Introduction to Remote Sensing and GIS

MSTL, NALSAR

III SEM: Laws of Remote Sensing and Geospatial Data

19 08 2023

EARTH OBSERVATIONS FROM SPACE

Valuable tool for…

Understanding earth science and human interactions with earth system

Modelling the behaviour

Prediction of natural process

Through…

Non invasive observations

Monitoring

Change detection

Measurement

Identification

Deriving knowledge

Image: NASA

HISTORY …SOME MILESTONES

1960 Television Infrared Observation satellite (TIROS-1)

……….First satellite for earth observations

1972 ..Landsat-1 (Earth Resources Technology Satellite-1)

…………Multispectral Scanner & Return Beam Vidicon

1982 & 1984…. Landsats 4 & 5 .. Thematic Mapper (Photo diode/..

1986 …SPOT-1 (FRANCE), Multi- linear array devices

1988…. IRS-1A (INDIA), CCD based Linear Imaging Self Scanners

1991.. ALMAZ-1 (RUSSIA) Synthetic Aperture RADAR

1991….ERS-1 (European Space Agency) SAR, Altimeter, ATSR, 2384 Kg

1992… JERS-1 (Japan) L Band SAR payload, 18m Res.,1400Kg.

1995.. IRS-1C…Highest resolution (civilian) mission

1995…. RADARSAT-1 (Canada) . 8-100m resolution

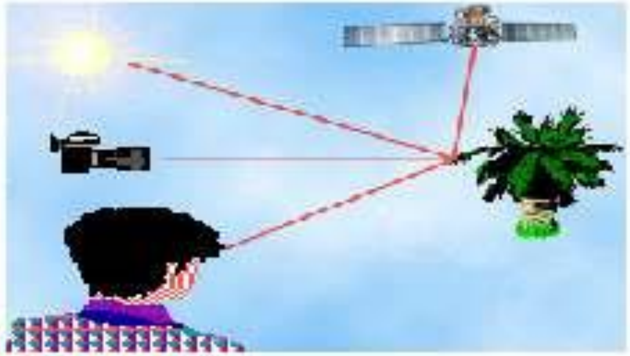
2000….IKONOS (Space Imaging)…Private Commercial 1m mission

Present: Small satellites, constellation, revolution in access and use

WHAT IS REMOTE SENSING ?

Science of making inferences about objects/targets from measurements made without actual physical contact with them. More commonly remote sensing is associated with identification of earth features by detecting and recording electro-magnetic (EM) radiation reflected or emitted from earth's surface and atmosphere

ACTIVE REMOTE SENSING



PASSIVE REMOTE SENSING

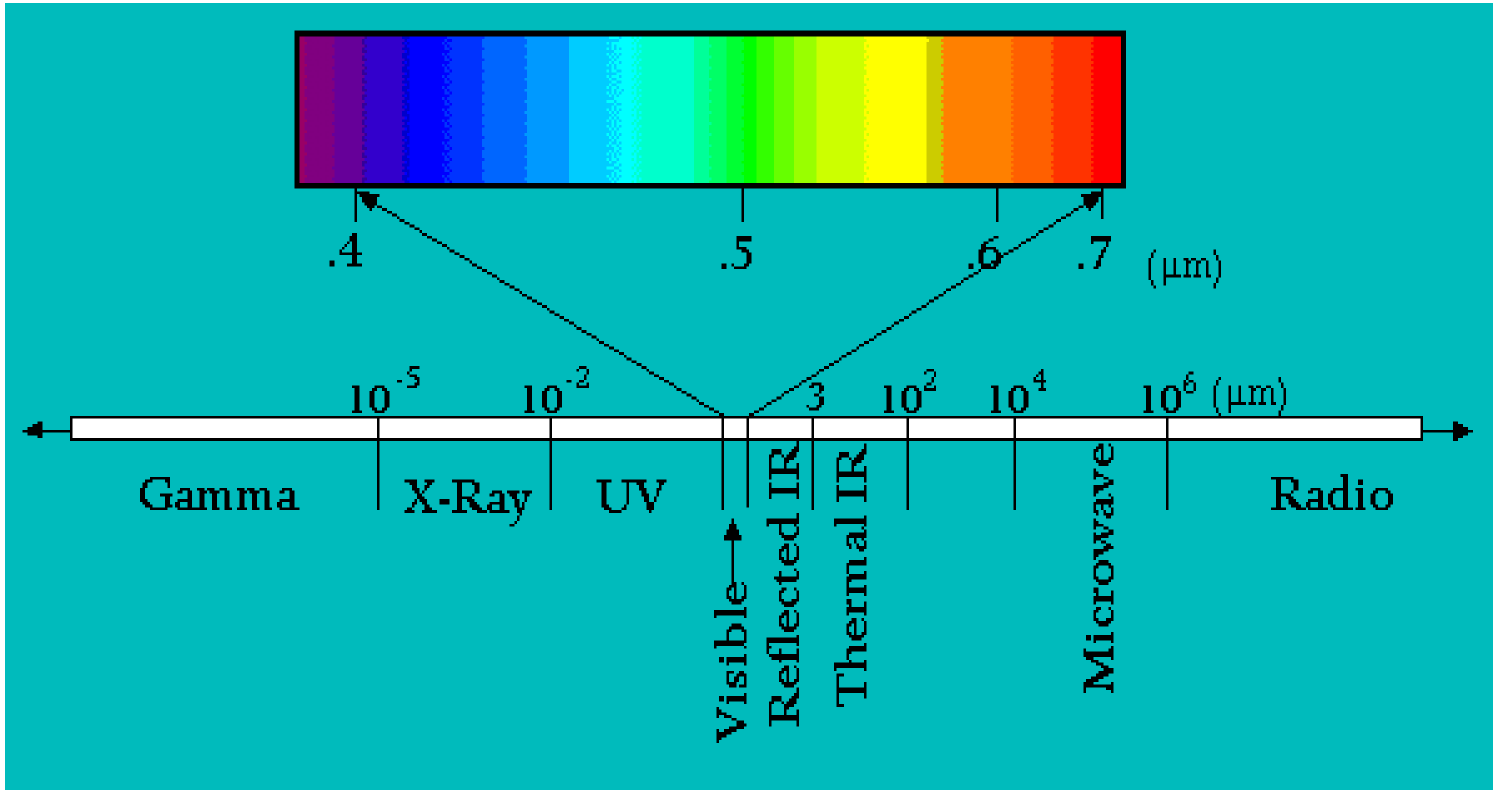
Illustration of the remote sensing concept:

An instrument (i.e., sensor or scanner) mounted on an aircraft or satellite records information about objects and/or areas on the ground.

Typically, these data are spectral in nature, meaning that they document the amount of electro-magnetic energy associated with the targeted objects and/or areas.

The extent, or footprint, of the geographic area captured in a single sensor scene depends on the sensor's design and the altitude of the aircraft or spacecraft on which it is mounted.

ELECTRO MAGNETIC SPECTRUM

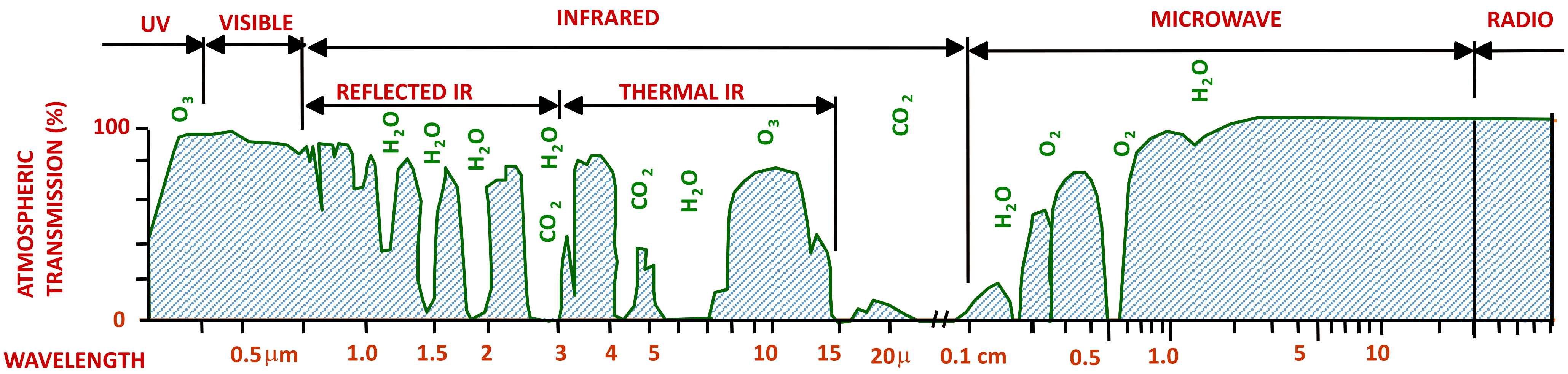


OPTICAL REMOTE SENSING	**: 0.4 – 3.0 μ meters**
MICROWAVE REMOTE SENSING	**: L, C, X, Ku, Ka bands**
THERMAL REMOTE SENSING	**: 8 – 15 μ meters**

ATMOSPHERIC WINDOWS FOR EARTH OBSERVATIONS

Atmosphere practically transparent in visible EM region, whereas opaque in other regions. Remote sensing utilizes the transparent regions known as windows to avoid the effects of absorption of radiation.

