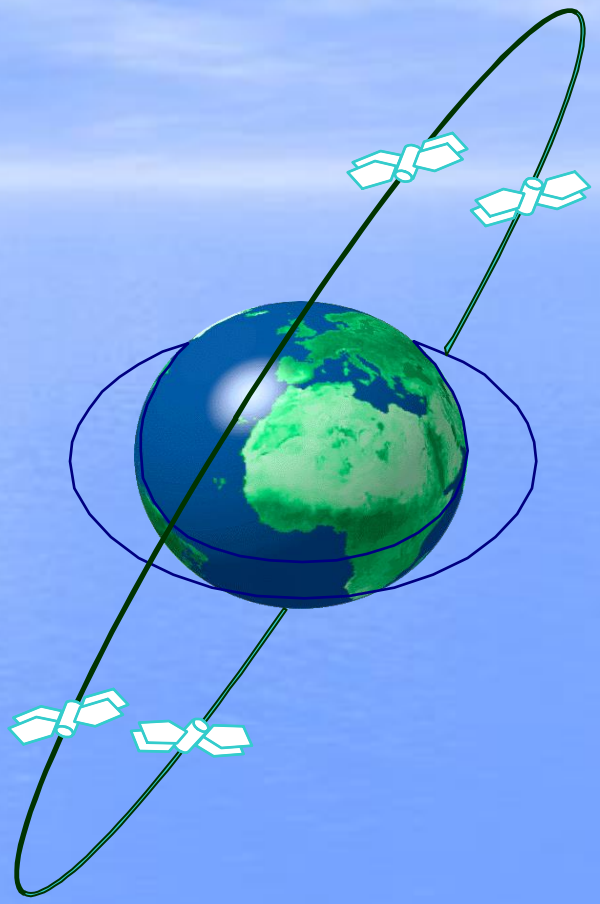
USER-SEGMENT

Receive Satellite Signal

CONTROL-SEGMENT

Central
Time Synchronisation
Tracking Stations

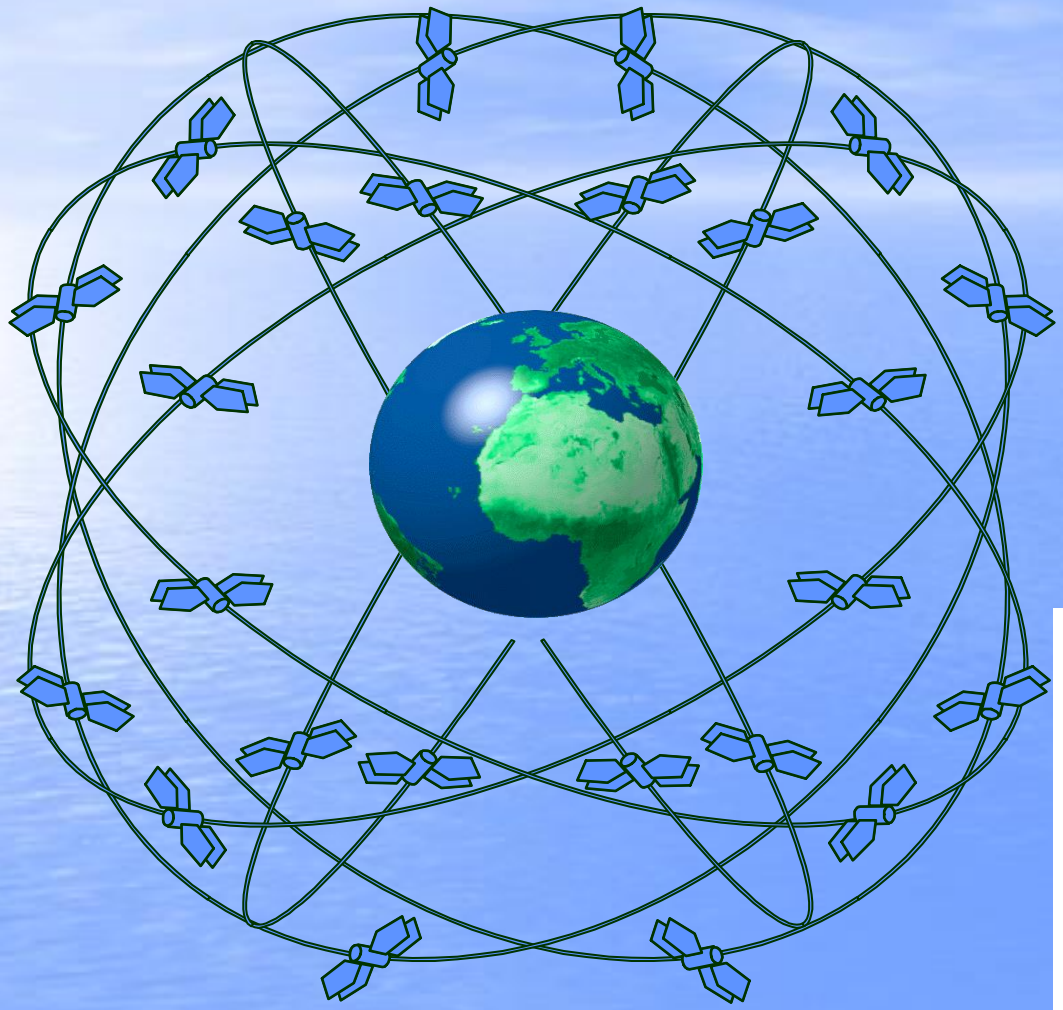
Satellite Constellation



4 Satellites per orbital plane

