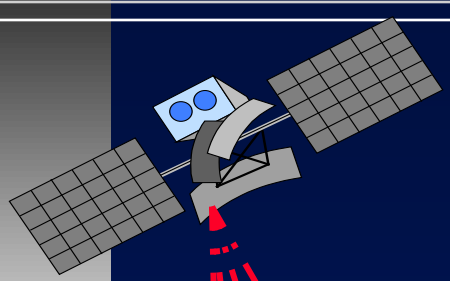
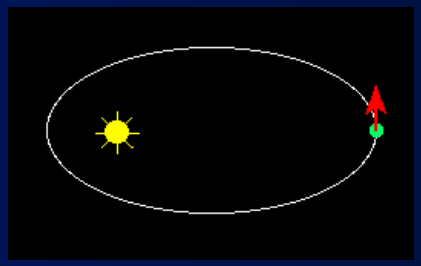


Satellites & Sensors



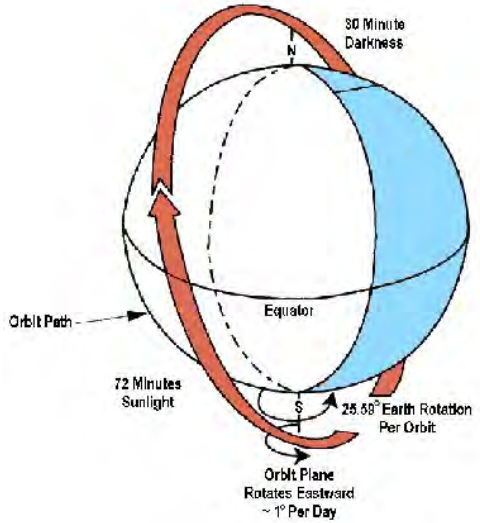
Dr. R.N. Sankhua

Polar satellites

- 800 km.
- 99° relative to the Equator
- S-N during *ascending leg* & N-S during *descending leg*
- Each orbit 100 minutes
- 14 orbits a day.

Sun-Synchronous

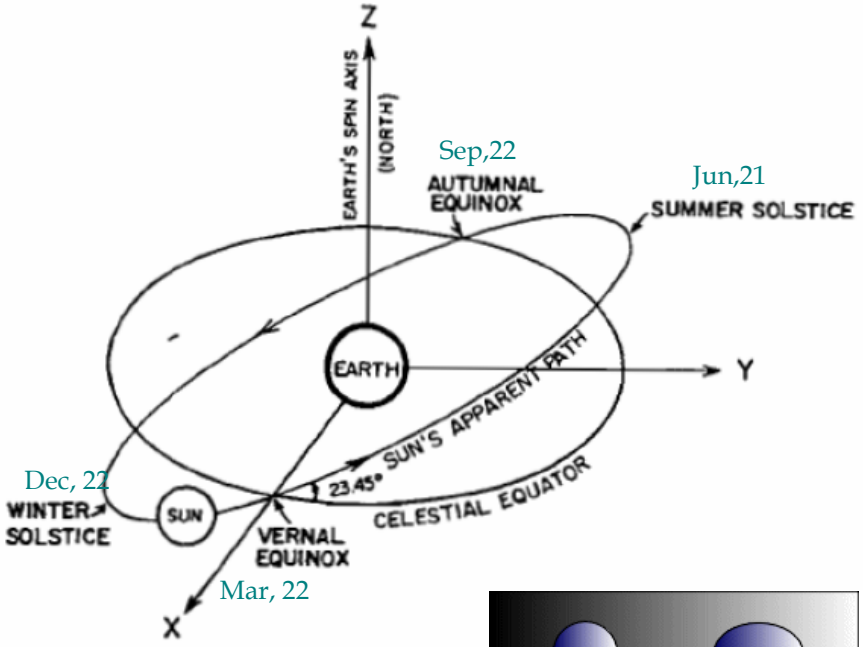
provides consistent lighting of Earth-scan view.
satellite passes the equator and each latitude at same time each day.
keep pace with the Earth's revolution around sun

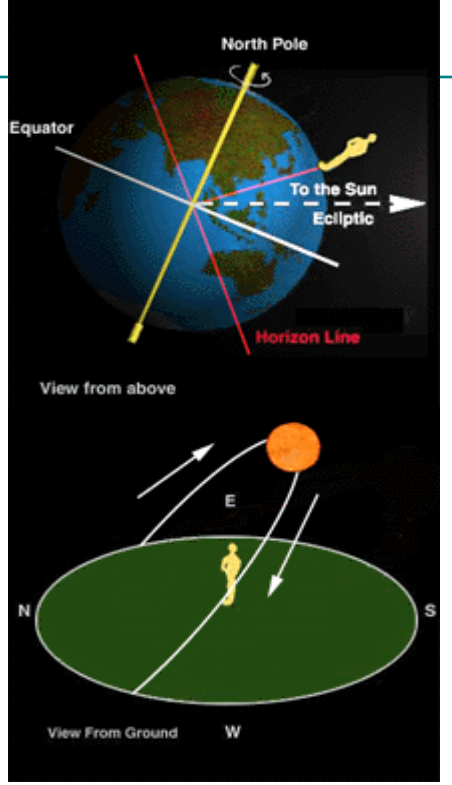


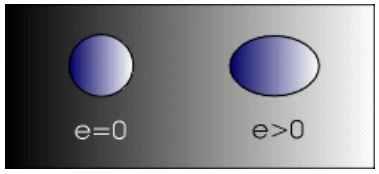
Geostationary satellites

- 35,800 kms
- speed that matches Earth's rotation
- same position relative to Earth & views same area
- covering large areas of Earth
- useful for monitoring impending weather systems
- Track movement of storms over long distances.
- position at Equator, no coverage of polar regions