- **0.38 - 0.78 Microns (visible)**
- **0.72 - 3.00 Microns (middle IR, near IR)**
- **8.00 - 14.00 Microns (thermal IR)**



Selection of Spectral Bands

Spectral range (µm)	Major Application
0.45 – 0.52 (B1)	Sensitivity to Chlorophyll ; coastal water mapping soil/vegetation discrimination, forest mapping
0.52 – 0.59 (B2)	Green reflectance from healthy vegetation
0.62 – 0.69 (B3)	Sensitivity to chlorophyll ; water type discrimination ; plant species identification
0.76 – 0.90 (B4)	Water body delineation ; vegetation vigour and biomass determination
1.55 – 1.75 (B5)	Water stress in vegetation, snow / cloud differentiation ; drought monitoring
2.08 – 2.35	Discrimination of minerals and Rock types, identification of hydrothermal alterations in rocks
10.4 – 12.5	Surface temperature mapping incl. SST

Useful Microwave channels

Frequency (GHz)	Application
1.4	Sea salinity, soil moisture
2.7	- do –
6.7 – 7.1	Ocean surface Temp.
10.6	Rain, snow, Ice
18.7	Water vapour
21	Liquid water content
36.5	Rain, snow, water vapour
50.3	O2 Temperature profiling
86 – 92	Clouds, oil spills, ice, snow
183	H2O, moisture profiles, N2O
200 – 209	H2O,O3,N2O

Satellite Imaging- Capability determinants

ORBITS
PLATFORMS
- Weight and power
- Agility
- Pointing & Jitter
- Data throughput
- Memory
- Onboard intelligence
- Programmed - commanding

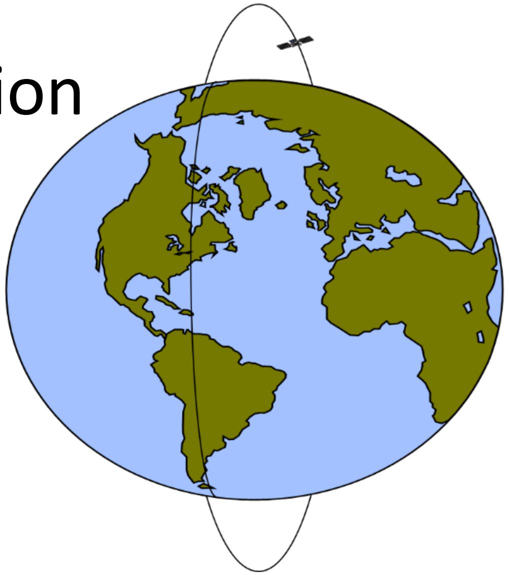
SENSORS
- Spatial resolution
- Spectral bands (V/IR/MW)
- spectral resolutions
- Temporal characteristics
- 2D/3D/Video

DATA RECEPTION
DATA PROCESSING
DATA/INFO DISSEMINATION

LIFE & RELIABILITY

ORBITS

- Orbit height, swath width, resolution and life time trade-offs
- Repetition of path/ revisit consideration



- SUN SYNCRONOUS POLAR ORBITS
  - Sub-recurrent orbit
  - Combined repeat cycle

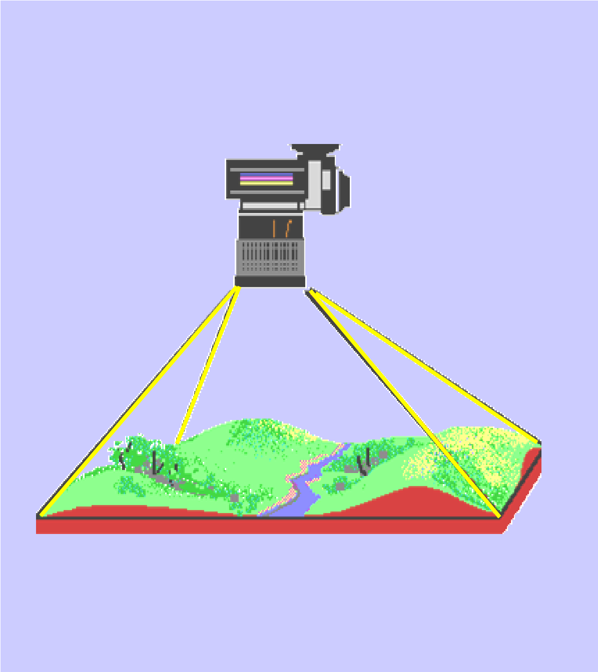
  Landsat 7 & 8 together….8 day repeat cycle

  Sentinel 2A and 2B together … 5 day revisit

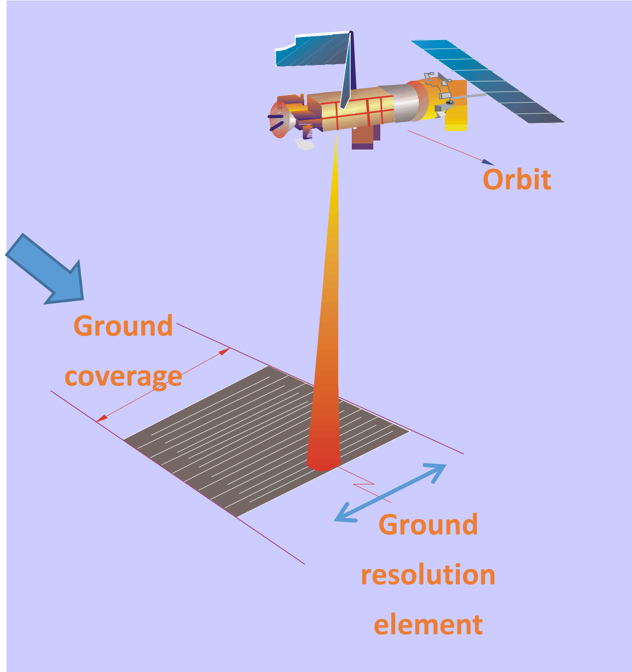
- GEOSTATIONARY EARTH ORBIT
  - Altitude 35, 786 km

- Constellations
- Formation flights

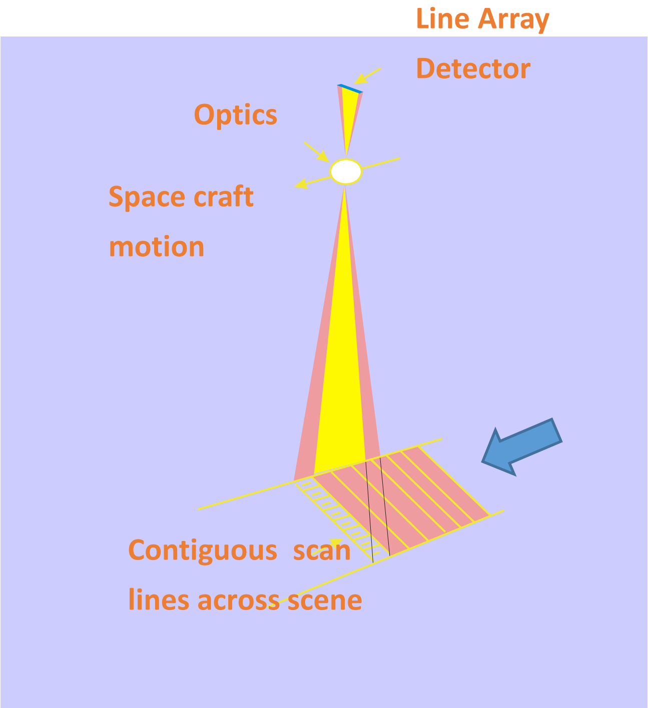
IMAGING SENSORS – TYPES OF SCANNING



AREA ARRAY



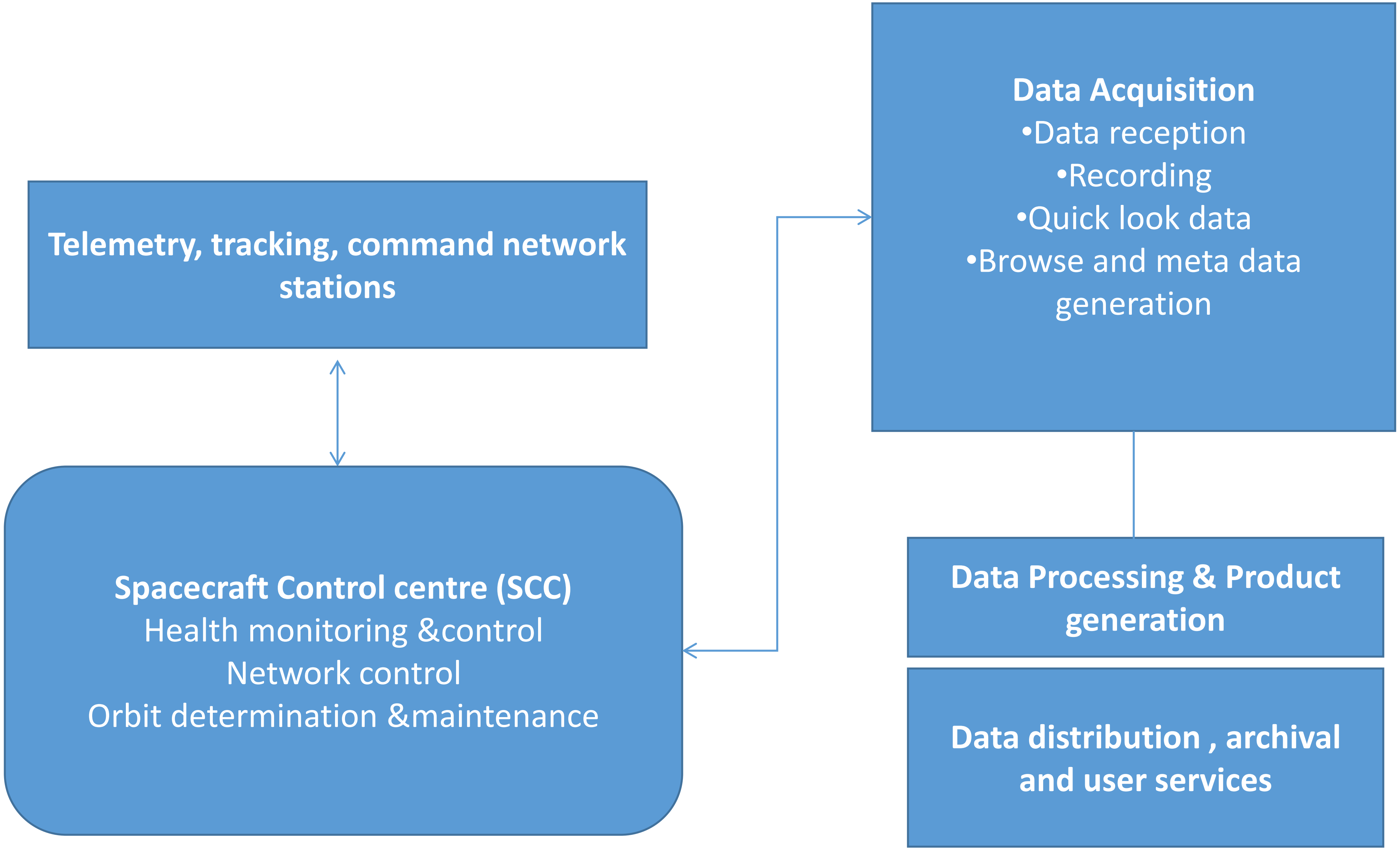
WHISK BROOM



PUSH BROOM

Push-broom Scanners using Charge Coupled Devices offer advantages like longer dwelling time (more signal), no moving parts (high reliability) and high geometric fidelity

Typical ground station functions



DATA RECEPTION AND PRE-PROCESSING

- Geometric Corrections
  - Earth rotation
  - Earth curvature
  - Platform attitude
  - Sensor alignments
- Radiometric Corrections
  - Sensor detector response variation
  - Non-uniform illumination

Johnson's criteria of interpretation

- Detection - an object is present: 2 +1/-0.5 pixels
- Orientation - symmetrical, asymmetric, horizontal or vertical: 2.8 +0.8/-0.4 pixels
- Recognition - the type object can be discerned, a person vs. a car: 8 +1.6/-0.4 pixels
- Identification - a specific object can be discerned, a woman vs. a man, the specific car: 12.8 +3.2/-2.8 pixels

  These measurements give a 50% probability of an observer discriminating an object to the specified level.