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

Satellite Constellation



55º Inclination to the Equator
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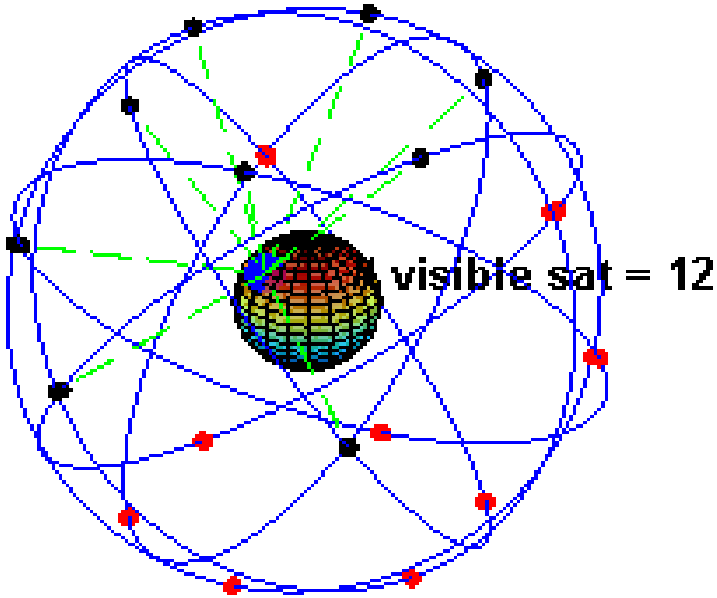
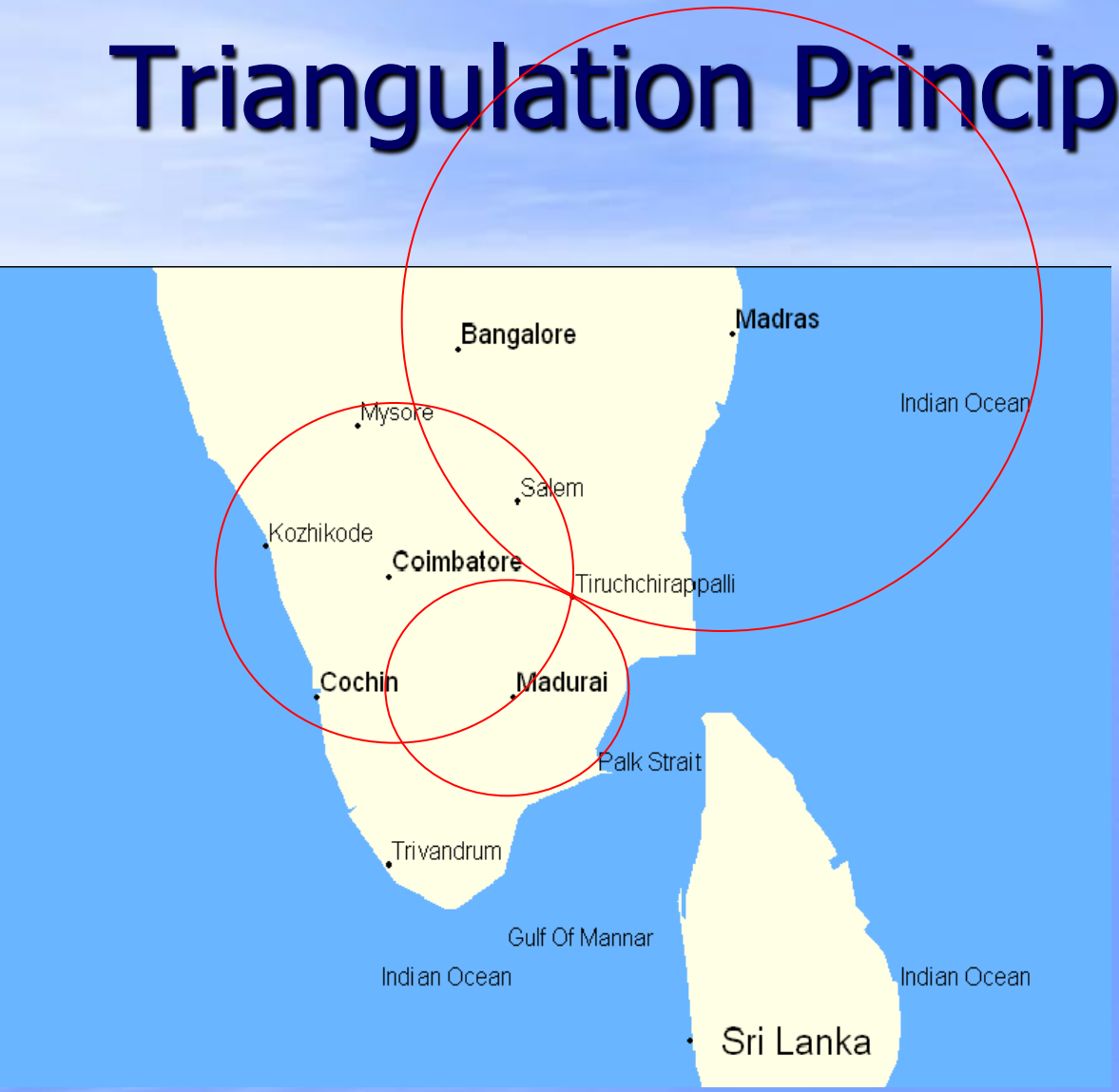