Satellites

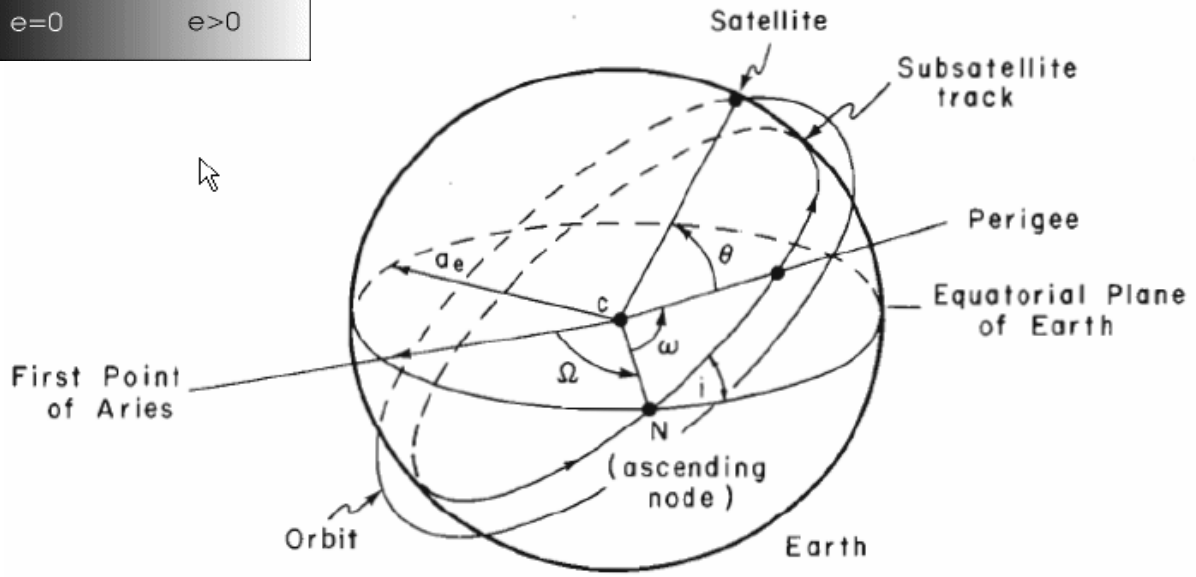




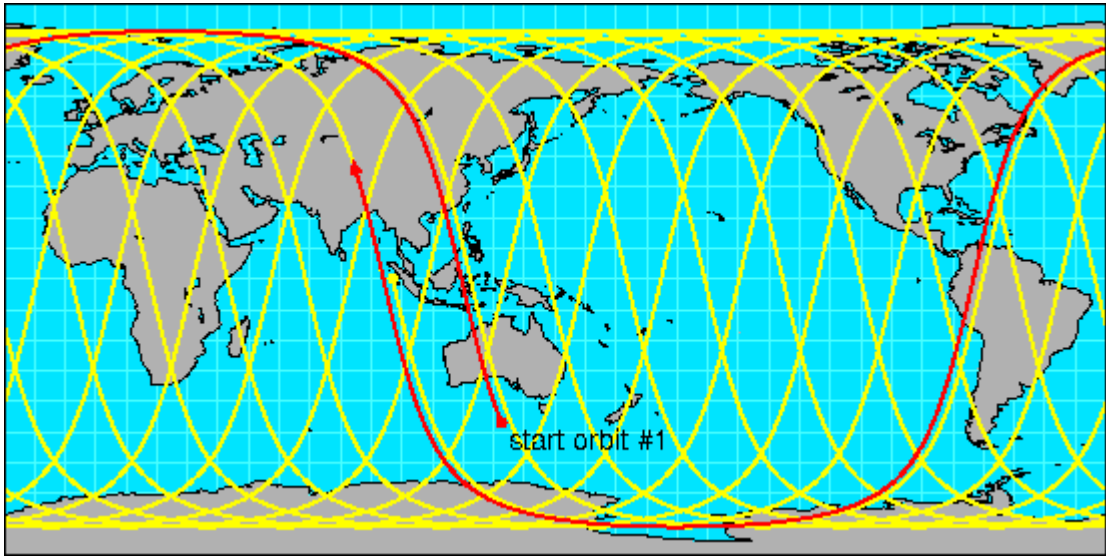


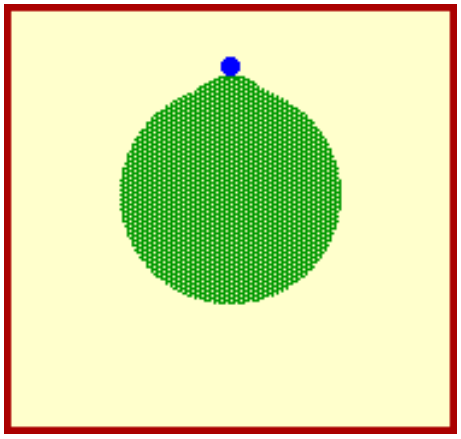
Prograde

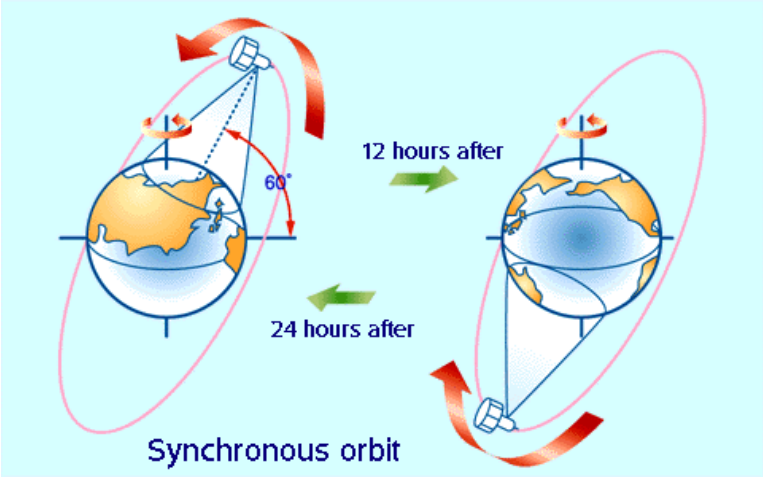
Retrograde



Satellites


start orbit #1



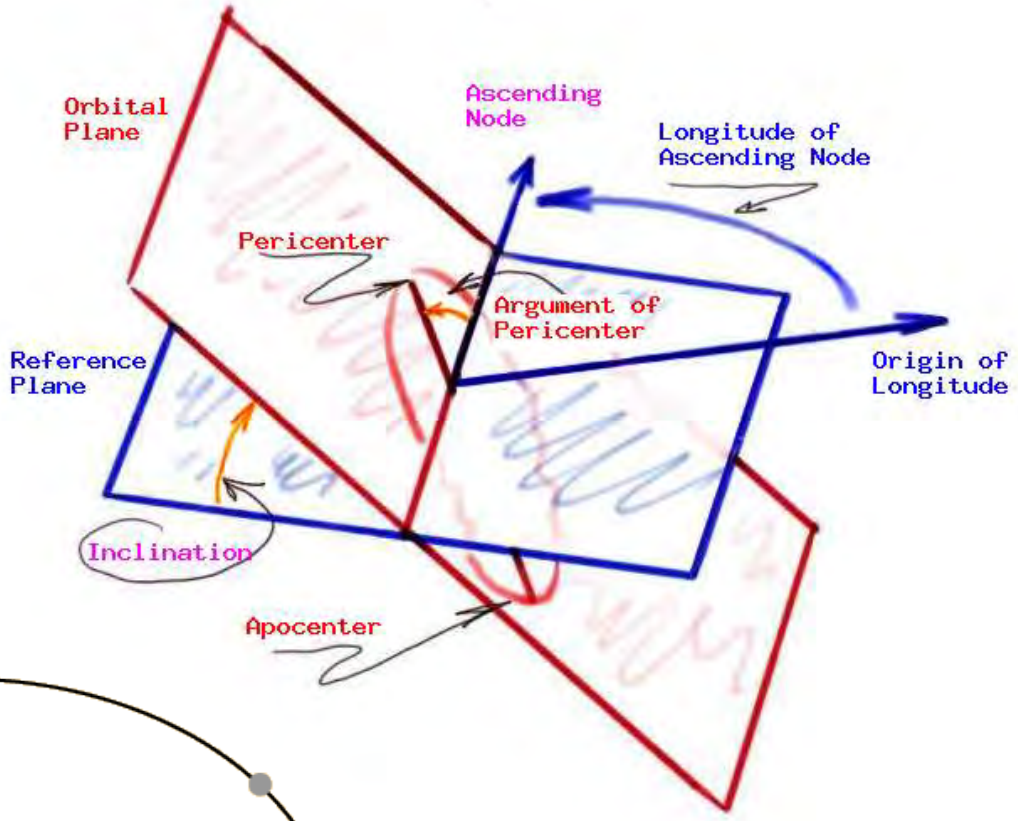

12 hours after
60°
24 hours after
Synchronous orbit

Orbital parameters

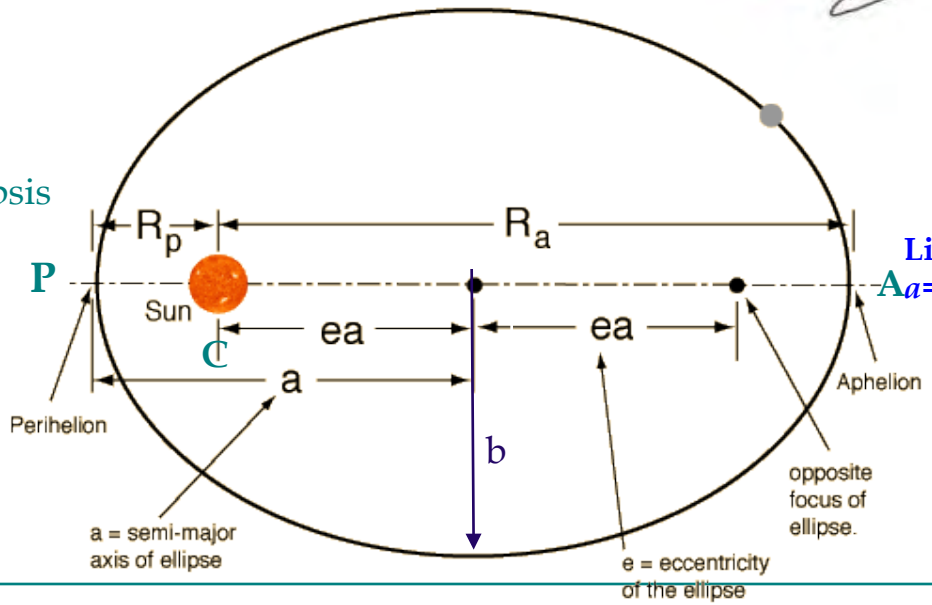
$$e = \mathrm{sqrt}(1 - \frac{b^2}{a^2})$$

$$a = semimajor\ \ axis$$

$$b = Semi\ \mathrm{min}\ or\ \ axis$$



Perigee, periapsis or perifocus



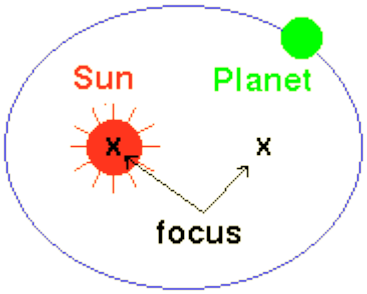
Line of Apsides - line betwn AC&PC

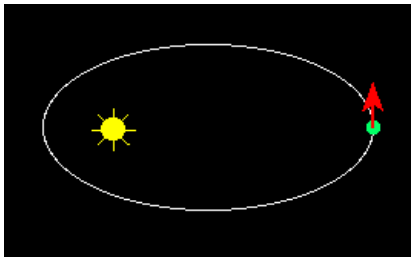
***a*= ½ (*pericenter* distance + *apocenter* distance)**

$R_a = a(1+e)$ $R_p = a(1-e)$

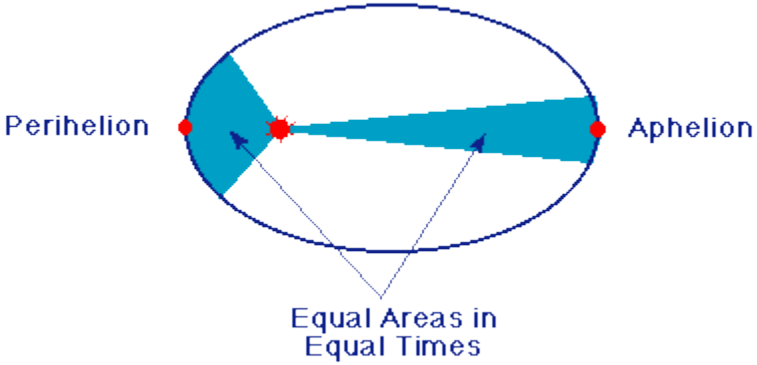
Laws of satellite motion

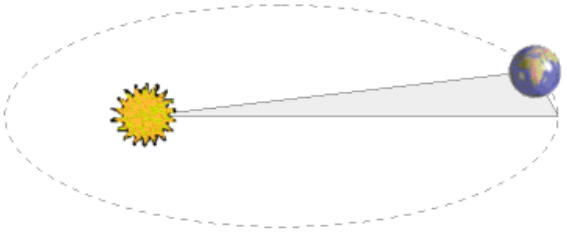
Law of Orbits: All satellites move in elliptical orbits, with the earth at one focus.





Law of Areas: A line that connects a satellite to earth sweeps out equal areas in equal times.





Law of Periods: square of the period of any planet is proportional to cube of semimajor axis of its orbit

$$T^2 = \frac{4\pi^2}{GM} a^3$$

$$\frac{P_1^2}{P_2^2} = \frac{R_1^3}{R_2^3}$$

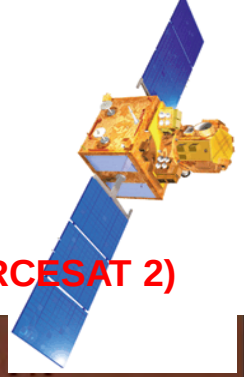
Earth Observation Satellites

IRS SERIES

IMAGING IMPROVEMENTS
- 1KM TO 0.46 M RESOLUTION

GLOBAL COVERAGE

APPLICATION-SPECIFIC



IRS 1A&1B

IRS P2

IRS P3

IRS 1C

IRS 1D

IRS P4 OCEANSAT-1

IRS P5 (CARTOSAT)

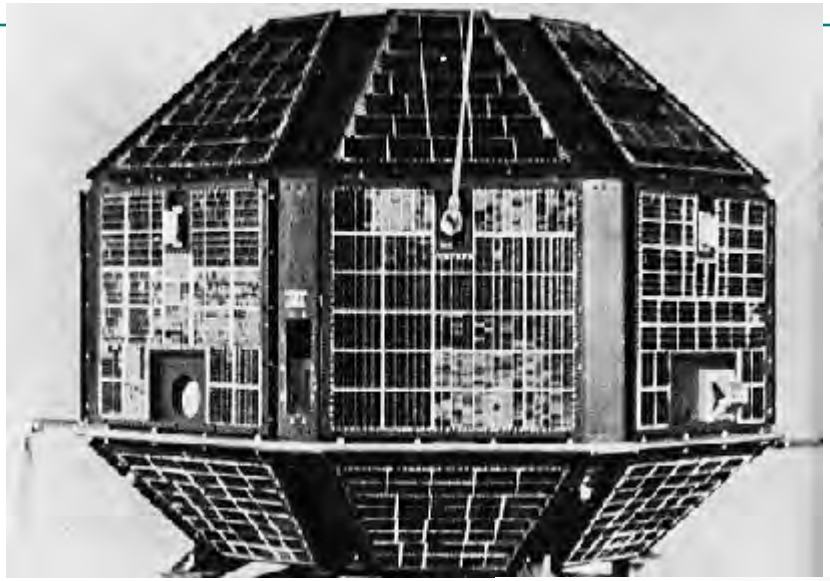
IRS P6 (RESOURCESAT 1)

BHASKARA

RS-D1

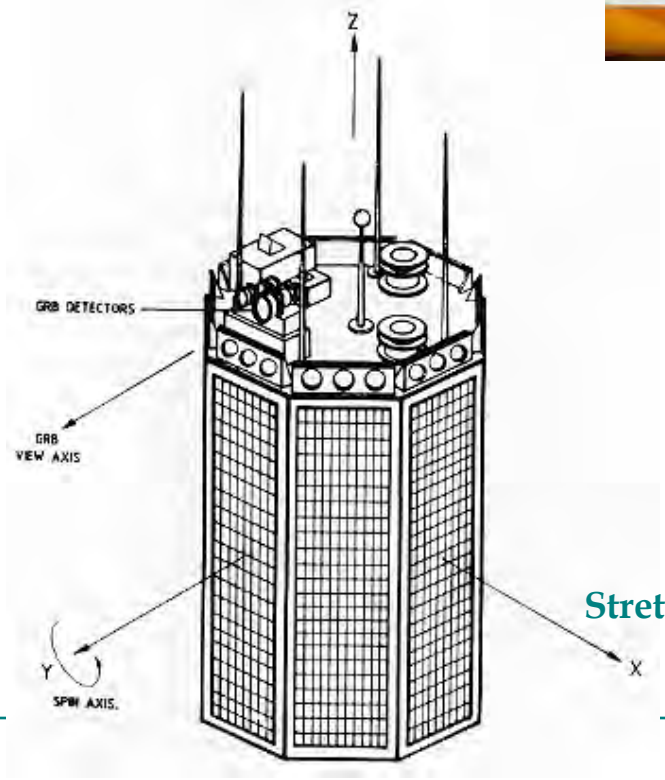
IRS P8 (CARTOSAT-2A)

IRS P7 (CARTOSAT-2)



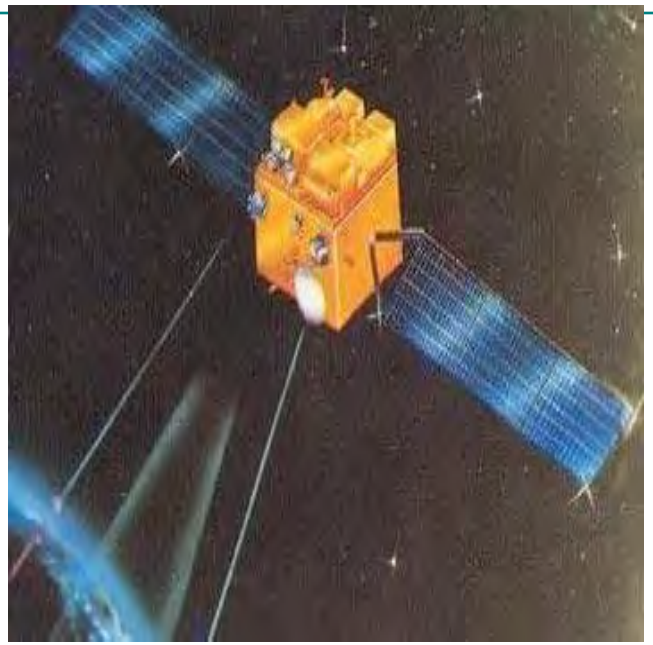
Aryabhatt

Rohini



Stretched Rohini Satellite Series

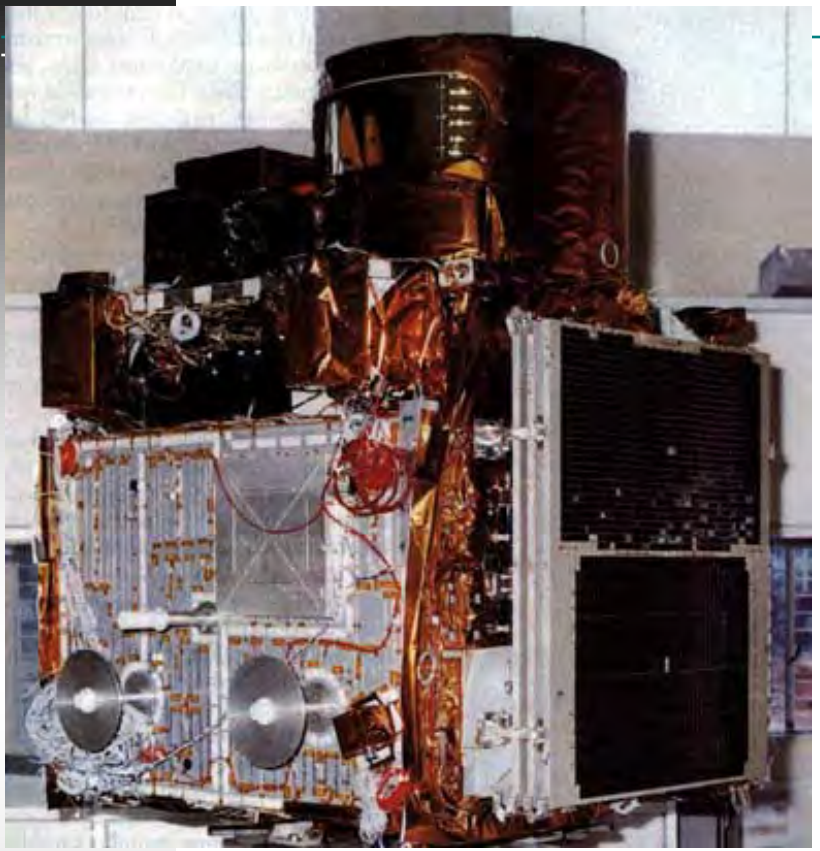
IRS-1A/B



IRS-P3

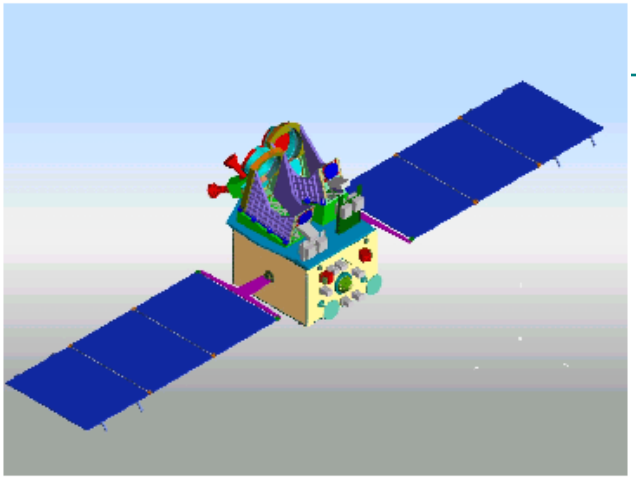
IRS-P4

TES(2001)
Defense
sat(1m R)