CONCEPT OF RESOLUTION

Quality of information derived from RS images strongly influenced by spatial, spectral, radiometric & temporal resolutions as well as by angular & polarimetric signatures

- **Spatial Resolution**

  instrument resolving power needed to spatially discriminate the smallest object

- **Spectral Resolution**

  encompasses the width of bands used from the wavelengths of the EM spectrum.

- **Radiometric Resolution**

  quantify No. of discernible signal levels in a band, {sensor's ability to discriminate radiance differences (NE$\Delta\rho$)}

- **Temporal Resolution**

  time interval between imaging collections over the same geographic location

Data Products

1. **Standard**
2. **Special (example merged products)**

Level 0 Uncorrected (raw data)
Level 1 Radiometrically corrected and geometrically corrected only for earth rotation (browse product)
Level 2 Both Radiometrically and geometrically corrected
Level 3 Special processing like precision processing using GCPs, merging, enhancement, ortho image using DEM (digital elevation model) etc after level 2 corrections

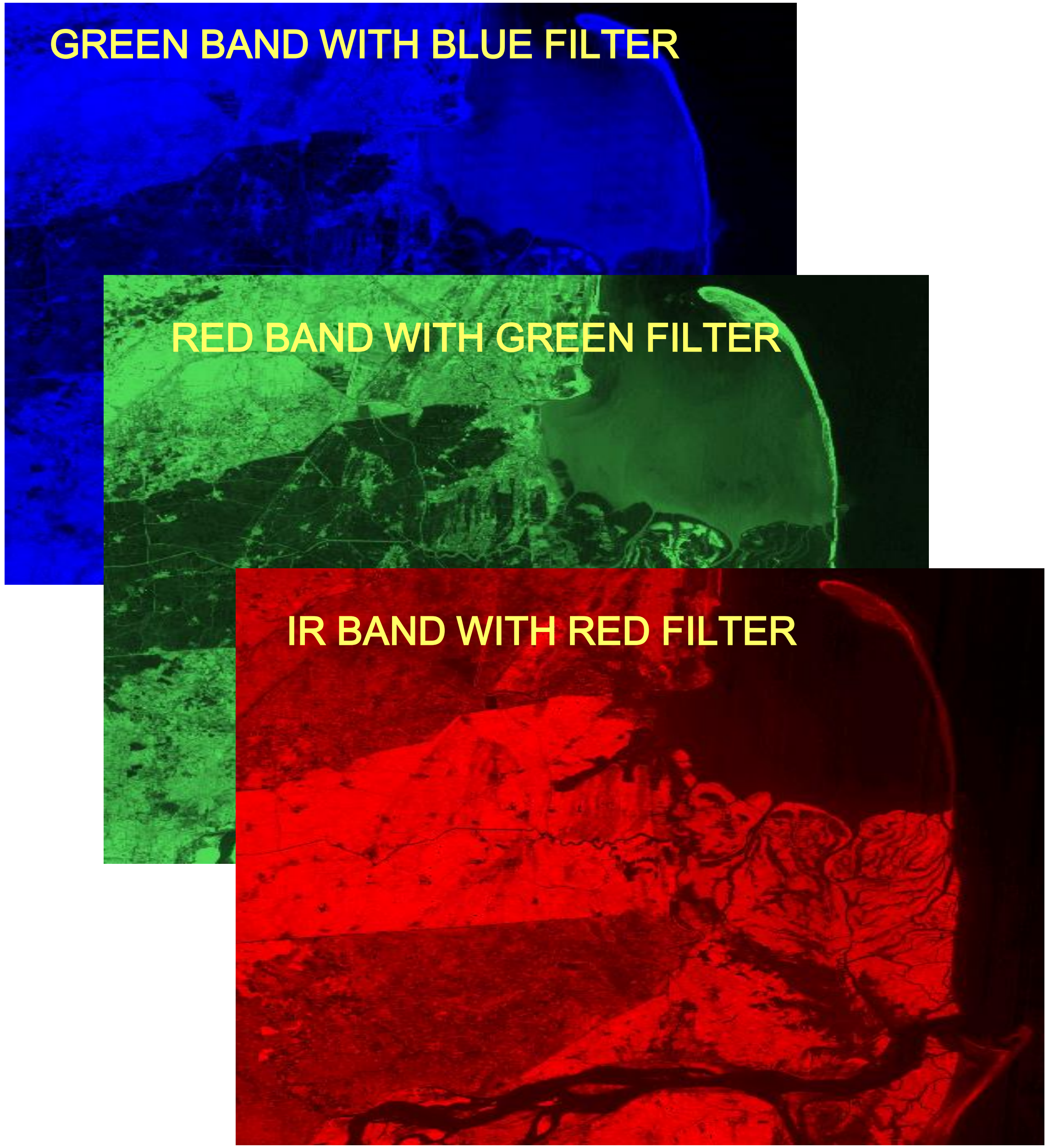
Image transforms

From images of two or three bands or two or three different time periods, create a new transformed image, whose pixels represent the ratio of the differences in pixel radiances of original images. Ratios of multiple bands can eliminate gain or bias errors. They can bring out features not discernible in original images

Principal Component transforms

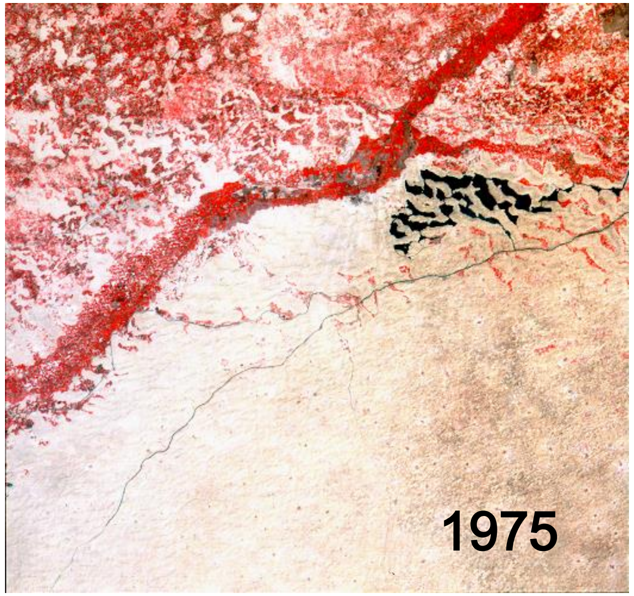
Multi spectral images often exhibit high correlation between spectral bands. When two data sets are perfectly correlated, then same information content in one set is available in the other set and hence second data set is redundant. Thus if there are n correlated spectral bands, PC transformation tries to reduce such redundancy in multi spectral data sets

