

Indian Remote Sensing Satellites

Yesterday - Today - Tomorrow

Timothy J. Puckorius
Senior Advisor



YESTERDAY

First Generation IRS Satellites



First Generation

- IRS 1A and 1B
 - 1988 to 1997
- Sensors
 - Liss1 at 72 meter resolution
 - Liss2 at 36 meter resolution
 - 4 spectral bands
 - 22 day revisit

TODAY

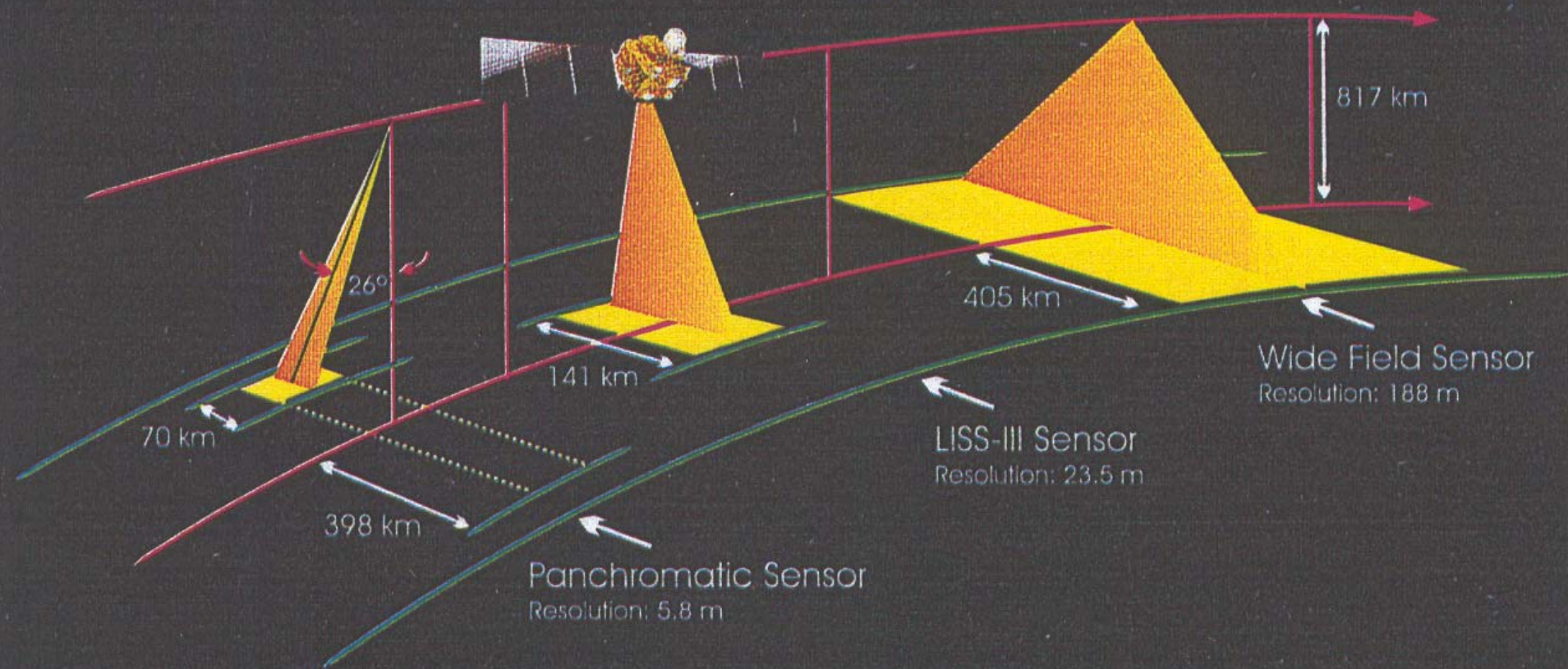
Second and Third Generation
IRS Satellites