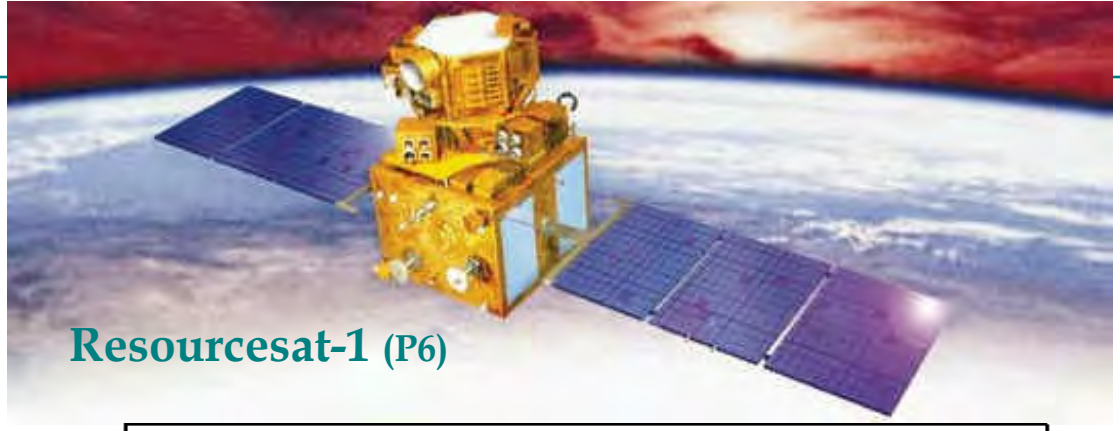


IRS-1C

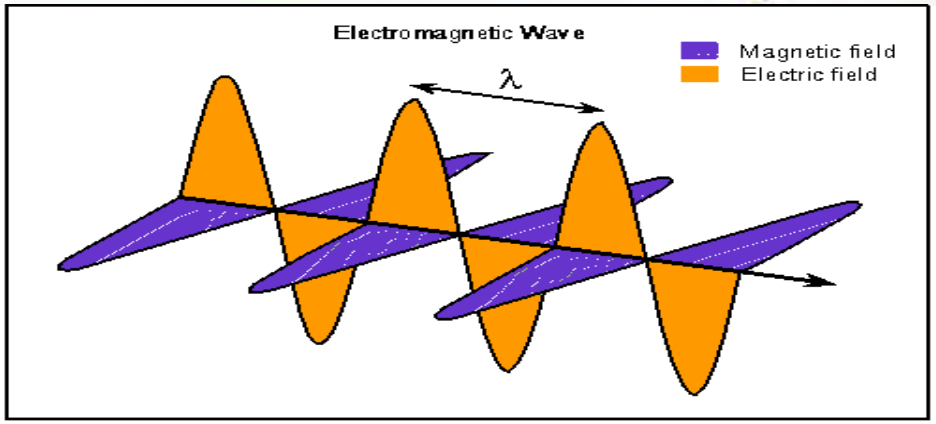
IRS-1D



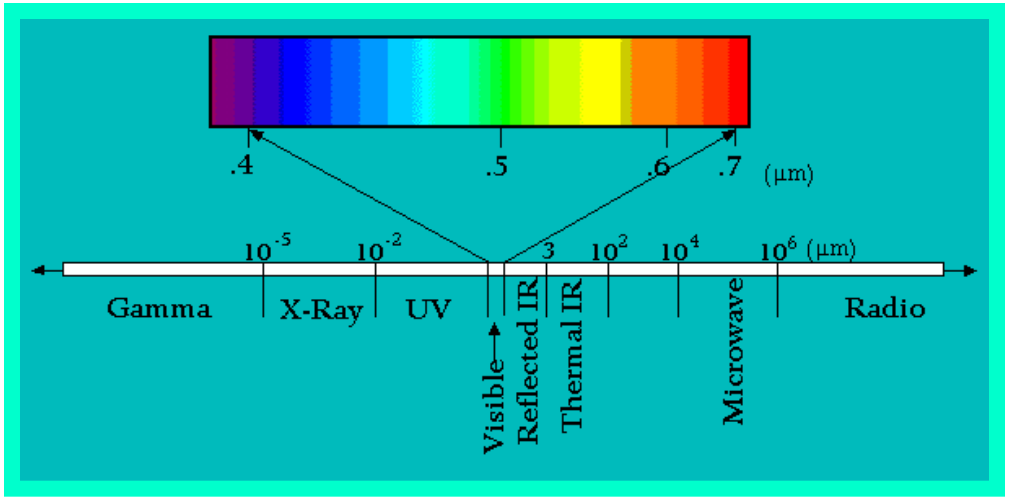
Cartosat-1 (P5)



Resourcesat-1 (P6)



(P7)



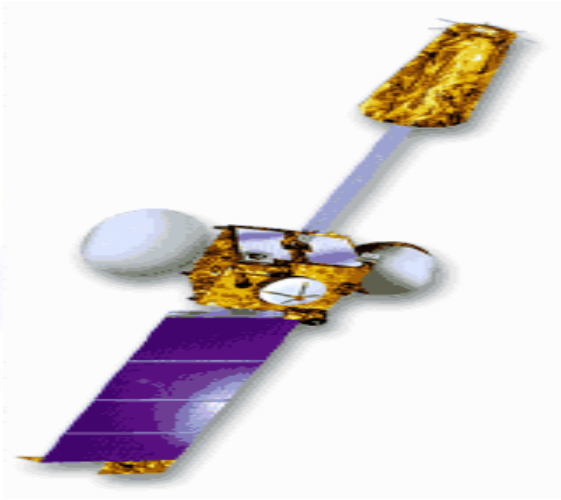
LISS IV

AWiFs

Resolution

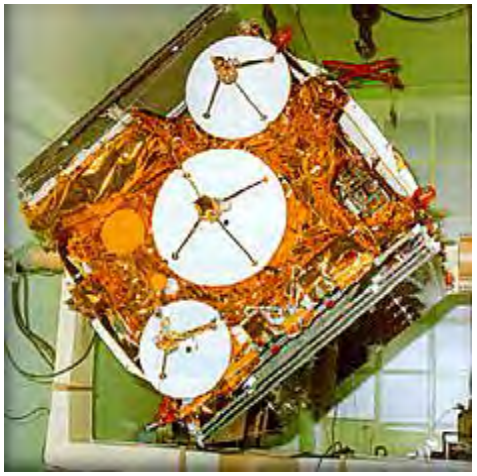
Spectral: no & width of bands measured by sensor
Radiometric: sensitivity of sensor to detect differences in signal strength
Spatial: ability of sensor to distinguish small objects; defines PIXEL size`
Temporal: frequency of revisit time

INSAT – 3C

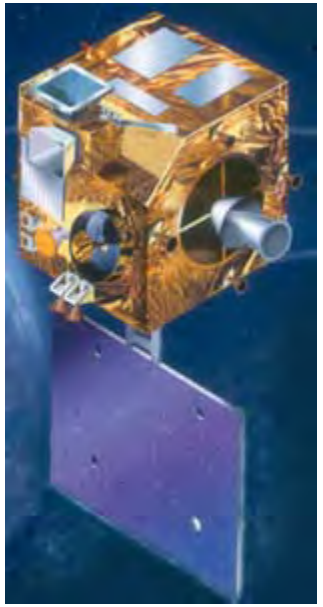


INSAT – 2E

INSAT – 3B

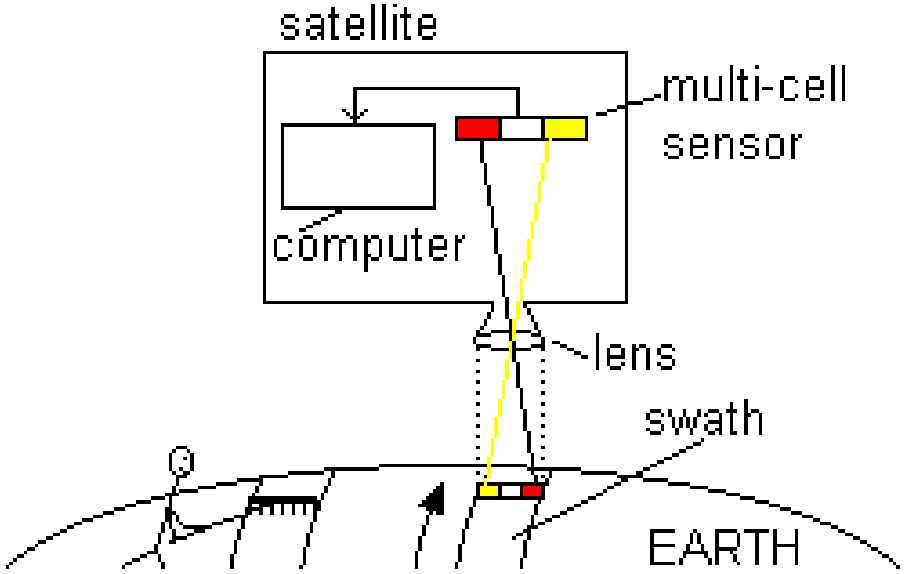


INSAT – 2C



KALPANA - 1 [METSAT]

PAYLOADS	LISS-4	LISS-3	AWiFS
Spatial Resolution (m)	5.8	23.5	56
Swath (km)	23.9 (MX mode) 70.3 (PAN mode)	141	740
Spectral Bands (micron)	0.52-0.59 0.62-0.68 0.77-0.86	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70

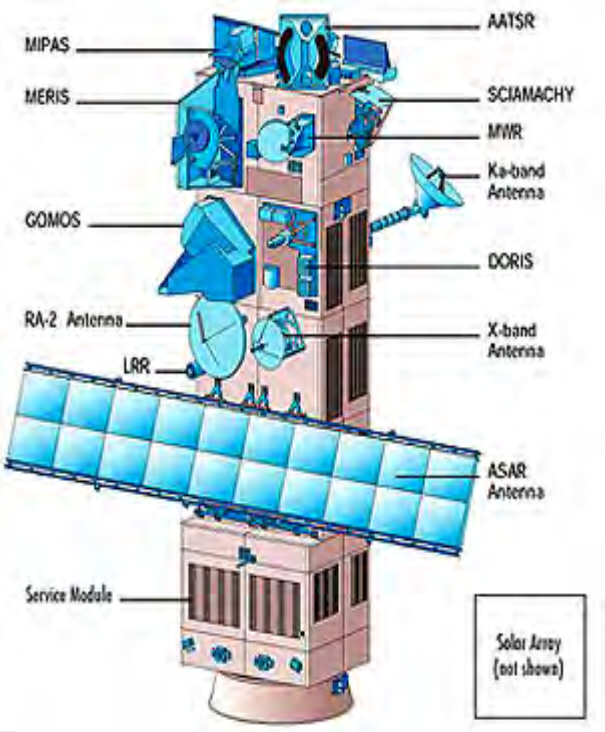


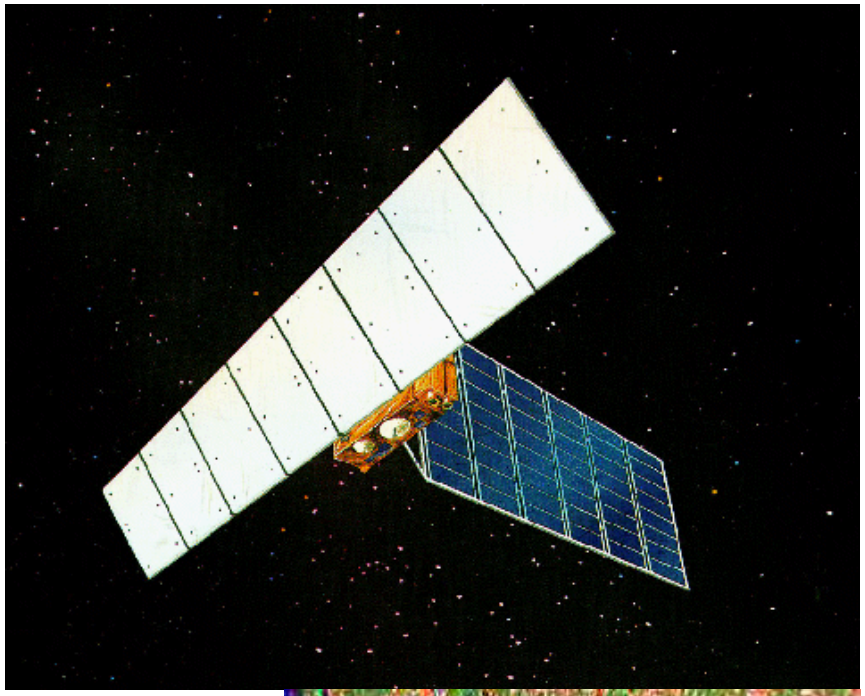
SPOT

Satellite	Launch Date	Notes
SPOT 1	22 February 1986	Not used
SPOT 2	22 January 1990	Operational
SPOT 3	26 September 1993	Failed November 1996
SPOT 4	24 March 1998	Operational
SPOT 5	4 May 2002	Operational