24 Satellites
6 Orbital Planes

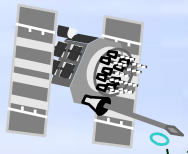
Triangulation Principal



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



t1

Signal containing:
- Time stamp…
- Satellite ID #
- Exact position of satellite

- Velocity = Distance Traveled / Time Taken
- Distance Traveled = 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 satellite images or aerial photographs for the purpose of identifying objects seen in them and judging their significance for further beneficial / societal relevant activities.

Fundamentals of image interpretation

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

Platforms

1. Aircrafts
2. Satellites and others – Baloons, Cranes…

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, disaster vulnerability - mapping, management and monitoring.**
  - Crop and forest inventory
  - Soil survey
  - Habitat mapping
  - Geological mapping
  - Urban land use
  - Change detection and analysis, etc.

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 3 important criteria:

- **Training** and **experience** of the interpreter
- **Nature of the objects** or **phenomena** being interpreted and
- **Quality** of the **photographs.**
- The most **skilled interpreters** generally have important abilities such as :
  a) **keen powers of observation**, coupled with
  b) an **ability to assimilate the details**
  c) **analyze information**
  d) **knowledge** of the **subject, geographic region** and the **sensor**.

Steps in interpretation

- Collect background information
- Label & index photos & maps
- Identify the effective area through:
  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

- Be familiar with the geographic, ecological setting and landuse / land cover types.
- Keep in mind the imagery details for interpretation such as: film type, date, scale, etc.
- Systematically consider all the elements of interpretation and evidence–deductive process.
- From more **General** to **Specific**

Image Elements Used in Interpretation of Aerial Photo / Satellite image

An acronym used to remember the key elements of interpretation is:

T^2S^3SAP

- **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 characterstics.

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

Let us start interpreting the **top right corner** of this imagery

If, a **Standard FCC Satellite image** of an unknown area like this is given, how to interpret it?

Tone – distinct Red (vegetation), White, Bluish Grey, black — grass lands,

Texture – Smooth & Coarse

Shape - Gently curved linear pathways – i.e., runways, rectangles-buildings

Size – covering bigger area – Buildings with elevated roofs

Shadow – of buildings

Site - Urban

Association – Accessible roads, overpass / underpass, parking lots…

Pattern – well structured / designed

Finally, based on the keys / elements, it is interpreted that a well designed airport with proper accessibility, amenity-aerobridges, parking lot… located in the north-eastern part of a city.

The very well planned inhabited area amid several plantation is seen on the western part with straight main roads and streets having accessibility to the criss-crossing highways.






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.

Examples for Dichotomous Keys:

- Texture - Smooth……CROPLAND
- Texture - Rough……..FOREST
- Color - Bluish green……...BARE SOIL
- Color - Red……CORN OR SOYBEAN
- Color - Red or magenta…….HARDWOODS
- Color - Very dark red …….CONIFER
- Site - Upland……Jack Pine
- Site - Lowland……..Black Spruce

Geotechnical Elements

- To study the features on the earth surface such as:
    1. Land form
    2. Drainage
    3. Vegetation
    4. Landuse / Land cover and
    5. Soil

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