Second Generation

- IRS 1C and 1D
 - 1995 to 2006
 - Large ground station network
- Sensors
 - WiFS
 - 188m resolution, 810 km swath, 2 spectral bands, 5 day revisit
 - Liss3
 - 23.5m and 70m resolution, 3 spectral bands VNIR (23.5m resolution), SWIR band (70m resolution), 24 day repeat cycle
 - Liss4
 - 5.8m resolution (Pan only), 5 day revisit

IRS-1C/D Sensor Swaths



IRS 1C & 1D International Ground Station Coverage

17 IRS 1C/1D ground stations throughout life of missions

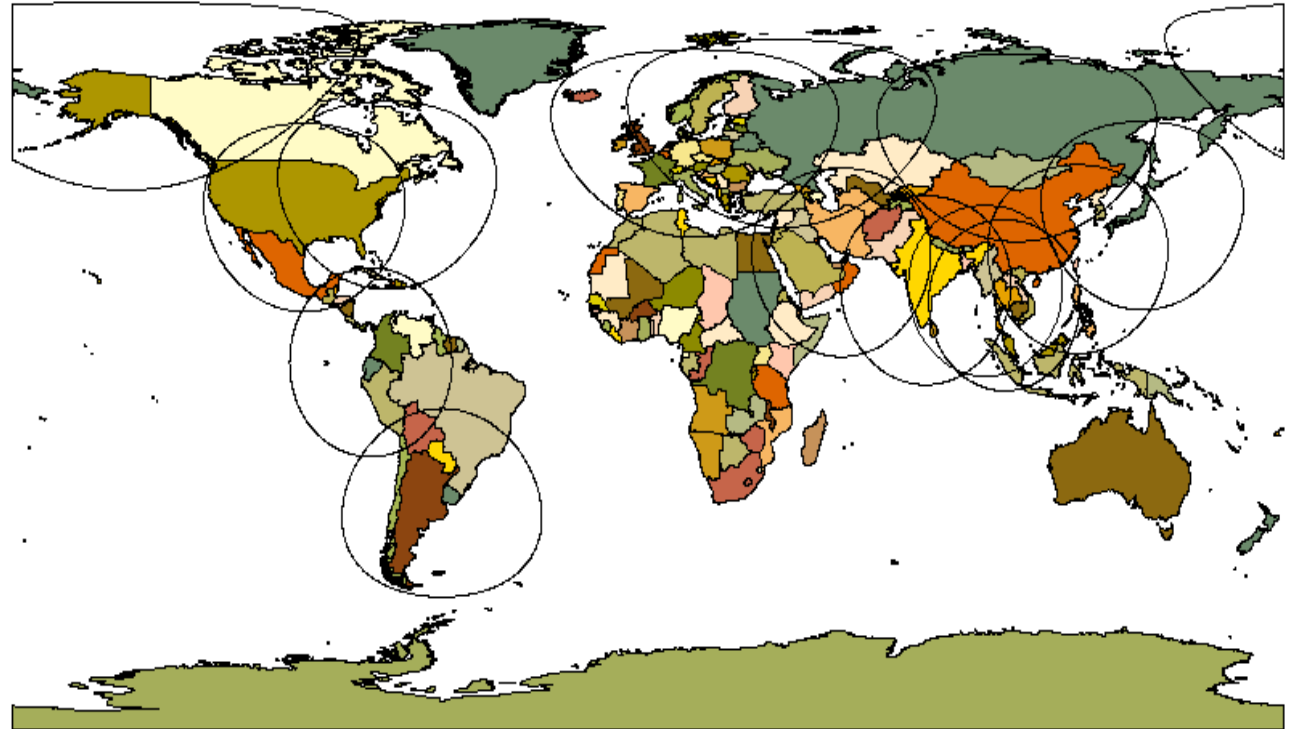
+ Data product sales and applications development

CURRENTLY OPERATING

- Union of Myanmar
- Eagle Vision 1, 2 & 5
- Scannex (Russia)
 - Moscow
 - Eastern Siberia
 - Kazakhstan

RECENTLY DISCONTINUED

- Taiwan (FRSC)
- Germany (NSG)
- Thailand (GISTDA)
- UAE (UAEAF)
- Japan (RESTEC)
- Argentina (CONAE)
- Ecuador (CLIRSEN)