Mode	Band	Spectral band	Resolution
XS-multispectral	XS1	0.50 – 0.59 µm	20m x 20m
	XS2	0.61 – 0.68 µm	20m x 20m
	XS3	0.79 – 0.89 µm	20m x 20m
P-panchromatic	PAN	0.51 – 0.73 µm	10m x 10m

Japanese Earth Resources Satellite (JERS)





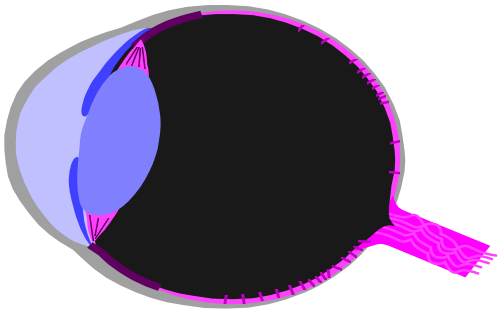
Frequency	1.3 GHZ L-band
Swath	75 km
Incidence Angle	35 degrees
Resolution	18 m

SATELLITE MISSIONS

- IRS series (50 sats)
  - IRS-1A/1B/P2 (L-II)
    - LISS-I and LISS-II
  - IRS-1C/1D
    - PAN, LISS-III and WiF
  - IRS-P3
    - MOS and WiFS
  - IRS-P4
    - OCM and MSMR
  - IRS P5 (Carto 1)
  - IRS-P6(RS 1)
  - IRS P7(carto 2)
  - IRS P8 (Carto 2A)
  - Resourcesat 2
- Landsat series
  - MSS(archived) and TM
- NOAA series
  - AVHRR & TOVS (TIROS Operational Vertical Sounder
- ERS-1 & 2
  - SAR
- SPOT
  - MLA/PLA(archived)
- RADARSAT

(Only data distribution)

IRS-1A/1B sensors



- **LISS-I**
  - Operates in 4 bands in the visible &NIR regions
  - Resolution 72.5 m
  - Swath 148 km
- **LISS-II**
  - Operates in same 4 bands as LISS-I
  - Resolution 36.25 m
  - Swath 74 km

IRS-1A/1B Missions

first operational indigenous remote sensing satellites

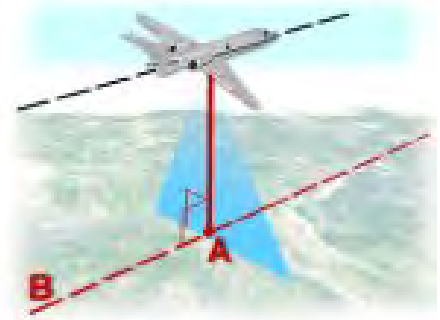
- **IRS-1A was launched in 1988 and provided data upto 1992**
- **IRS-1B launched in 1991 and continues to provide good quality data till date**
- **Two sensors (LISS-I & LISS-II)**

IRS-1C/1D Mission..best in the world

IRS-1C was launched in Dec 1995 and IRS-1D in Sep 1997

- **Three sensors (PAN, LISS-III & WiFS)**
- **On-board tape recorder (OBTR)**
- **Tilt facility of PAN camera gives stereo viewing capability & revisit of 5 days**
- **Large swath of WiFS gives 5 days repetitive coverage**

IRS-1C Mission.... Sensors



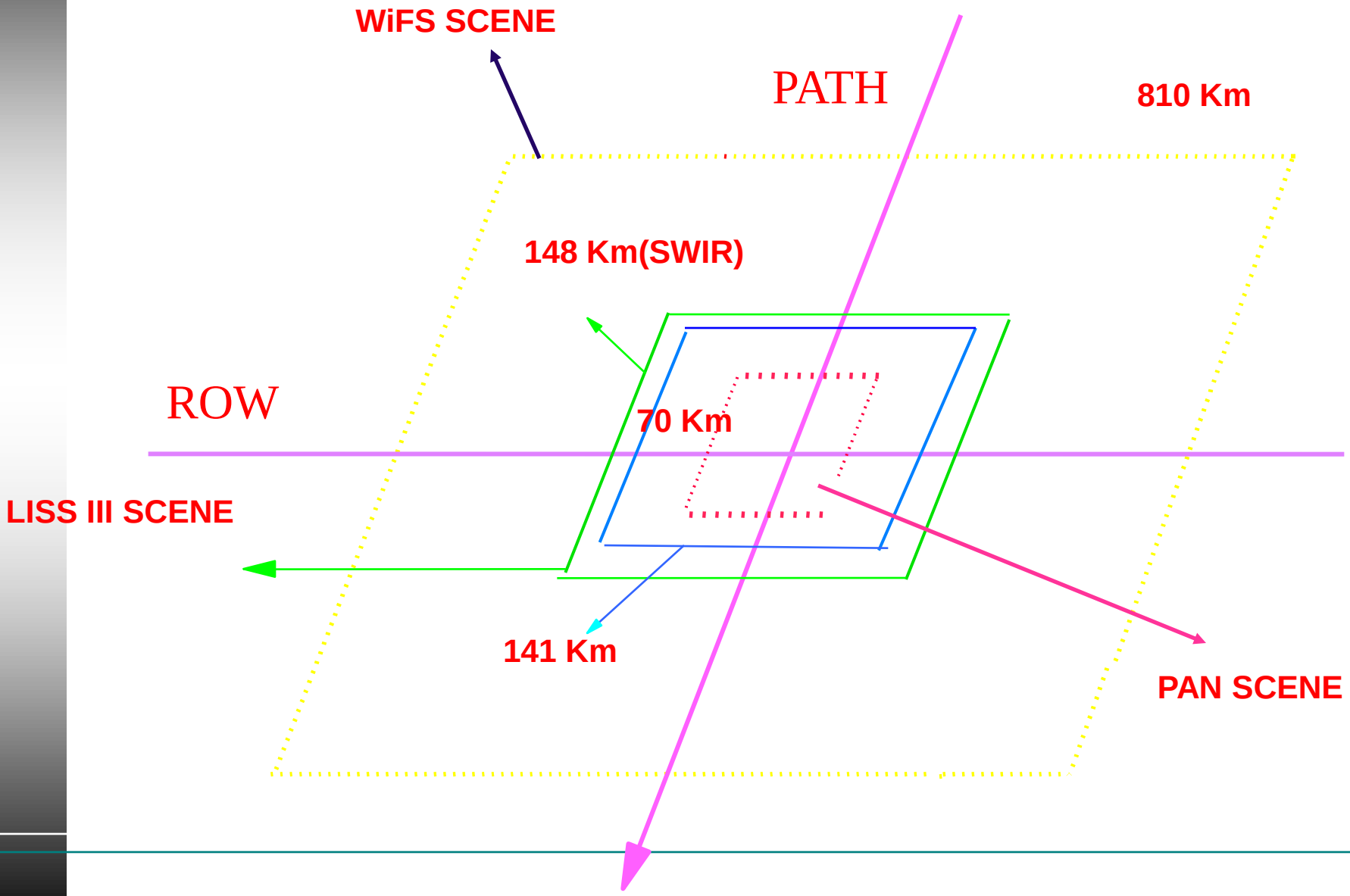
A - Nadir Point
B - Nadir Line

- **PAN**
  - Operates in one visible band
  - High resolution- 5.8 m
  - Swath - 70 km at *nadir* 90 km *off nadir*
  - Tilt capability ± 26 Degrees

- **LISS-III**
  - Operates in 4 bands (3 in visible and NIR & 1 in SWIR)
  - Resolution – 23.5 m
  - Swath - 141 km

- **WiFS**
  - Operates in 2 bands in visible and near infrared
  - Resolution 188 m
  - Swath 810 km

IRS-1C COVERAGE



IRS-P3

- IRS-P3 is a experimental payload launched during Mar,1996 by PSLV-D3 rocket. It has one X-ray astronomy payload and two remote sensing payloads namely
  - Wide Field sensor (WiFS)
  - Modular Opto-electronics Scanner(MOS)

IRS-P3 (out of service 2004)

	WiFS	MOS-A	MOS-B	MOS-C
Sensors				
Resolution	188 m	1569x1395	523x523	523x644
No. of bands	3	4	13	1
Spectral	620-680	755-768	408-1010	1500-1700
Swath	770 km	195 km	200 km	192 km
Repetivity	24 (5) days	24 days	24 days	24 days

IRS-P4

- **SENSORS - Ocean Colour Monitor (OCM)**
  - 8 Spectral Bands
    - 402-422 , 433-453 , 480-500 , 500-520, 545-565 , 668-680 , 745-785, 845-885
  - 360 m x 236 m spatial resolution
  - high radiometric sensitivity
  - large dynamic range
  - 12 bit radiometric resolution
  - swath 1420 km
  - FOV = +/- 43 deg.

IRS-P4

- **SENSORS - Multi-frequency Scanning Microwave Radiometer(MSMR)**
  - **Four frequencies**
    - **6.6 , 10.65 , 18.7 and 21.3 GHz**
  - **Polarisation**
    - **V and H**
  - **Spatial Resolution**
    - **120 , 80 , 40 and 40 meters**
  - **Swath**
    - **1420 kms**

IRS-P4 OCM Applications

Development of algorithms for retrieval of ocean and atmospheric parameters.

- identification of potential fishing zones in coastal waters.

- exploration of deep sea fishery resources .

- primary production model and fish stock assessment.

- selection and monitoring of algal blooms,

Coastal processes

- sediment dynamics

- dynamics of estuarine/tidal inlets.

- circulation and dispersal pattern.

- Upwelling; coastal/oceanic fronts and surface currents.

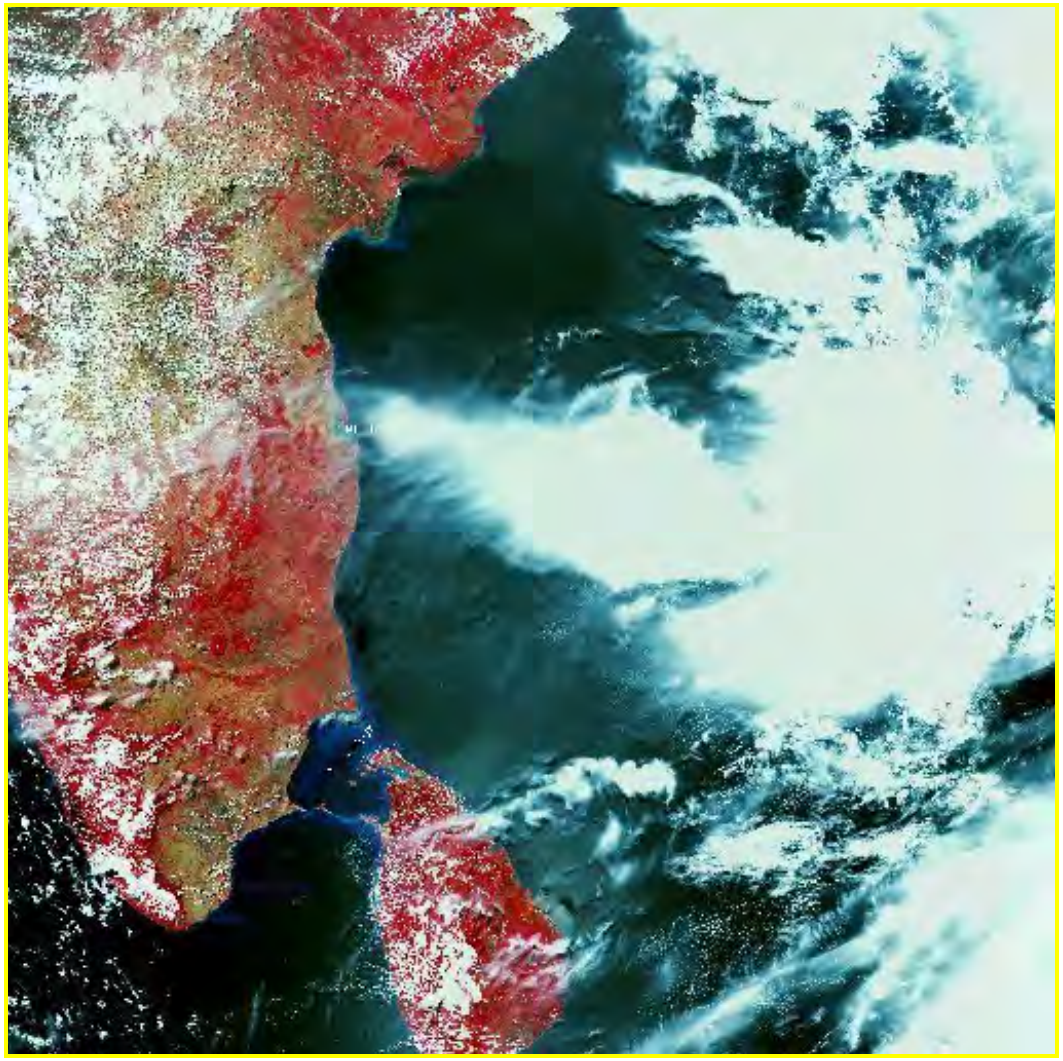
- marine pollution and oil slicks.

- coral reef studies.

IRS-P4 MSMR Characteristics &Applications

- **geophysical parameters SST, Wind speed, precipitable water in atmosphere, influence black body radiation.**
- **passive microwave radiometers.**
- **All weather capability**
- **Large swath**
- **High resolution**

IRS-P4 IMAGE - OCM



The first day image over South India.