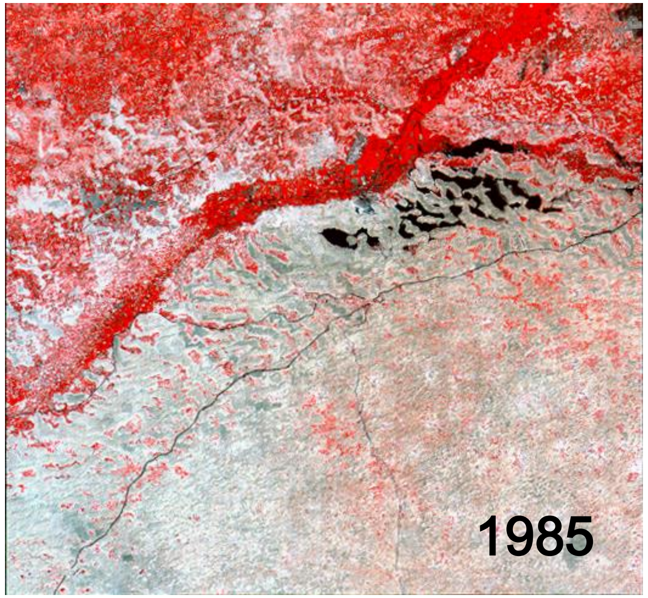
GENERATION OF FALSE COLOUR COMPOSITE

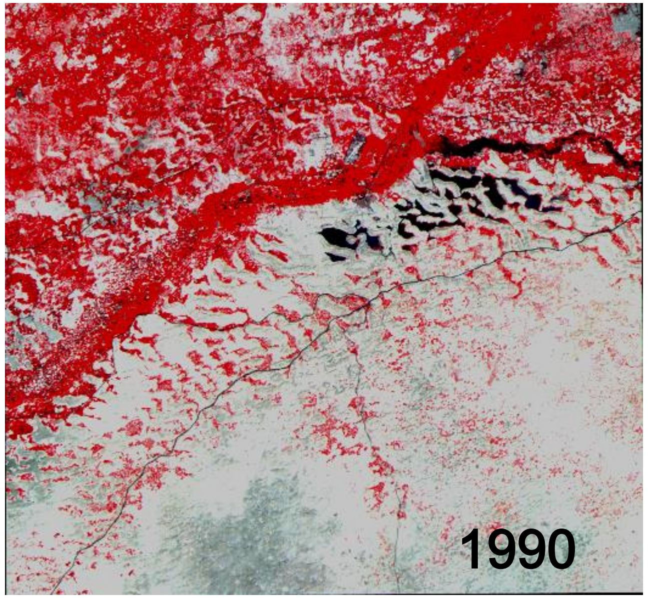


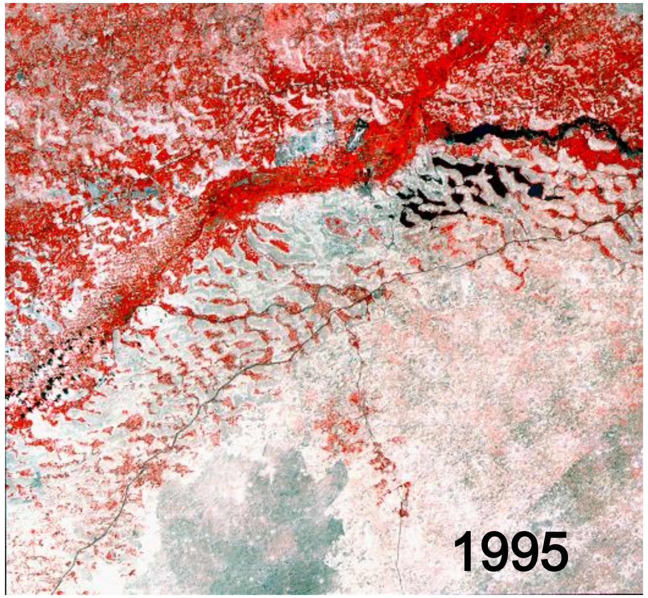
STANDARD FALSE COLOUR COMPOSITE

MULTI –TEMPORAL COVERAGE



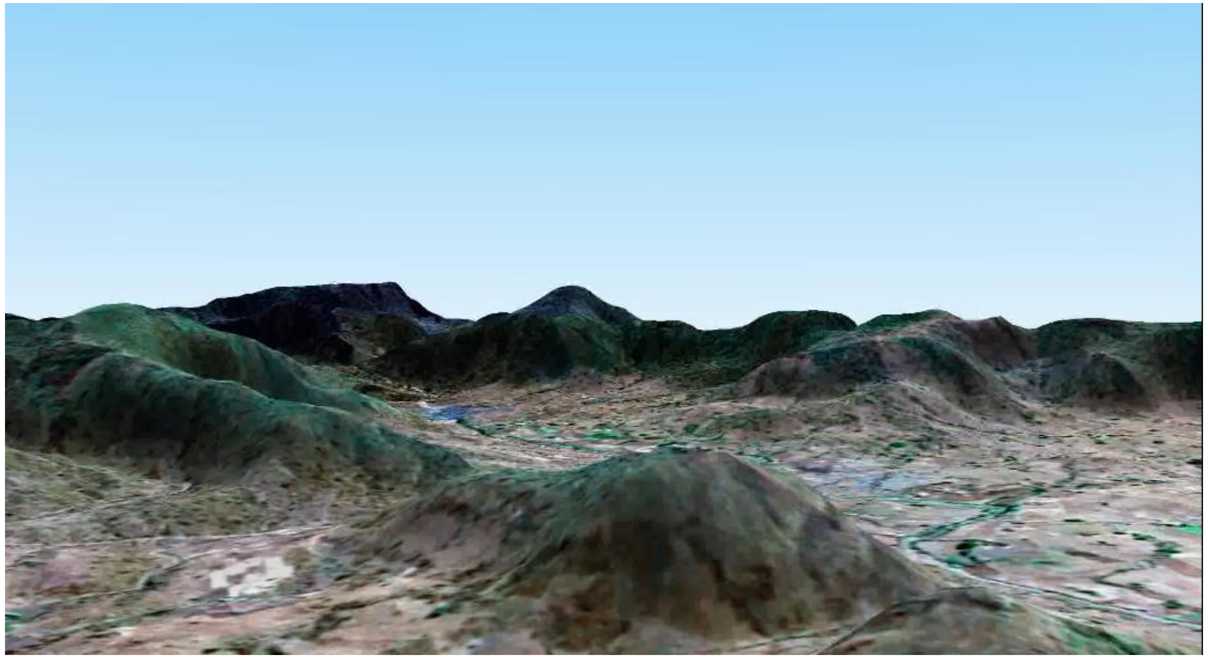


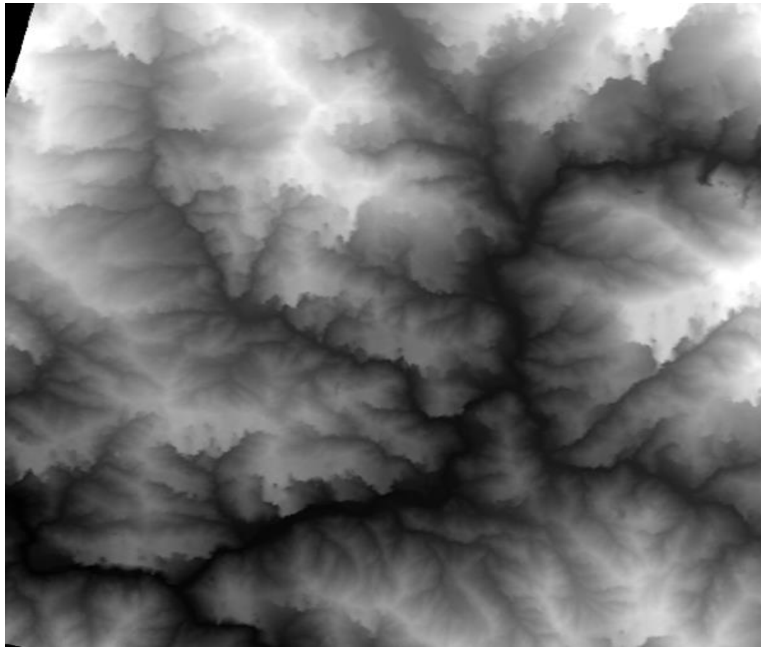


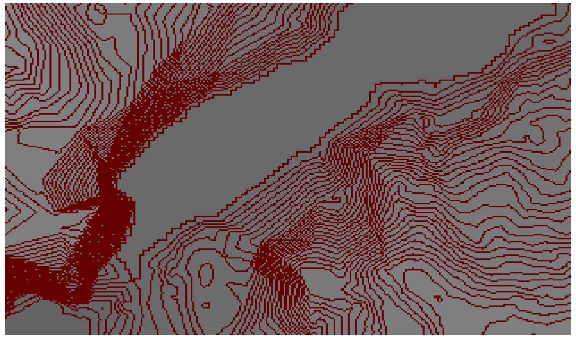


2.5m resolution stereo image from Cartosat-1- DEM draped.

DEM

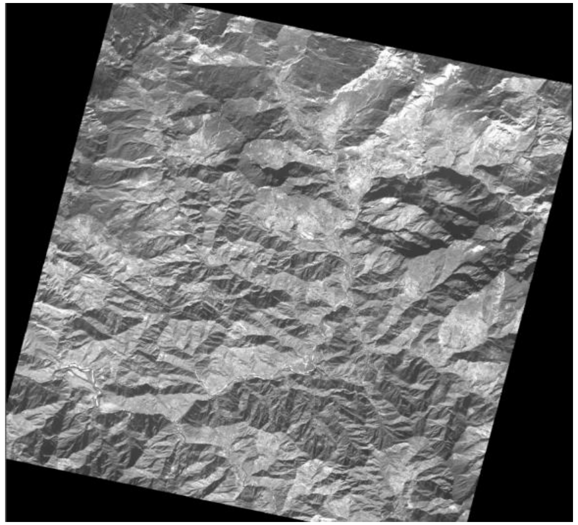






CONTOUR

ORTHO



Stereo imaging capability

Visual interpretation keys

Tone (colour)
Texture
Shape
Size
Shadow
Pattern
Site
Height
Association

Supervised classification

In supervised classification, the analyst based on prior information on the spectral characteristics of these classes, trains the computer to generate boundaries in the feature space within which each class should lie

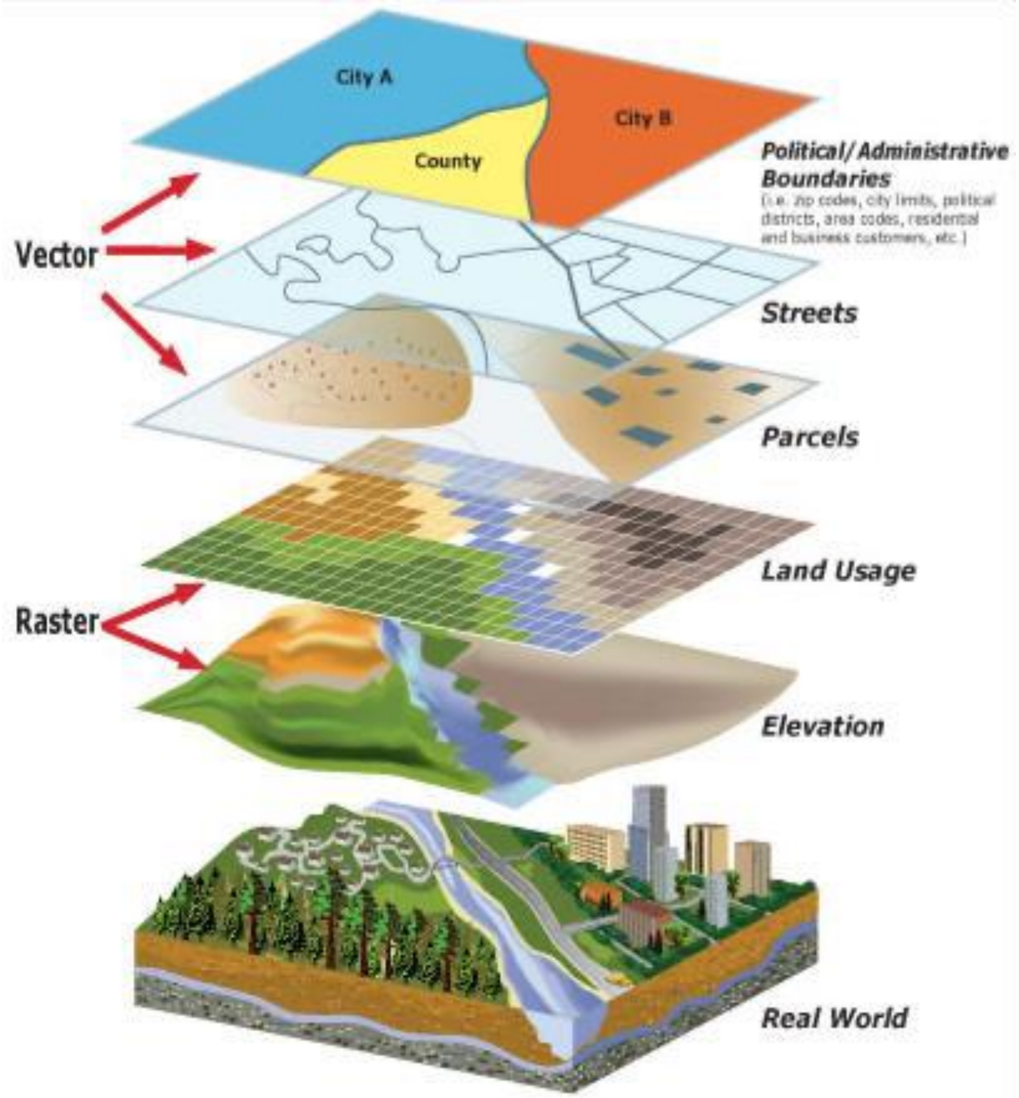
Geographical Information System (GIS)