IRS-1C/1D IMAGE - WiFS

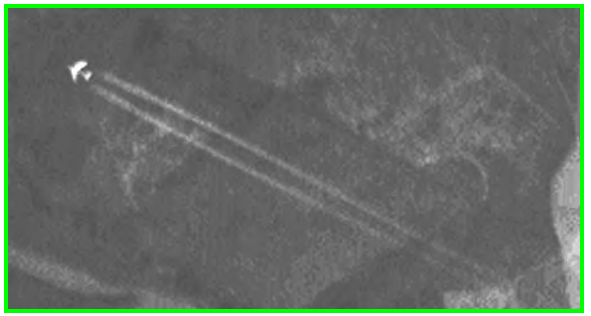
IRS-1C/1D WiFS image over South India. swath - 810 km and 180m resolution

IRS-1C/1D IMAGE - LISS-III

IRS-1C/1D LISS-III picture of Srisailam reservoir, A.P. ,India with 23.5 m resolution .

IRS-1C/1D IMAGE - PAN

This image shows part of Hyderabad city, A.P., India with 5.8 m resolution



PAN high resolution image. Here you can see an Aircraft that is flying. This image was captured South of Frankfurt, Germany

IRS-1C/1D IMAGE -PAN

This image shows the part of Delhi, India.

- **specifications**
  - **618 km altitude**
  - **Sun synchronous with local mean time = 10.30 hrs**
  - **ground track variations within 1 km**
  - **two Pan cameras**
  - **semi major axis 7001.16 km, i= 97.89^0**
  - **Total cycle period of 116 days**
  - **path to path distance 23.4 km**
  - Better than 2.5 m resolution
  - Swath 27.5 km for stereo and 55 km for monoscopic mode.
  - 8 km overlap between adjacent paths
  - 10 bits
  - Facility for across track tilt to give better revisit

IRS-P5 PAN products and applications

- **Updation of topographic maps**
- **Utilities planning**
- **Terrain visualisation**
- **Generation of topographic databases**

IRS-P6 Resoursat Sensors

- LISS-IV
  - 3 bands
  - Spatial resolution of 5.8 m
  - 25 km swath
  - tiltable camera for 5 day revisit
- LISS-III
  - Spatial resolution of 23 m
  - 141 km swath
  - 24 days repetivity
- AWiFS
  - 3 bands
  - Spatial resolution of 80 m
  - 1400 km swath

Name		Wavelength		Res	SW
Band 1	MS	0.520	0.590	5.8	70
Band 2	MS	0.620	0.680	5.8	70
Band 3	MS	0.770	0.860	5.8	70

Band 1	MS	0.520	0.590	23.5	140
Band 2	MS	0.620	0.680	23.5	140
Band 3	MS	0.770	0.860	23.5	140
Band 4	MS	1.550	1.700	23.5	140

Band 1	MS	0.620	0.680	70	740
Band 2	MS	0.770	0.860	70	740
Band 3	MS	1.550	1.700	70	740

World View 2

Polar Sun Synchronous- 770km

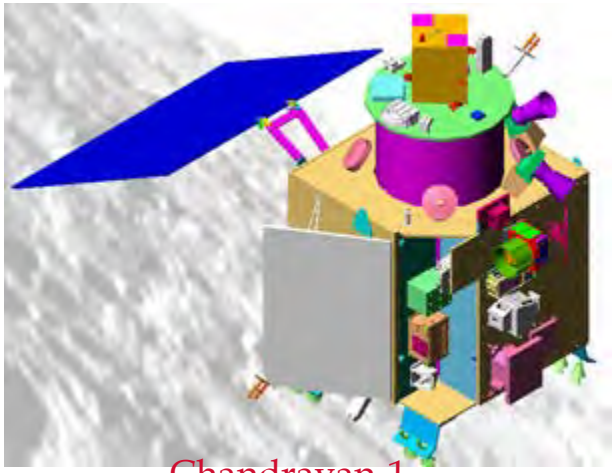
Orbit inclination (°) 97.2

Period of revolution (min)100

Orbit cycle (1 day)-

Equatorial crossing (descending node)10:30 AM

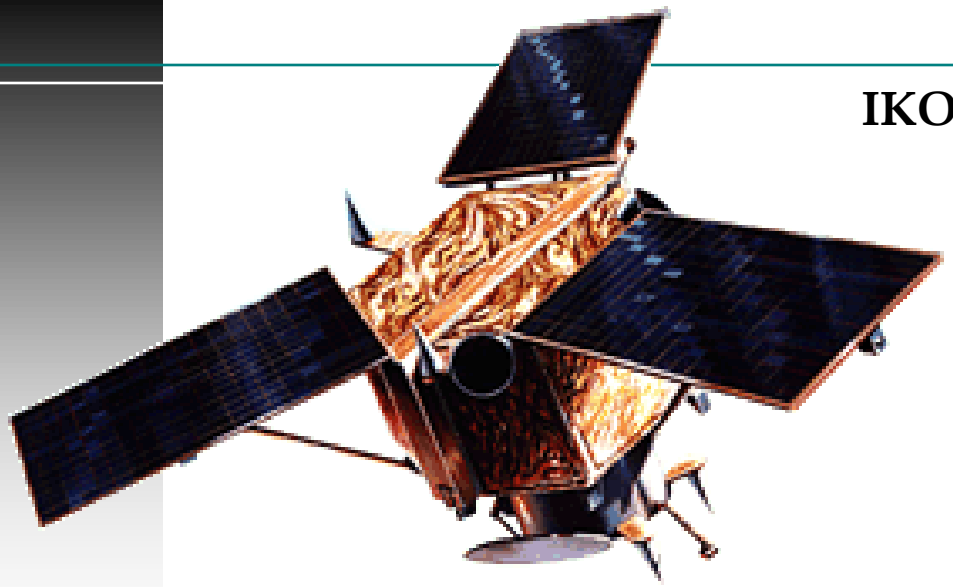
Resolution-
46 cm nadir/52 cm off nadir
1.8m MS
PAN-50cm

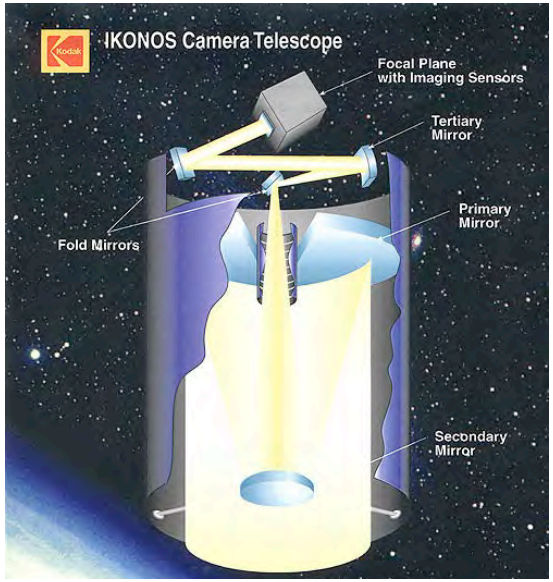


Chandrayan-1

Panchro	**0.450**	**0.900**	**0.46**	**-**	**16.4**km
Red	**-**	**-**	**1.84**	**-**	**16.4**
Blue	**-**	**-**	**1.84**	**-**	**16.4**
Green	**-**	**-**	**1.84**	**-**	**16.4**
Near-IR1	**-**	**-**	**1.84**	**-**	**16.4**
Red edge	**-**	**-**	**1.84**	**-**	**16.4**
Coastal	**-**	**-**	**1.84**	**-**	**16.4**
Yellow	**-**	**-**	**1.84**	**-**	**16.4**
Near-IR2	**-**	**-**	**1.84**	**-**	**16.4**

IKONOS - *Image*





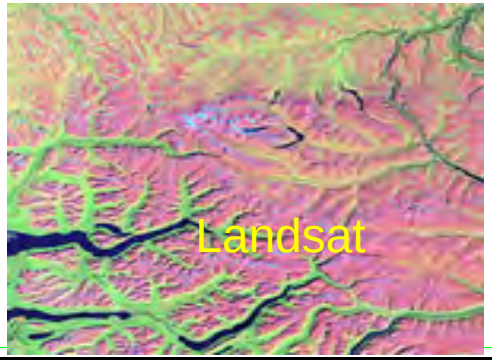
Altitude	Equator Crossing	Repeat Coverage
681km	10:30 a.m.	2.9 days (PAN) 1.5 days (MS)

Resolution (m)	Swath (km)	Sensor Channels	Spectral Bands (µm)
1	13	PAN	0.45-0.90
4	13	IKONOS1 IKONOS2 IKONOS3 IKONOS4	0.45-0.52(blue) 0.52-0.60 (green) 0.63-0.69 (red) 0.76-0.90 (near IR)

Landsat

Satellite	Launch Date	Notes
Landsat 1	23 July 1972	Decommissioned 6 January 1978
Landsat 2	22 January 1975	Decommissioned 25 February 1982
Landsat 3	5 March 1978	Decommissioned 31 March 1983
Landsat 4	16 July 1982	Decommissioned June 2001
Landsat 5	1 March 1984	Operational -
Landsat 6	October 1993	Failed on launch
Landsat 7	15 April 1999	Operational -185 km swath

Orbview 4
R-1m
T-3 days
Swath-5-8 km



MODIS (Mod Res. Imaging Spectroradiometer)
36 bands
Resolution-
(1-2 bands)-250m
(3-7bands)-500m
(8-36bands)-1000m
1 day
Swath-2200 km

ASTER (Adv. Spaceborne Thermal Emission & Reflec. Radiometer)

Resolution 15-90 m
14 bands
Swath-60km

CHARACTERISTIC	LANDSATs 1-3	LANDSATs 4-5
Nominal orbital altitude (km)	920	705
Orbital type	POLAR SUN SYNCHRONOUS	
Inclination (degrees)	99.1-99.2	98.2
Equatorial crossing (local time)	8:50-9:30am	9:45am
Paths	251	233
Repeat coverage	18 days	16 days
Sensor type	MSS	MSS/TM

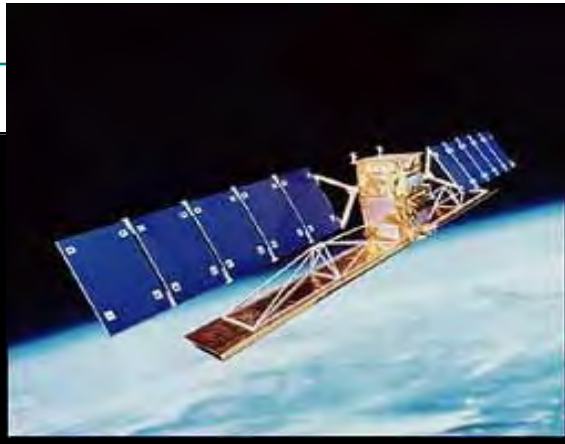
Landsat

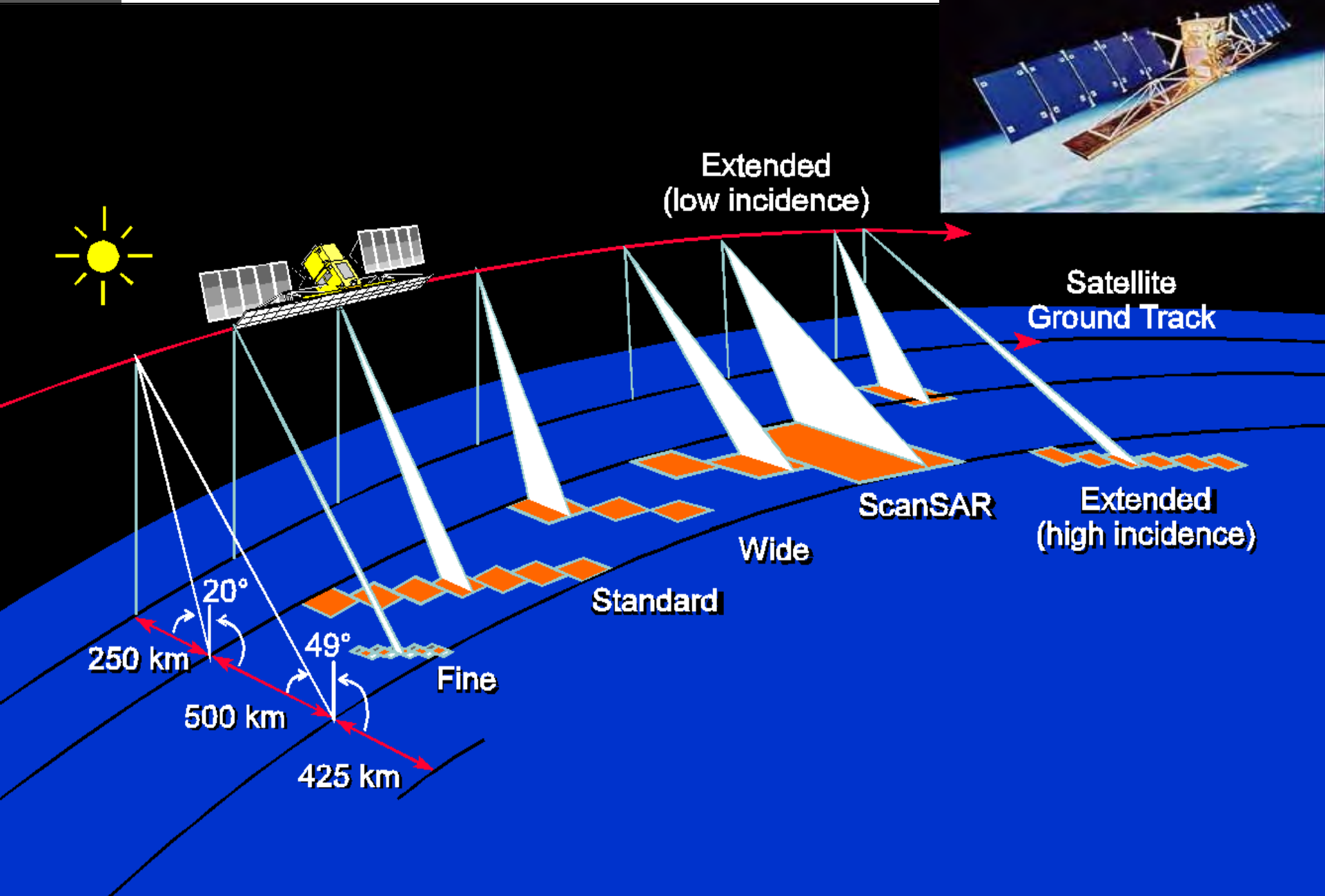
LANDSAT SATELLITES AND SENSORS

Satellite	Sensor	Bandwidths	Resolution
LANDSATs 1-2	RBV	(1) 0.48 to 0.57	80
		(2) 0.58 to 0.68	80
		(3) 0.70 to 0.83	80
	MSS	(4) 0.5 to 0.6	79
		(5) 0.6 to 0.7	79
		(6) 0.7 to 0.8	79
		(7) 0.8 to 1.1	79
LANDSAT 3	RBV	(1) 0.505 to 0.75	40
	MSS	(4) 0.5 to 0.6	79
		(5) 0.6 to 0.7	79
		(6) 0.7 to 0.8	79
		(7) 0.8 to 1.1	79
		(8) 10.4 to 12.6	240