Geographical Information System (GIS) is a system (of hardware /Software /data /applications/policies) that deals with spatially referenced and geographically tagged/linked data.

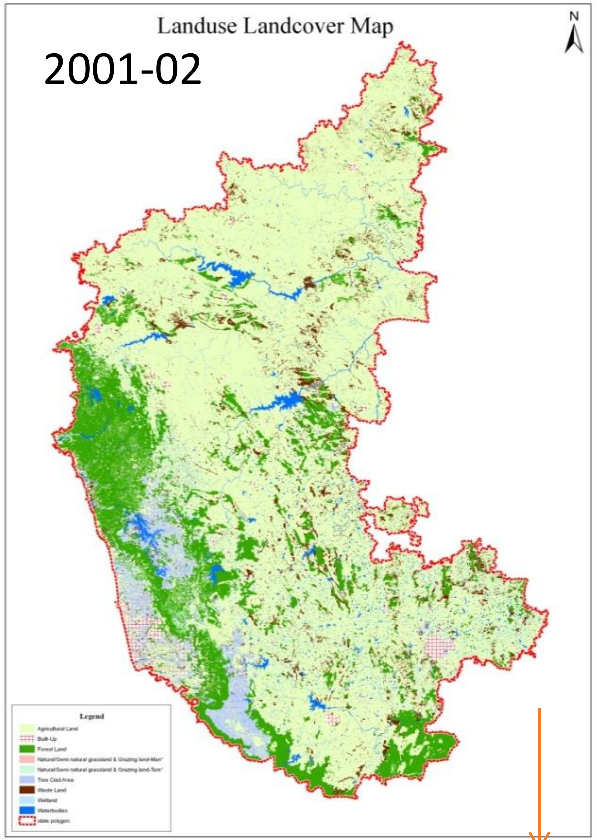
GIS allows analysis and integration of various map/image layers and geo-tagged tabular data to determine the spatial distribution, the relationship among various entities and the correlation of the variables in a geographic unit.

Further, the capability of GIS systems now allows creating map visualization of tabular data and making amenable the spatial or map representation of population data, migration data, consumer data, financial transactions, and beneficiary data and so on.

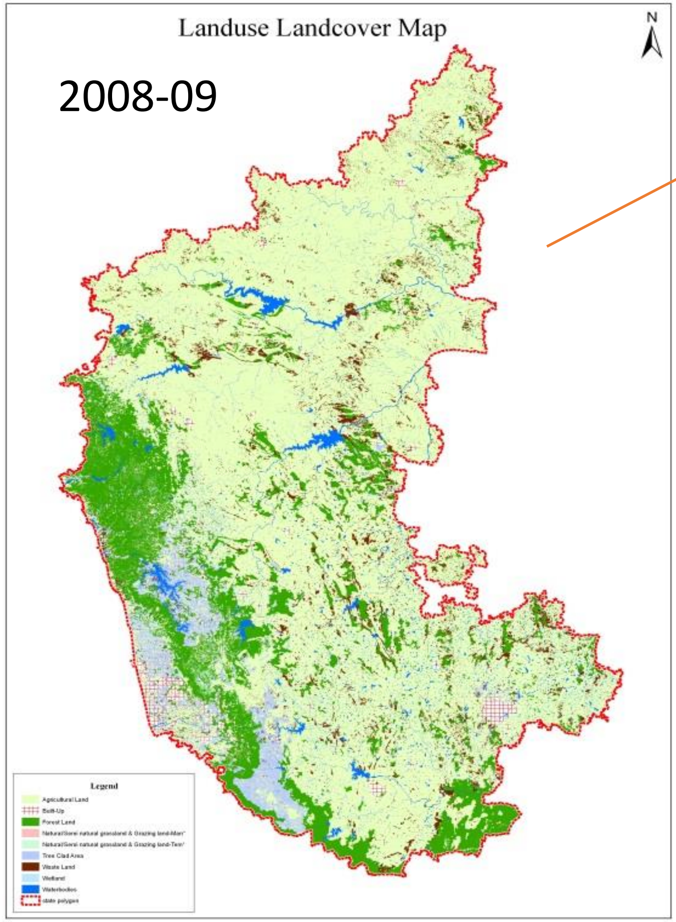
GIS components and concept



Example of GIS use: Land Use Status



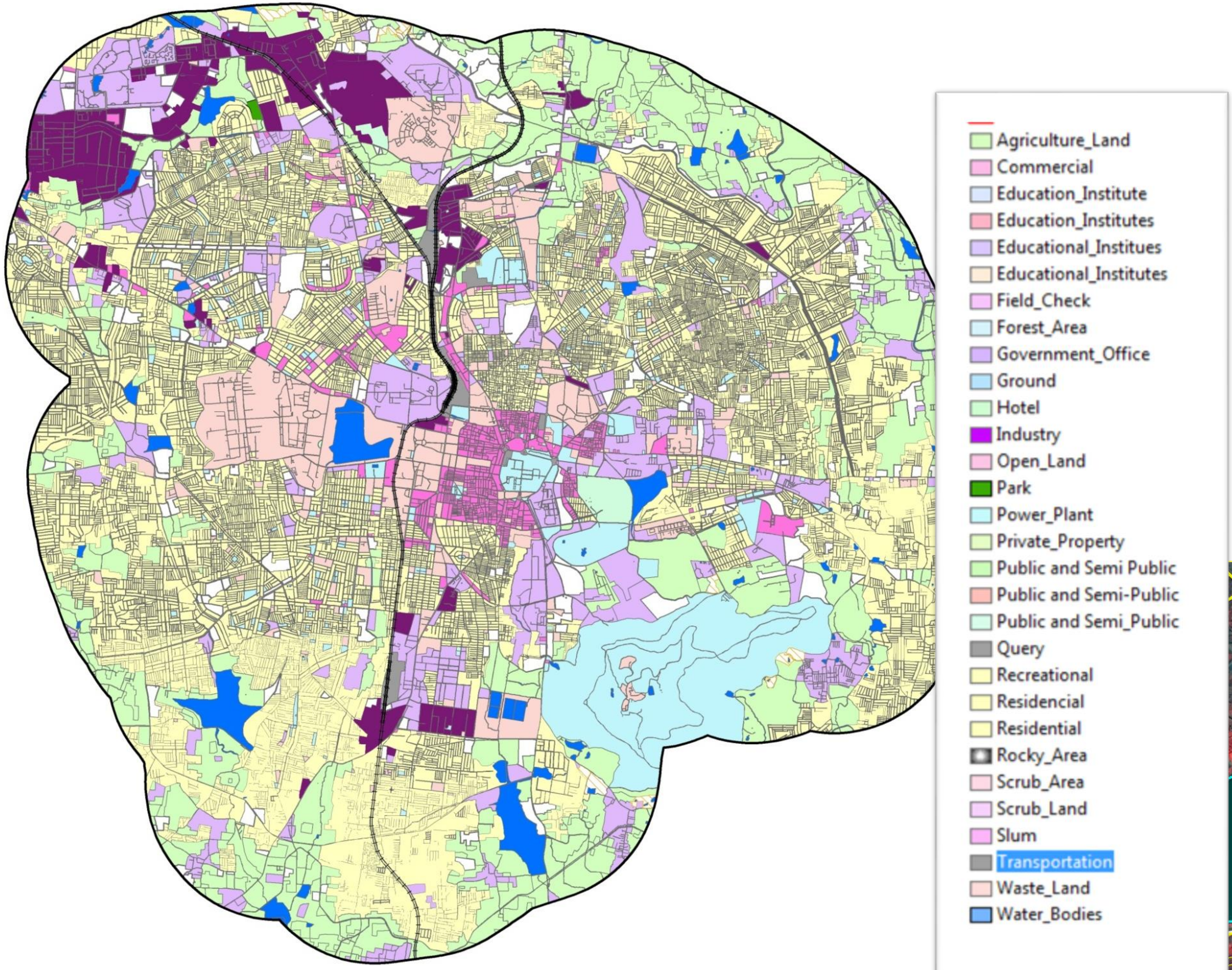
Agricultural land	130264.82
Built-up land	3480.32
Forest Cover	27391.95
Grassland / Grazing land	781.73
Others	10851.94
Wastelands	11831.66
Water Bodies	7154.62
Wetlands	35.84



Sl No	Description	Area in Sqkm
1	Agricultural Land	133191.42
2	Built-Up	5449.41
3	Forest Cover	29248.17
4	Natural/Semi natural grassland & Grazing land	636.55
5	Tree Clad Area	7413.86
6	Waste Land	8529.93
7	Waterbodies	7232.80
8	Wetland	86.12