Satellite	Sensor	Bandwidths	Resolution
LANDSATs 4-5	MSS	(4) 0.5 to 0.6	82
		(5) 0.6 to 0.7	82
		(6) 0.7 to 0.8	82
		(7) 0.8 to 1.1	82
	TM	(1) 0.45 to 0.52	30
		(2) 0.52 to 0.60	30
		(3) 0.63 to 0.69	30
		(4) 0.76 to 0.90	30
		(5) 1.55 to 1.75	30
		(6) 10.4 to 12.5	120
		(7) 2.08 to 2.35	30
LANDSAT 7	ETM	(1) 0.45 to 0.52	30
		(2) 0.52 to 0.60	30
		(3) 0.63 to 0.69	30
		(4) 0.76 to 0.90	30
		(5) 1.55 to 1.75	30
		(6) 10.4 to 12.5	150
		(7) 2.08 to 2.35	30
		PAN 0.50 to 0.90	15

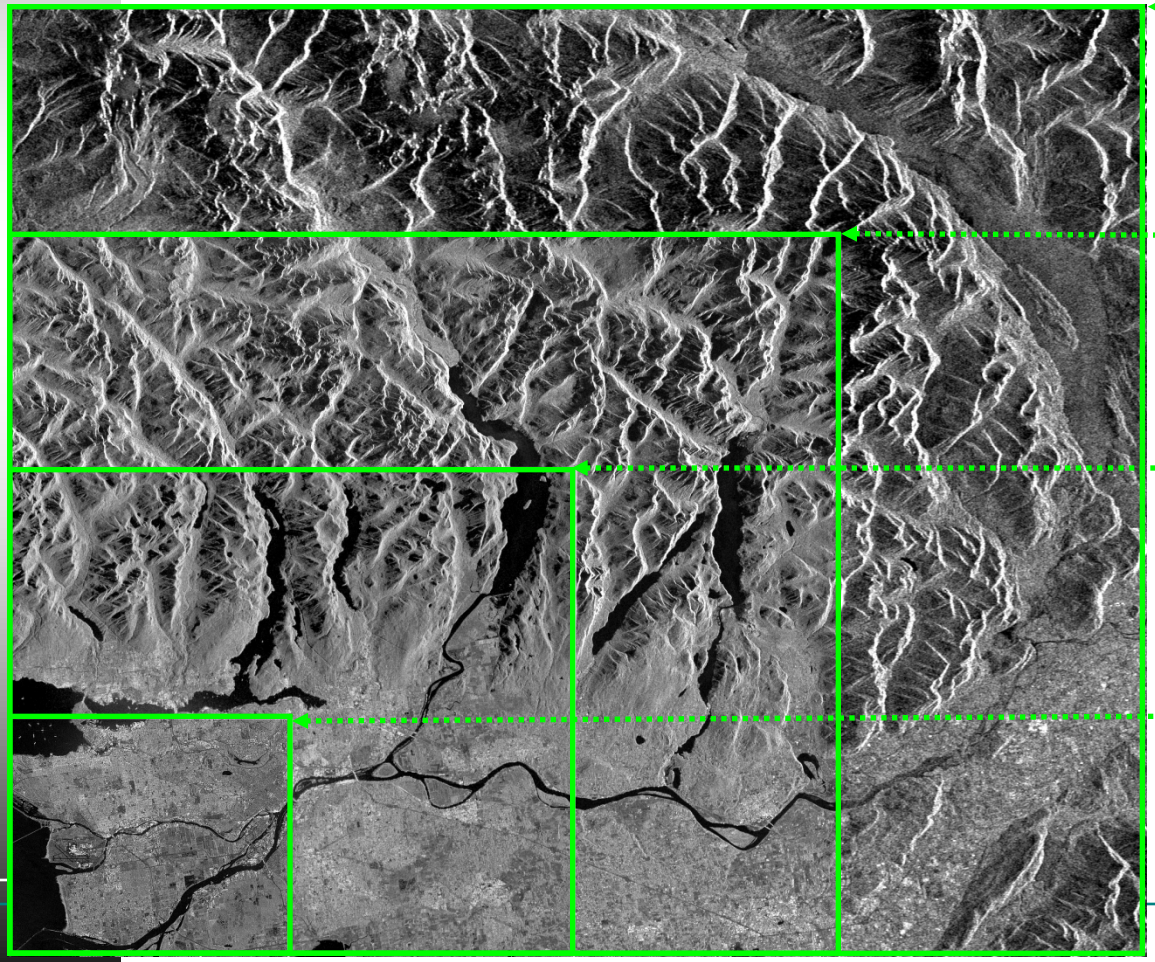
RADARSAT SAR Beam Modes





RADARSAT Beam Modes & Resolutions

5-24 days revisit
launch_- 1995 & 2007



ScanSAR Wide
500 x 500 km,
100m resolution

Wide
150 X 150 km,
30m resolution

Standard
100 x 100 km, 25m resolution

Fine
50 x 50 km,
8m resolution

RADARSAT Products

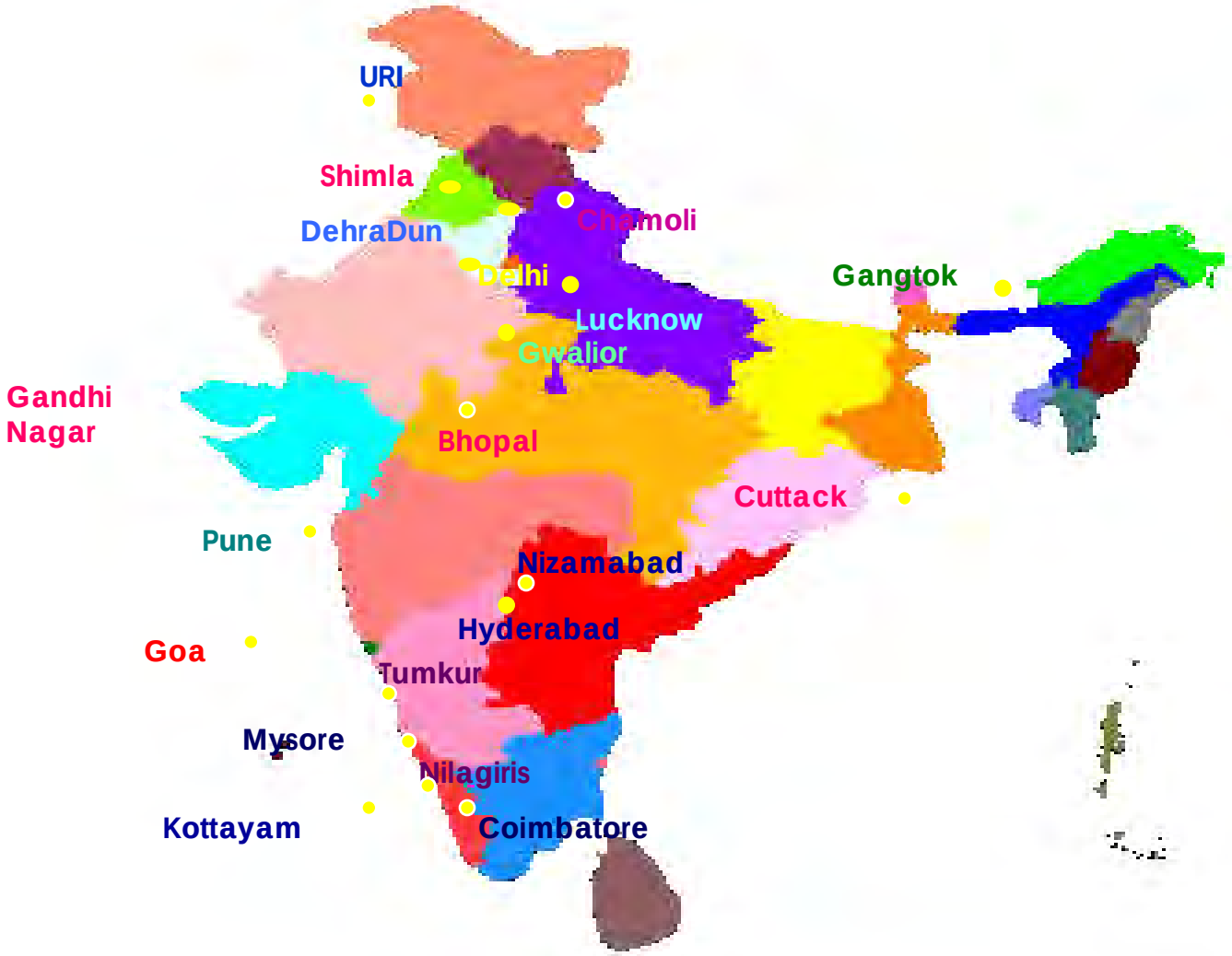
Beam Mode	Signal Data	Single Look Complex	Path Image	Path Image Plus	Map Image	Precision Map Image
Fine	●	●	●	●	●	●
Standard	●	●	●	●	●	●
Wide	●	●	●	●	●	●
ScanSAR-N	●	Not Available	●	Not Available	Not Available	Not Available
ScanSAR-W	●	Not Available	●	Not Available	Not Available	Not Available
Extended	●	●	●	●	●	●

European Remote Sensing satellite (ERS)-1

Satellite details :

- Near polar, sun synchronous orbit
- Altitude 785 km
- Equator crossing time 10.30 am
- Sensors : AMI, SAR(Image), SAR(Wave), Wind Scatterometer, Radar Altimeter, Along the Track Scanning Radiometer, Microwave Sounder, Laser Retroreflector
- Spatial resolution for SAR (Image): 25m
- Swath : 100 km

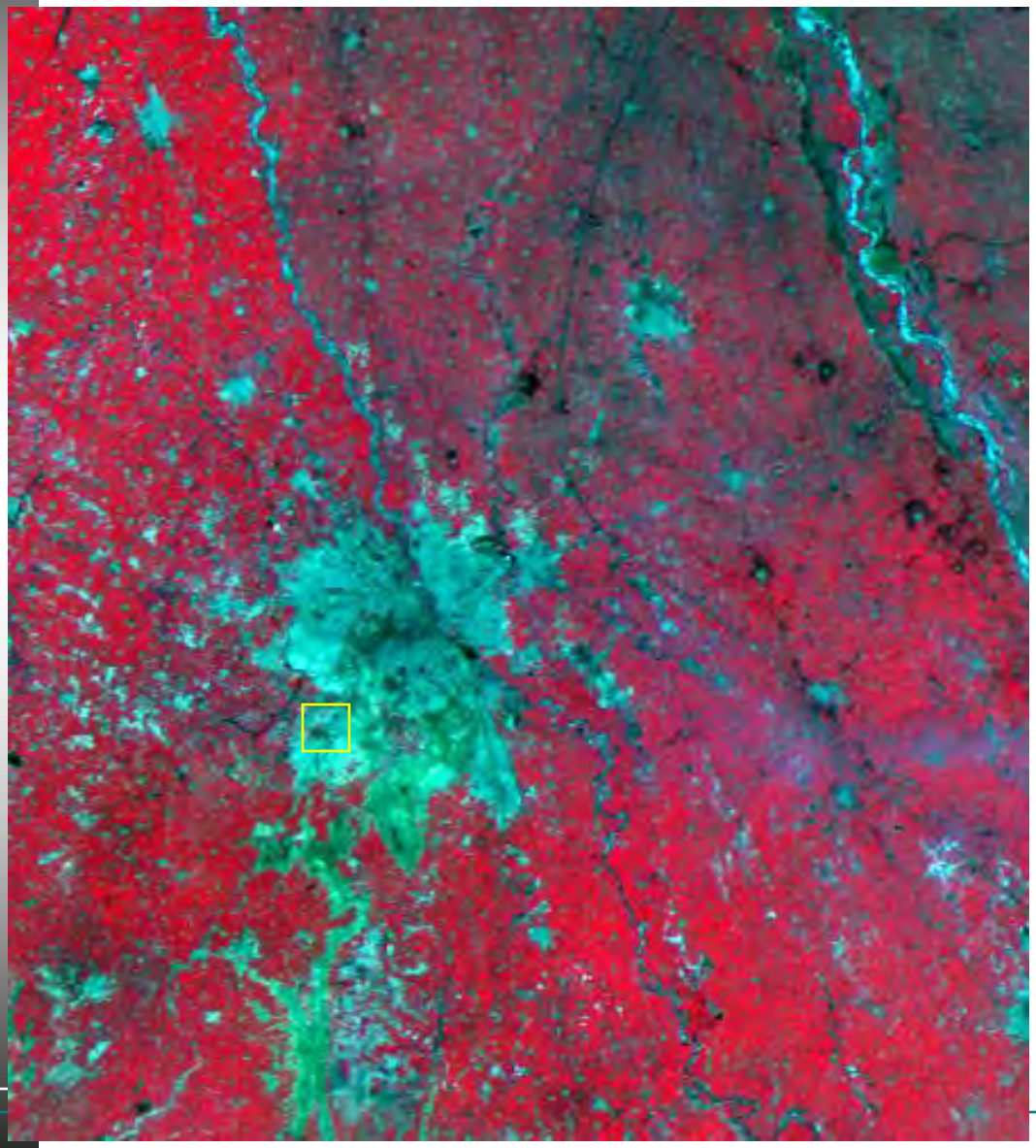
LOCATION OF ARCHIVED STEREOPAIRS



Classification of Satellite Data

	Medium Resolution 100 to 20 m	High Resolution 20 to 5 m	Very High Resolution Less than 5m
Optical Multi Band	TM, LISS-III LISS-II, MSS LISS-I, AWiFS	SPOT MLA LISS-IV	IKONOS
Optical Single Band		SPOT PLA 1C/1D PAN	IKONOS P5 PAN
Microwave	ERS-1/2	Radarsat 1 Fine beam	Radarsat2 Fine /Ultra