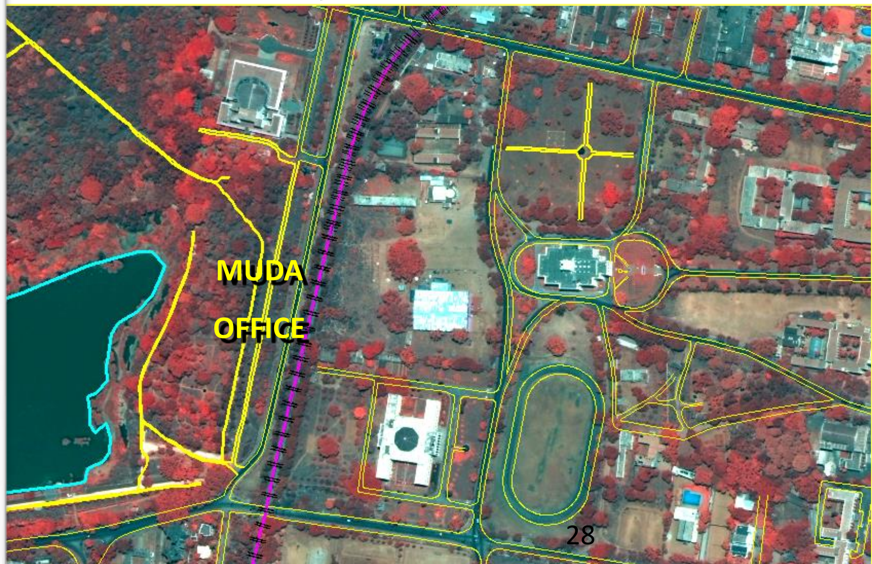
Courtesy: K-GIS WORKSHOP- JANUARY 23, 2013

CITY-GIS FOR MASTER PLANNING



Courtesy KSRSAC
K-GIS WORKSHOP-
JANUARY 23, 2013

SATELLITE IMAGE FOR UPDATING



Spatial data quality

- Spatial data---data about positions, attributes and relationships in space
- Cartographer’s traditional approach– produce best possible accurate maps
- Advances in database and digital technologies- multiple sources, greater content, linkages and higher speeds and greater visualisation
- Multiplicity/ remoteness of players in creation and use of spatial data
- TWO ISSUES:
  - Quality information is essential for user – to choose the data set
  - Computer rendering shows high accuracies- need for data quality information included in the data set.

Spatial data quality

- Foundation step: Adoption of ISO9000 international standard (ISO 1987)
- Tenet: Give no more quality or less quality than the customer requires
- Specification of spatial data quality:

Definition of elements of spatial data quality

Specification of spatial data quality

Presenting known data quality in visualisations

Spatial Data Quality

<u>Definition of spatial data quality- efforts in different parts of globe</u>

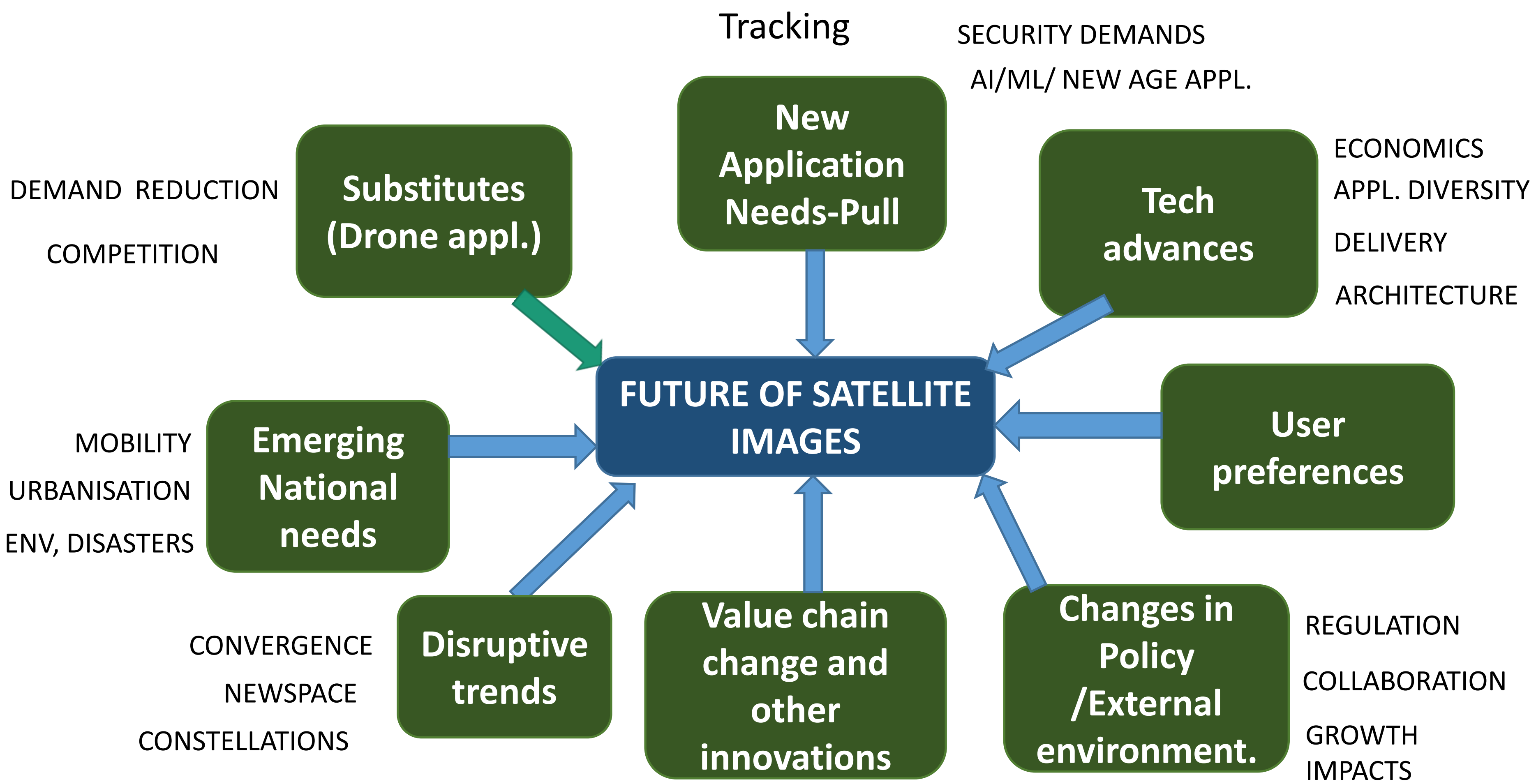
- USA- National Committee on Digital Cartographic Data Standards(NCDCDS) - Draft 1987
- User to decide fitness for purpose of use
- Reporting data quality
  - Lineage,
  - positional accuracy,
  - attribute accuracy,
  - logical consistency, and
  - completeness.
- Europe- *Comite Europeen de Normalisation Technical committee 287 (CEN/TC287) 1992*
- *Commission on Sp. Data Quality of Intl. Cartographic Assoc.*
  - Addition of 2 more elements– Semantic and Temporal (1995)

Is there some thing unique about satellite images?

- SYNOPTIC COVERAGE
- REPEATED OBSERVATION
- STEREO/ VIDEO COVERAGE
- MULTI SPECTRAL IMAGING/RADAR DATA
- INFORMATION IN SPATIAL DOMAIN
- CONSISTENT, SYSTEMATIC GLOBAL DATA SETS
- TIMELINESS AND ECONOMIC RATIONALE, LONG LIFE
- GLOBAL TO LOCAL APPLICATIONS

FREEDOM OF
ACCESS TO
SPACE

Future of Satellite Images – What factors drive it?



TRENDS

- More than 60 nations had acquired capacity for space based EO
- Over one decade in past, 1000 EO satellites are in orbit
- Ownership shift towards private EO systems, who make available the very high resolution EO images in global markets
- Blurring boundaries between commercial imaging satellites and defence satellites
- Development of hybrid procurement schemes, combining proprietary missions and data buy framework contracts, partly triggered by the budgetary constraints of public customers.

TRENDS – Contd..

- EO data becoming mainstay for many Geographical Information Systems (GIS) applications

- Converging EO, GIS and Positioning technologies, leading to many innovative applications, with timely and user friendly access to services

- Emergence of NewSpace enterprises - mostly financed by private venture capital, with the promise of **mass market applications** and creation of new markets with **disruptive pricing models.**

NewSpace is Disruptive

- NewSpace takes advantage of:
  - Advances in micro and nanosatellites,
  - Using Commercially-Off-The-Shelf (COTS) components
  - Bulk production processes, and,
  - Often adopting constellation approach to orbital deployment – enhanced throughput
  - Aim at provisioning data or services at revolutionary costs and never before achieved revisits

New Space EO…

- Least dependence on governments for financing.
- Reconfiguration of value chain which legacy system find it difficult to adapt.
- Converging into other larger industry and business segments in Information Technology enabled services using the power of Cloud technology, Artificial Intelligence and Machine Learning.
- An ensemble of several innovations that give power to NewSpace.

- New space trend involves not only start-ups but also big web actors with substantial investment capacity.

- Aim to transforming space into a commodity, taking benefit from the convergence between Information technology and EO.

- For Earth observation markets, target is high resolution and high revisit.

- EO Data Buckets in Big Data domain in a significant manner

New Space EO system examples

No	Private EO Missions	Observations
1	Planet (US)	300 dove constellation; <20kgs each – 3m and 90 cms; Daily Earth coverage
2	Urthecast (US)	ISS based payloads; Deimos OptiSar (670/1400kg) combination; 1m SAR and optical data; Spot-scan coverage
3	Jilin (China)	60 satellites (~100-200kgs); 72cm imaging and UHD video; aims for all-weather data
4	Satellogic (Arg.)	~300 (when complete) smallsats (~35kgs); 1m XS and 2-hourly revisit
5	AstroDigital (US)	25+ smallsats (~10-20 kgs); 2.5m GSD; Daily coverage of Earth
6	NOVASAR (UK)	SAR satellites (~400kgs); SAR strip; 6m S-Band SAR small strips

Quantum leaps in onboard technologies

- Processor speeds up by million times in 40 years

- Storage capacity up from typical 10 GB (late 1990's) to 8 TB (2010)

- Solar power generators 100$/watt (1970) to 5 $/Watt (2010)----Inflatable lightweight arrays

- Data transmission..X-band upto 1Gbps;
- With Adaptive Coding and Modulation… 1 TB per day;
- Higher bandwidth through use of 26 GHz band link;
- LEO-GEO- High Altitude Platform- Ground link using optical communications, upto 76 Tb per day possible.