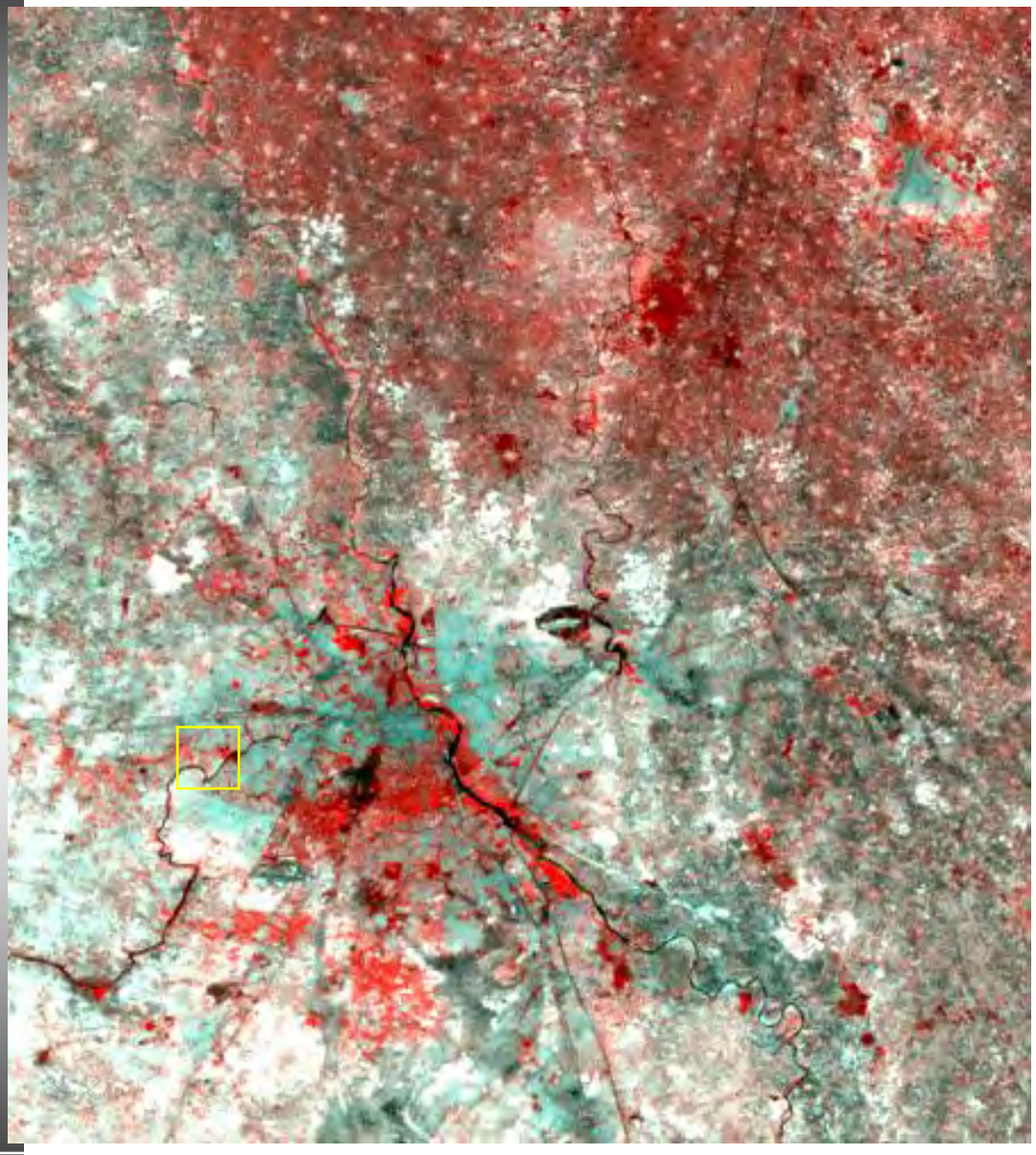
Delhi and its surroundings through IRS-P4 OCM



IRS-P4 OCM

- 8 Spectral Bands (nanometers) 402-422 , 433-453, 480-500 , 500-520, 545-565, 668-680 , 745-785, 845-885
- 360 m x 236 m spatial resolution
- High radiometric sensitivity
- Large dynamic range
- 12 bit radiometric resolution
- Swath 1420 km
- Along track steering to avoid sun glint ± 20 deg.
- Repetivity of 2 days

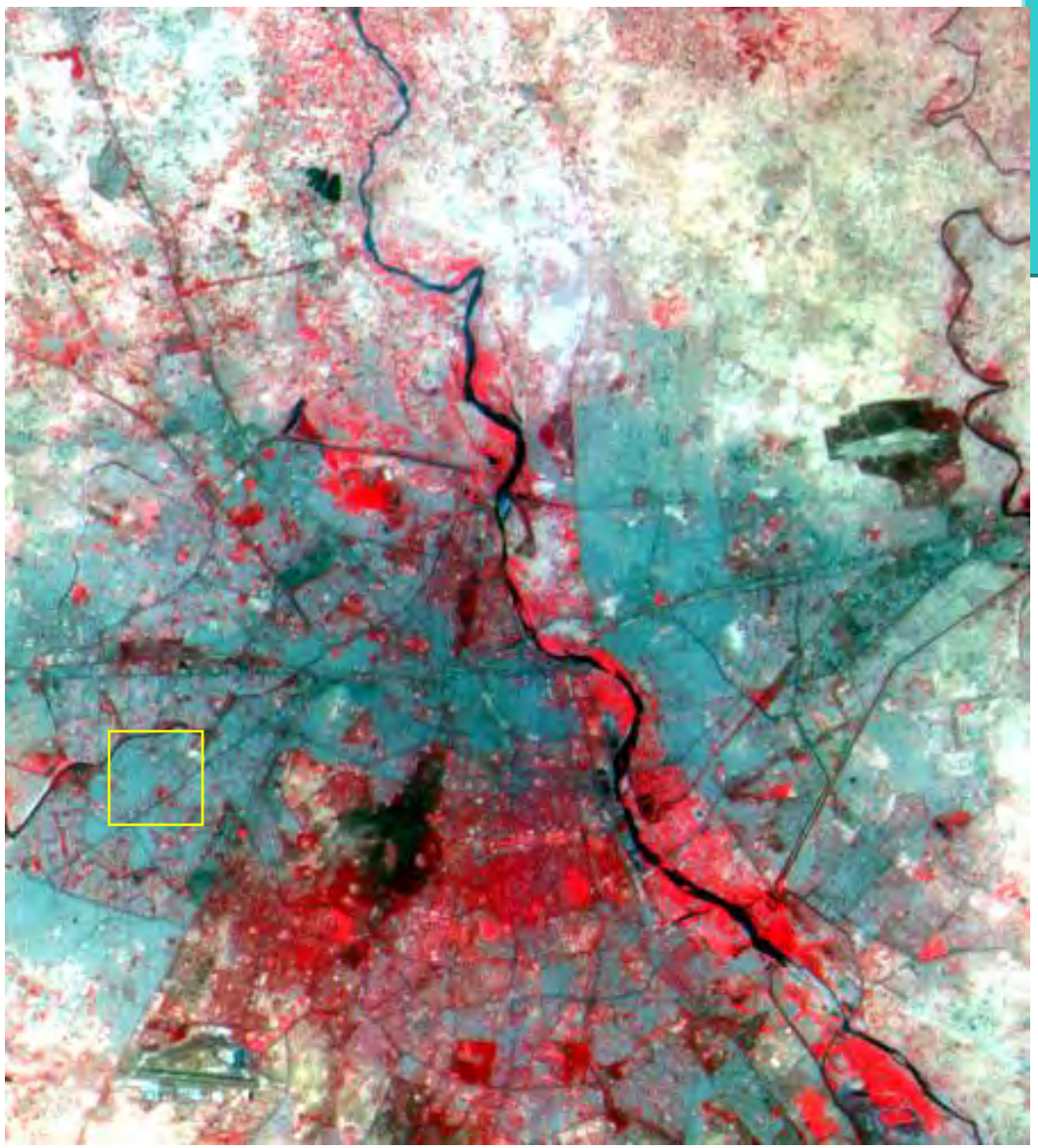
Delhi & its surroundings through IRS-1D WiFS



IRS-1C/1D WiFS

- Operates in 2 bands in visible & NIR
- Resolution 188 m
- Swath 810 km
- Repetivity of 5 days

Delhi through IRS-1B LISS-I



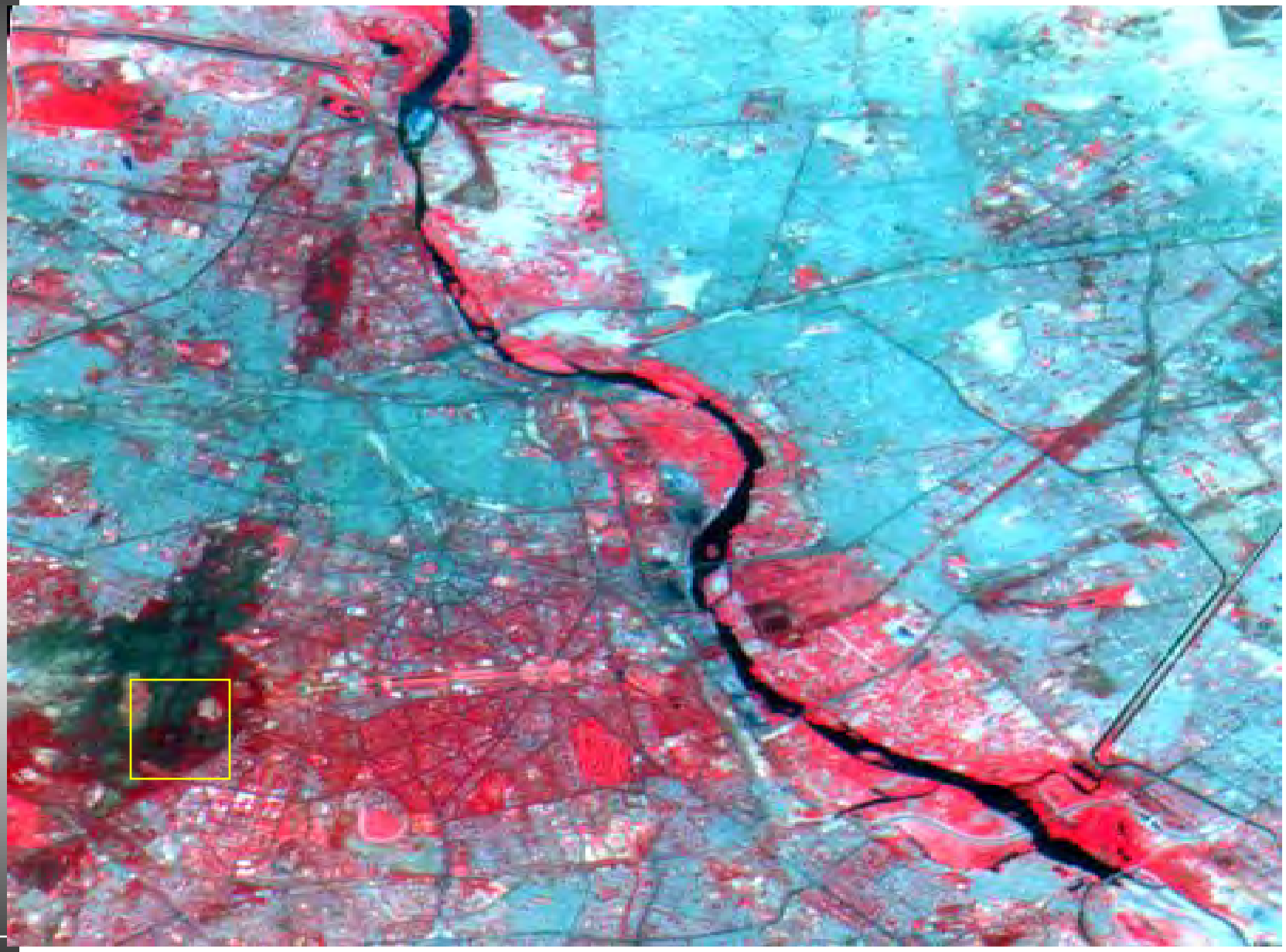
IRS-1A/1B LISS-I

- 4 bands
  (1 visible & 3 in visible)
- Resolution - 72 m
- Swath - 148 km
- Repetivity of 22 days