Quantum leaps in onboard technologies

- Advent of Agile satellites for spot imaging

Example: Pleiades Agility for roll or pitch 60 degrees in 25 secs

- Improvement of specific energy densities from 40Wh/Kg (Ni Hydride) to >100 Wh/Kg (Lithium Ion)

- Synthetic Aperture Radar

From 8m resolution (RADARSAT,1995) to 1 m (TerraSAR-X, 2007) and even 25 cm resolution in *staring spot light* mode

Satellite's overall platform technologies

Legacy

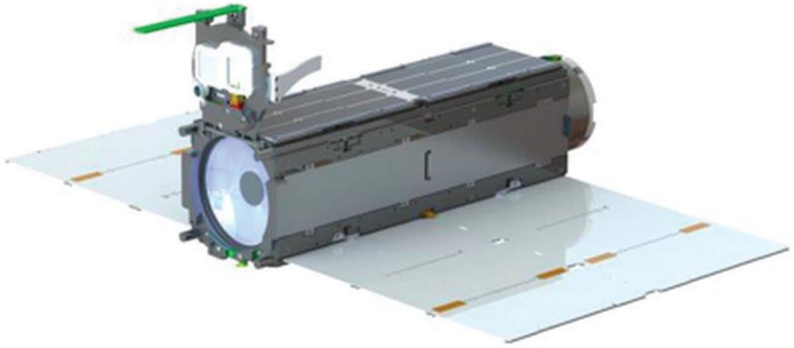
Landsat 8

image: usgs.gov

Mass 2071 Kg.
9 Visible+ 2 IR bands,
15m & 30m resolution
12 bit radiometry
Global coverage: 16 days
3.14 Tb onboard memory
Cost: 855 mi USD
Down link: 384 Mbps

NewSpace

Planet Lab's Dove



5Kg mass;
3-5m resolution, 3 bands;
29 MP CCD detector;
One Global image set per day with the full constellation deployed,
200Mbps data downlink

India’s EO Programme- Sensor Epochs

IRS 1A (1988)	**CCD based 4-band MS camera (3 #), 72m & 36m resolution (LISS 1&2)**
INSAT 2A (1993)	Very High Resolution Radiometer (2.75 km Visible/11km thermal IR)
IRS- 1C (1995)	LISS-3 (23.6m), PAN CAMERA (<6m), WiFS (189m), SWIR band
Oceansat-1 (1999)	Ocean Color Monitor (8 band, 360m) Multi band Scanning Microwave Radiometer (MSMR)
TES (2001)	1 meter resolution , Step and stare imaging
INSAT 3A (2003) Resourcesat 1 (2003)	Improved VHRR (2 km VIS band /8 km W V /8km Ther. IR), CCD Camera LISS 4 (5 m MS) Advanced WiFs
Cartosat-1 (2005)	2.5m Fore & Aft cameras (In track stereo), Global DEM sets
Cartosat 2 (2007, 16)	Operational HR <1m resolution, HR colour, Step & Stare
Oceansat-2 (2009)	Ocean Colour Monitor (OCM), Scatterometer and ROSA payloads
Resourcesat 2 (2011)	LISS 4 (5m MS, 10 bit, 70km swath), AWiFS (12 bits), 200 GB Memory
Megha-tropiques (2011)	ISRO-CNES mission - MADRAS microwave radiometer, SAPHIR humidity profiler , SCARAB Radiation budget instrument
RISAT 1 (2012)	Synthetic Aperture Radar Payload
INSAT 3D (2013)	6 Channel Imager & 19 Channel Sounder
SARAL(2013)	: Ka band Altimeter

Indian High resolution systems

Parameter/ Sensor name	TES	Carto sat-2, 2A, 2B	Cartosat-2C, 2D, 2E		Cartosat-3, 3A, 3B		
	PAN	PAN	PAN	MX	PAN	MX	HySI
Spectral range(μ)	0.5 – 0.85	0.5 – 0.85	0.45 – 0.9	0.45 – 0.86	0.45 – 0.9	0.45 – 0.86	0.4 – 2.5
Channels	1	1	1	4	1	4	>200
Resolution (m)	1	0.8	0.65	2	0.25	1	12
Swath(km)	16	10	10	10	16	16	5
Quantization	7	10	11	11	11	11	11

Source: N N R M S B U L L E T I N - M A R C H 2 0 1 3

Developments in Microwave sensors

Day & Night, all weather imaging/ measurement

Multi-band passive microwave radiometers
Alti meters
Synthetic Aperture Radars
Scatterometers

Laser instruments
LiDARs
Terrain mappers

IMPACT OF "COTS " APPROACH TO CAMERA

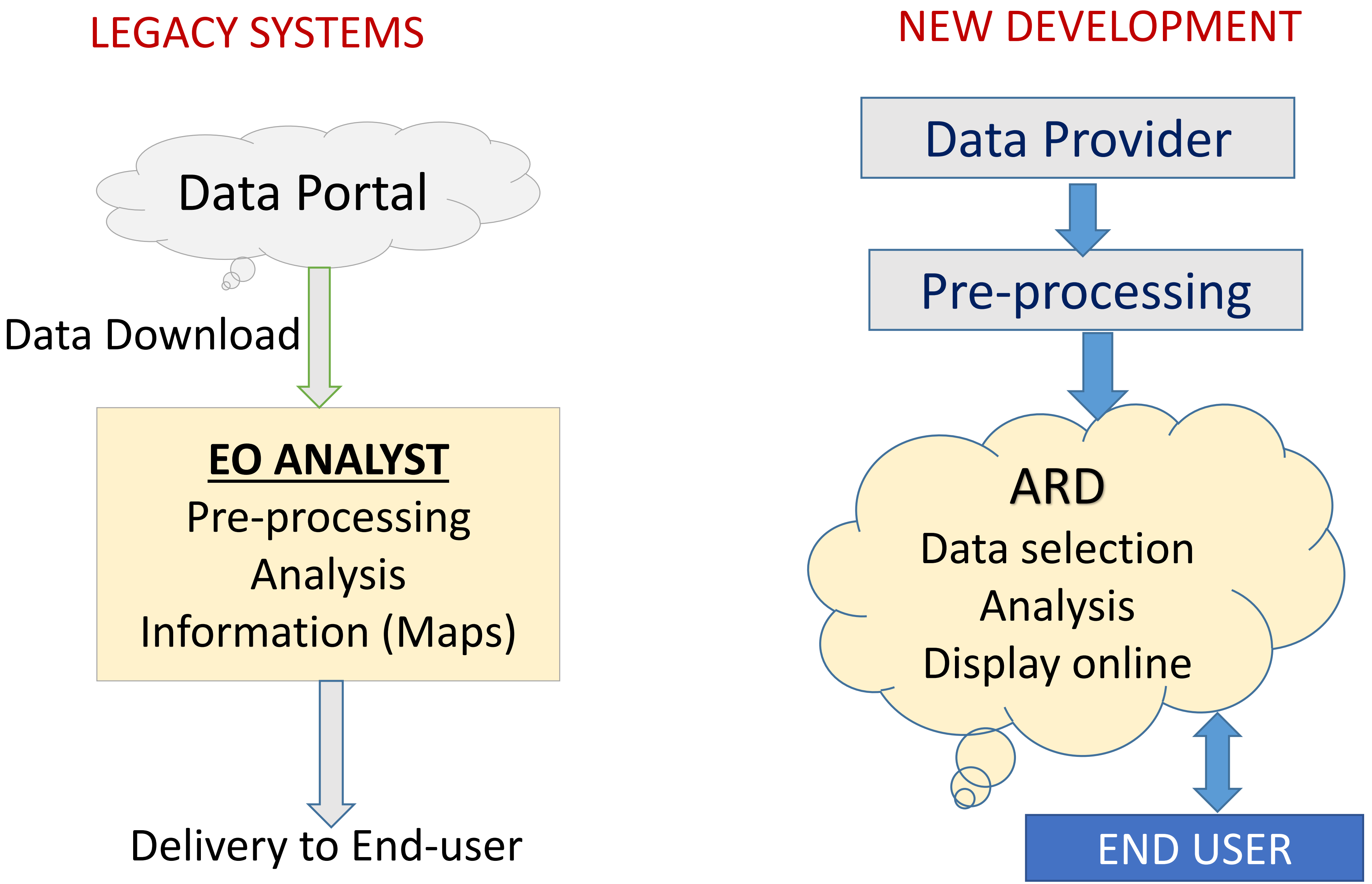
LISS III SENSOR
(RESOURCESAT)

Medium Resolution
4 bands
23 meter spatial res.
70W power
140 km swath
106 Kg

CUBESAT Camera

High resolution image & video
5m spatial resolution
3388 x 2712 pixel frame (9MP)
5.1 w power, 398 gram
Model: Imperx B 3412 DX
Mirror
Optics SY: 500mm f/6.3

Data access and Data Processing



Managed Ground Segments

- Availability of fully managed ground station as a service, as available through AWS ground stations

- facilitate users to undertake tasking, commanding, downlinking and processing of satellite data in cloud and distribute them.

- Integration of EO data into cloud based services such as AWS enables easy scaling of satellite operations by the user rapidly and cost effectively on the basis of the extent of usage.

Overview of portals for Big Earth data.

Download, Upload and processing online

Name	Data Structure	Data availability
Google Earth Engine	2D gridded raster bands	Satellite Imagery; Satellite-derived data products (Landsat, MODIS, Sentinel). Programming Env.(IDE)
Amazon Web Services	Image files	Satellite Imagery; Satellite-derived products (Landsat, Copernicus &MODIS, and DEMs)
Earth Server	Data cube	Satellite Imagery; Satellite-derived data products; Model outputs
EODC (water resource monitor)	Image files	Satellite Imagery; Satellite-derived products (EO/GIS users) (Copernicus)
Swiss Data Cube	Data cube	Satellite Imagery; Satellite-derived products
Digital Earth Australia	Data cube	Satellite Imagery
CODE-DE (Germany..)	Image files	Sentinel Imagery -Copernicus services

Data download porta

Name	Data Structure	Data Availability
NSIDC (Snow & Ice data)	Raster, Point, Vector data	In-situ data sets; Model Outputs; Satellite derived data products (soil moisture..)
EUMETSAT	Image Files	Satellite Imagery; Satellite derived data products
Earth Explorer (USGS)	Image files	Satellite Imagery; UAS Imagery, Data products, Digital Maps
Copernicus Open Access Hub	Image files	Satellite Imagery
PEPS (French)	Image files	Satellite Imagery, Copernicus ..