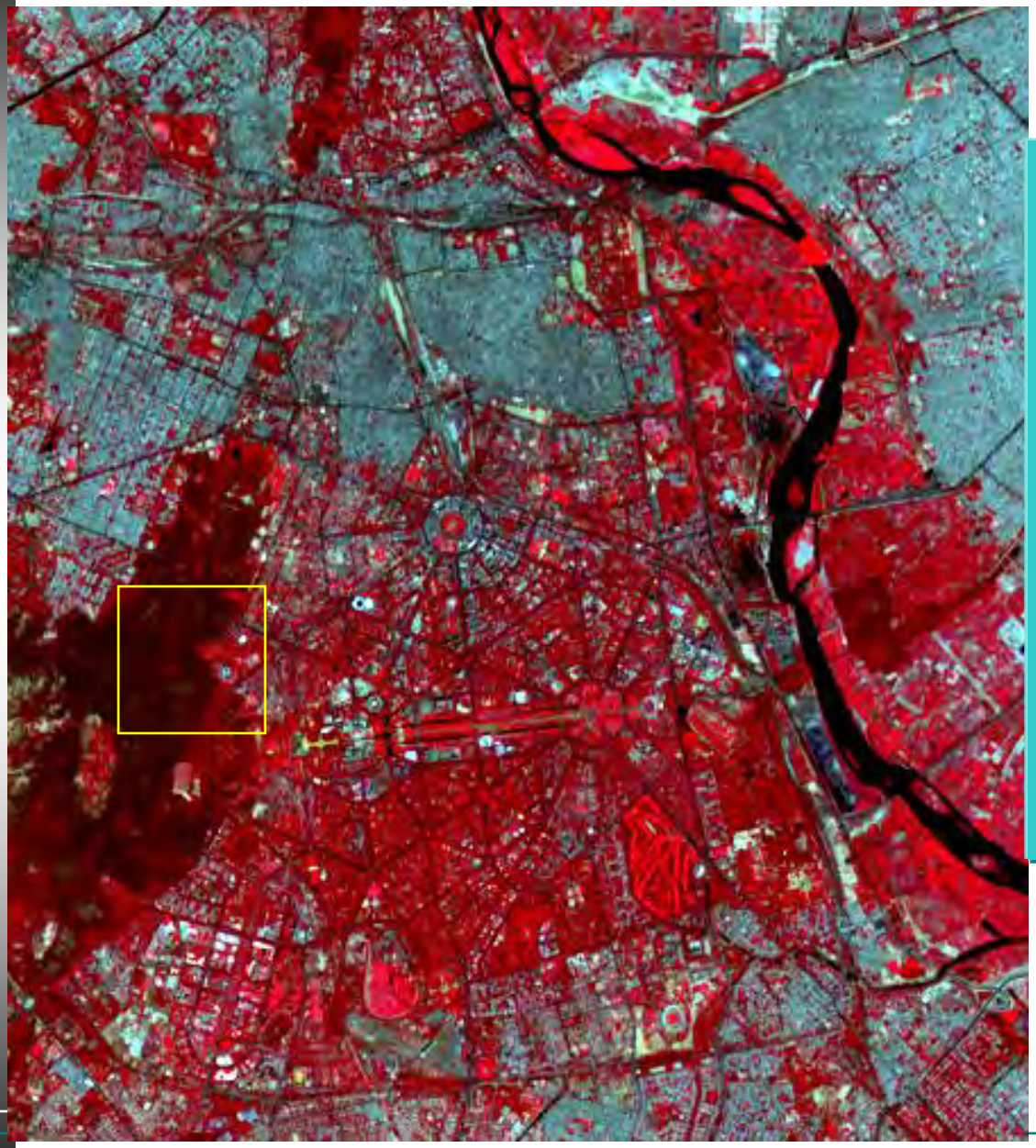
IRS-1A/1B LISS-II

- Operates in 4 bands (1 visible and 3 in visible)
- Resolution - 36 m
- Swath - 74 km
- Repetivity of 22 days

Part of Delhi through IRS-1D LISS-II



Part of Delhi through IRS-1D LISS-III



IRS-1C /1DLISS-III

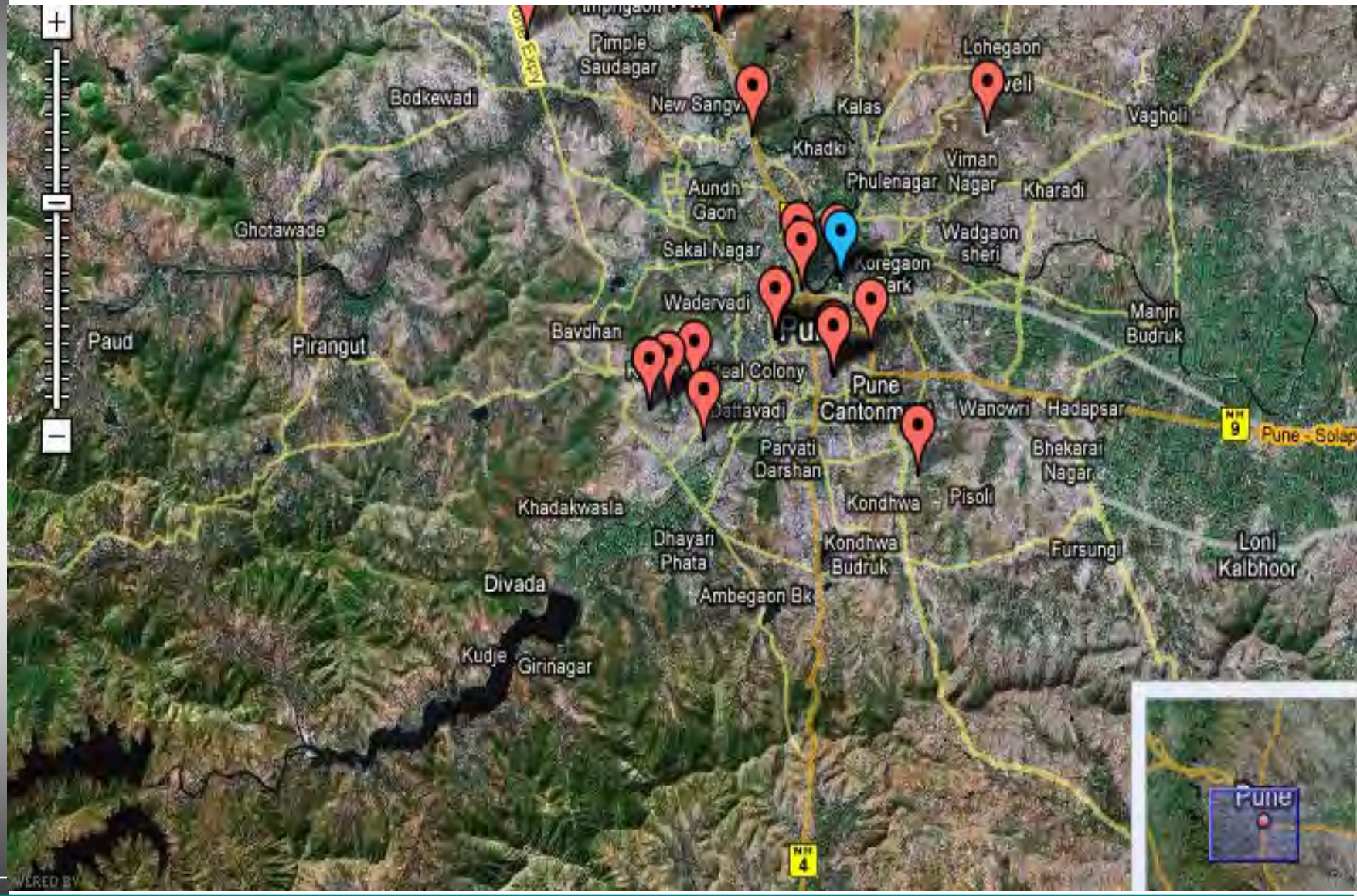
- Operates in 4 bands (3 in visible and NIR & 1 band in short wave infrared)
- Resolution - 23 m
- Swath - 141 km
- Repetivity of 24 days

Part of Delhi through IRS-1D PAN

IRS-1C /1D PAN

- 1 band
  Resolution - 5.6 m
- Swath - 70 km
- Repetivity of 5 days
- Camera tiltable to ±26 deg

Part of Pune


Pimple Saudagar
Lohegaon
Bodkewadi
New Sangv
Kalas
Vagholi
Khadki
Viman Nagar
Phulenagar
Kharadi
Aundh Gaon
Ghotawade
Sakal Nagar
Wadgaon sheri
Wadervadi
Manjri Budruk
Paud
Pirangut
Bavdhan
Pune Cantonm
Wanowri
Hadapsar
Pune - Solap
Parvati Darshan
Bhekarai Nagar
Khadakwasla
Kondhwa
Pisoli
Dhayari Phata
Kondhwa Budruk
Fursungi
Loni Kalbhoor
Divada
Ambegaon Bk
Kudje
Girinagar
Pune

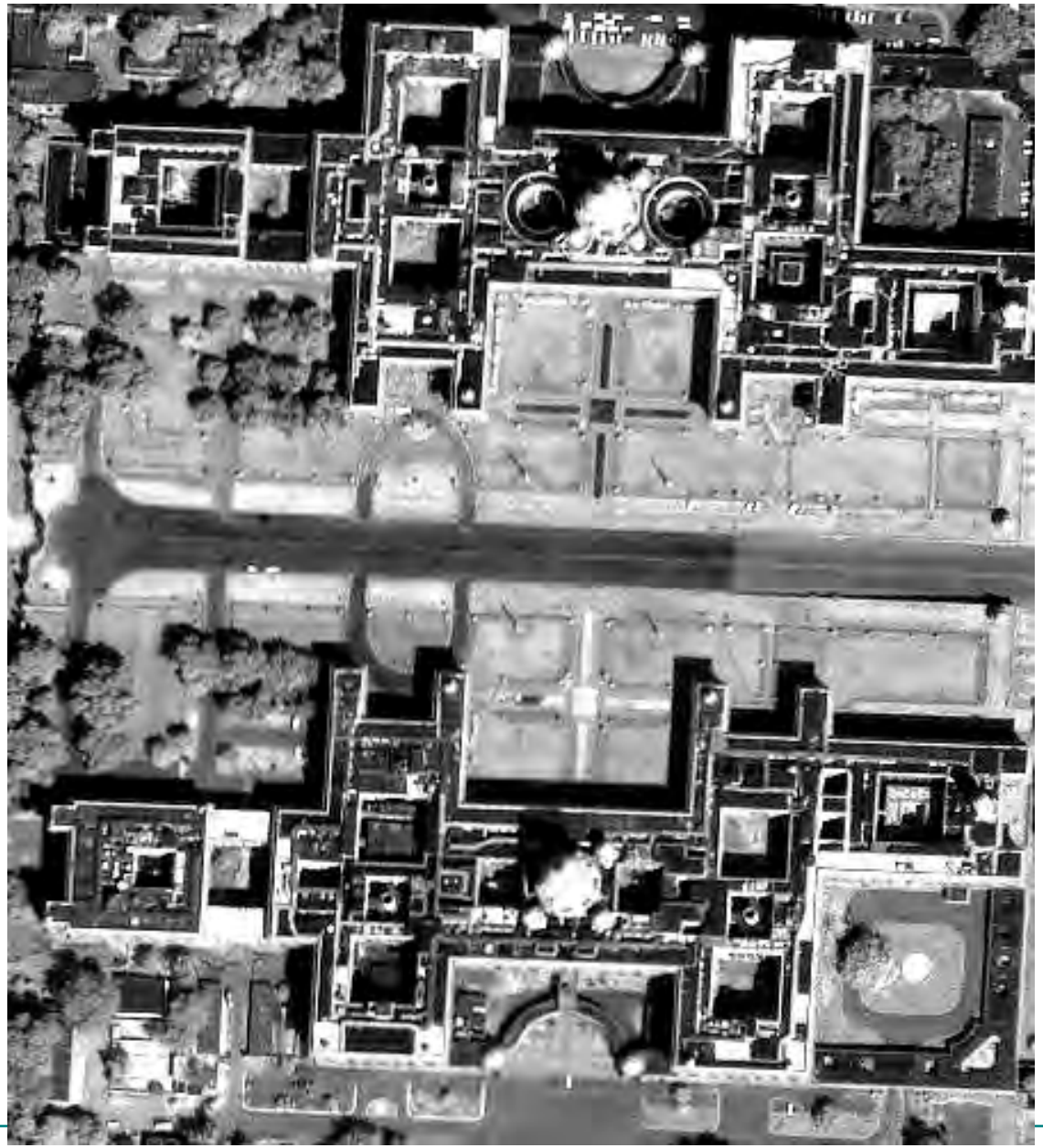
Part of Delhi through IRS-1D LISS-III + PAN

Part of Delhi through IKONOS

- Panchromatic (single band - black and white) images with a spatial resolution of 1 m and
- Multispectral images in four spectral bands with 4 m spatial resolution.

- four bands are:
  Blue :0.45 - 0.52 mm;
  Green : 0.52 - 0.60 mm ;
  Red : 0.63 - 0.69 mm & NIR: 0.76-0.90 mm.
- 11 bit

Part of Delhi through IKONOS




Thank You