Download & upload

PANGEA (Environ. Science)	Raster, Point, Vector data	Model Outputs; Satellite derived data products

Other notable user resources

- NASA Sensor Web Suite – software tools for access, process and analysis of data
- For Landsat products—Earth explorer, GloVis and LandsatLook Viewer
- DIAS- Copernicus Data and Information Access Services

REFERENCE ON BIG EARTH DATA MANAGEMENT:

Martin Sudmanns, Dirk Tiede, Stefan Lang, Helena Bergstedt, Georg Trost, Hannah Augustin, Andrea Baraldi & Thomas Blaschke (2019): Big Earth data: disruptive changes in Earth observation data management and analysis?, International Journal of Digital Earth, DOI: 10.1080/17538947.2019.1585976--

Bhuvan Geo-portal

Geo spatial services

- IRS data hosting for visualisation (1m or coarser)
- Free down load of Resourcesat data (more than 2 year old)
- Satellite derived products
- Project / theme specific database information and visualisation
  - Natural Resource Census
  - Agriculture
  - Forestry & environment
  - Rural development
  - Water resources
  - Geo sciences
  - Urban & infrastructure
  - Ocean sciences and atmosphere
  - Disaster Management support
- Mobile applications

bhuvan.nrsc.gov.in/bhuvan_links.php#

bhuvan

Indian Geo-Platform of ISRO

National Remote Sensing Centre

NRSC | Search | Bhuvan Store | Bhuvan Collabora

------------ *Visualisation & Free Download* ------------

Bhuvan-2D | **Bhuvan-3D** | **Open Data Archive** *Free Download* | **Climate & Environment** *EO derived Products*

------------ *Maps & OGC services* ------------

Thematic Services | **Disaster Management Support Services** | **Ocean Services** | **Create a Map / GIS** *My Map | My GIS*

Governance/Central Ministries   g-Governance Dashboard

nment & rest | ENVIS | CRIS | Flycatchers Distribution | Island Information | School Bhuvan | Toll Information | Ground Water

Application Sectors

Collaborative applications - Platform to share your data and create governance applications

Agriculture | Forestry | E-Governance | Water | Tourism | Urban | Rural

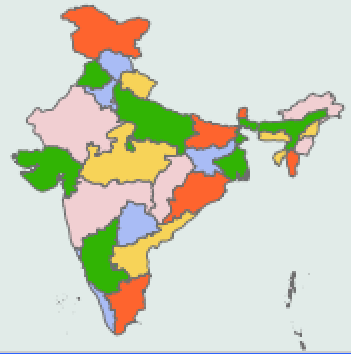
Rural

Ground Water | Watersheds | MGNREGA

Special Applications

Data Discovery | Decision Support Dashboard | Hydrological Products | Image Gallery

State Portals/Applications (Click on any State)



State: ANDHRA PRADESH

Andhra Pradesh | Asset Mapping

Visit State Portal of ANDHRA PRADESH

Updates | **Download**

- Updation of Orthorectified AWiFS and LISS-3 datasets in NOEDA Portal New
- Release of Telangana Forest Portal New
- Release of Punjab Forest Portal New
- Visualization of IMD Weather Products
- Visualization of Weather Climate Environment Modelled Products
- g-Governance: Dashboard

Emerging India – New Paradigms

Needs of New Technological Regime

- ❑ *Transparency of governance*
- ❑ *Paths for inclusivity in society*
- ❑ *Empowering enterprise*
- ❑ *Guaranteed public delivery*
- ❑ *Total Quality Management*
- ❑ *Citizens' participation*

- **INDIA …A VIBRANT, GROWING, KNOWLEDGABLE AND ASPIRATIONAL SOCIETY:**
  - **1.4 B POPULATION – Educational challenge**
  - **>50% POPULATION below 30 years**
  - **PRESENT ~3.4 TRILLION $ ECONOMY**

Vastly New Approaches Needed

- **590 million in urban areas, 7400 km Metros/subways, 68 cities, >1million population, new skills and employment**
- **Vast changes in land use pattern, shrinking per capita agricultural land**
- **Climate change effects, severe weather events-precipitation, storm surges, agricultural yields.**
- **Water demand gap ~ 40%**
- **Evolving demands on national security**

LAWS, POLICIES, PLANS …….. WILL PLAY AN INCREASING ROLE

APPLICATIONS DRIVERS

Monitoring Agriculture – crop areas, crop health and yield estimates

Water resource mapping, ground water targeting, water pollution monitoring, fisheries information

Environmental impact assessments, and environment monitoring, weather observations, cyclone tracking, Forestry applications

Cartography and Mapping applications- digital elevation models,
Asset mapping, and mobile assets tracking, Urban applications,
Land use and land cover changes
Information support for decentralised planning
Monitoring Disasters, warning and assessment of damages

Monitoring infringement of Laws – encroachments of forest lands, illegal mining, infringement of coastal zone regulations etc.

Market opportunities for EO in India

Needs

Education, Health, Mobility, Infrastructure development and Commercial services.

Demands for services

GIS based decision support systems, mobile multimedia, positioning and navigation services, disaster management support, rural connectivity and national security

National Missions

Digital India, Make in India, Smart City, Swach Bharat, National Education Mission and National Skill Mission programmes

Future data market potential IR 5 bi.
Value added market for info/solutions IR 60 bi

SATELLITE IMAGES & EO DATA – GLOBAL RELEVANCE

Satellite data/ observations playing key role in major international framework initiatives:

International Global Observing Strategy (IGOS)

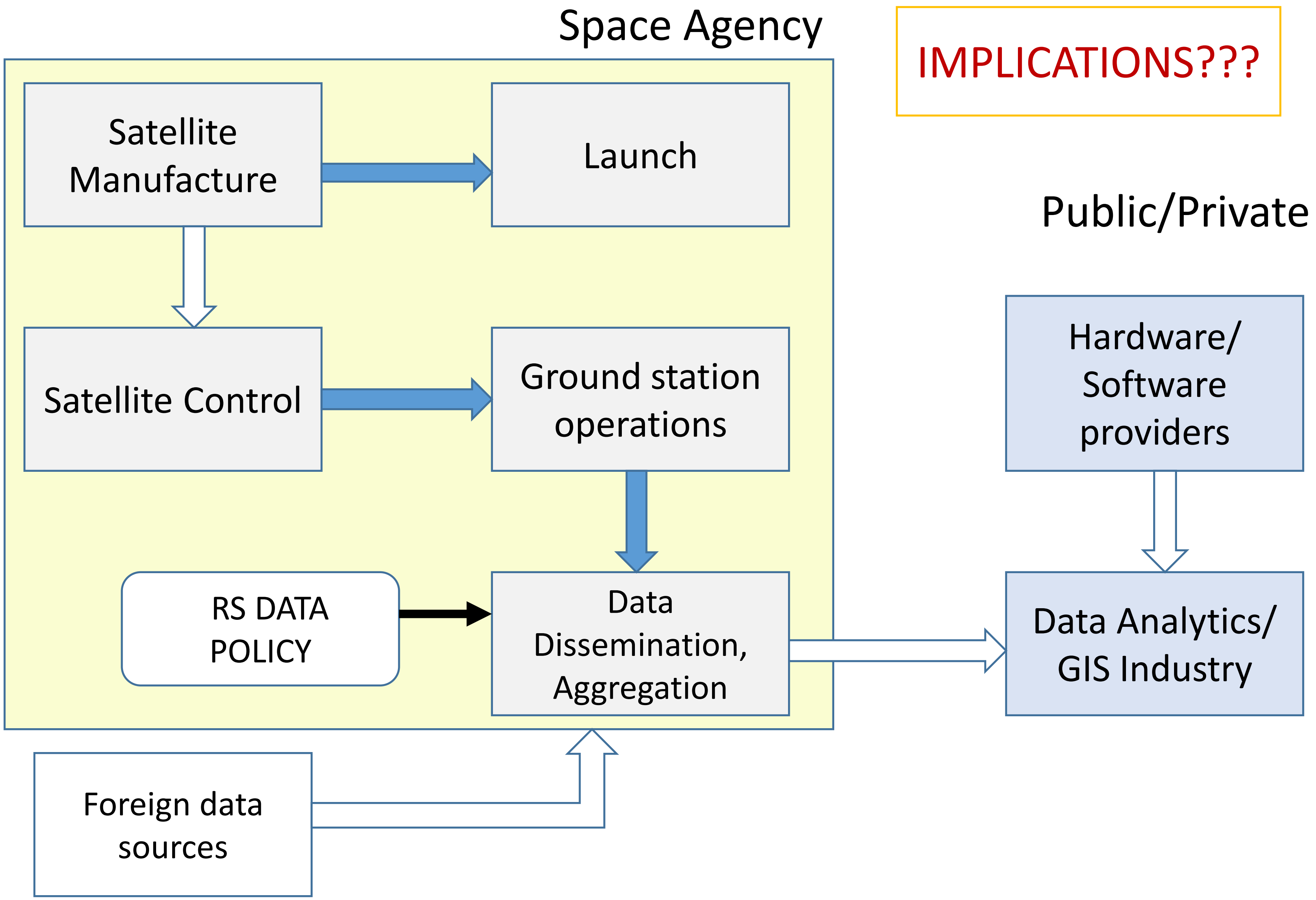
United Nations Sustainable Development Goals

Sendai framework for Disaster Reduction

Paris Agreement on Climate Change

New Urban Agenda

EO – past organisational architecture in India



Future of Satellite images???

- Real-time on demand imaging service
- Information or service centric shifts
- Converging with main stream sectors
- Tackling societal issues important
- Commoditisation and ubiquity, wider use
- Growth of security demands & Drones role
- Cyber and data security and privacy issues

Thanking You

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