Expected Life of Satellites:

- Both have exceeded design life
- Resourcesat-1 replaces these missions
- IRS 1C end of 2005, IRS 1D end of 2006

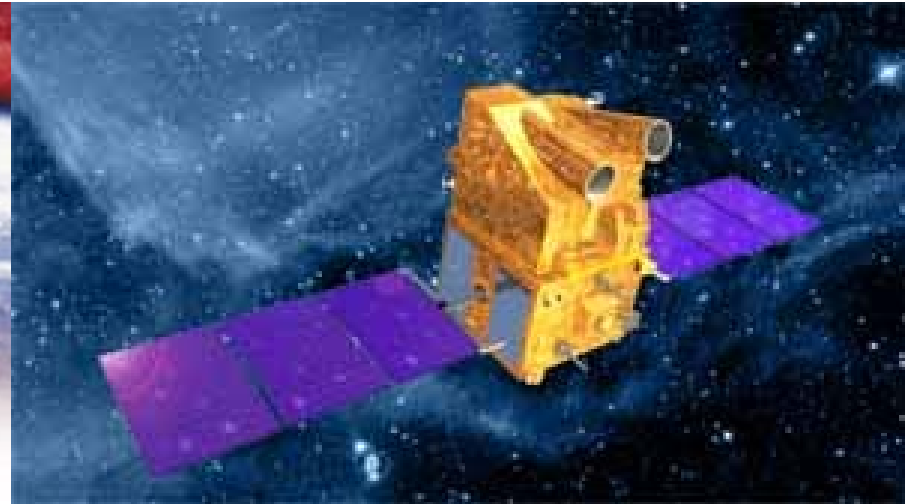
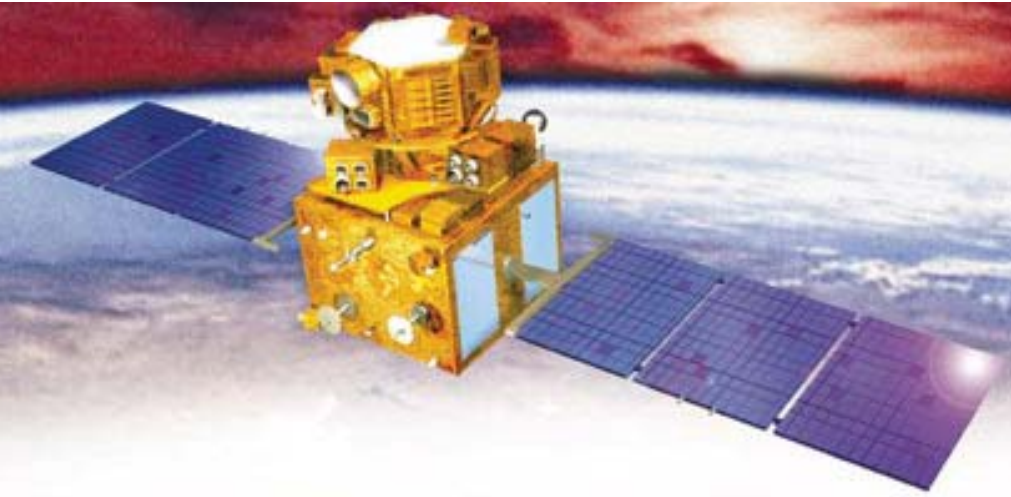
The IRS-P4 (Oceansat)

The IRS-P4 (Oceansat), the eighth satellite built in India under the indigenous Indian Remote Sensing Satellite program was successfully launched on 26 May 1999 carrying two payloads Ocean Color Monitor (OCM) and Multifrequency Scanning Microwave Radiometer (MSMR).



OCM		MSMR
•Spectral bands (in nanometres):		•Frequencies:(GHz)
1	402-422	06.60
2	433-453	10.65
3	480-500	18
4	500-520	21
5	545-565	
6	660-680	
7	745-785	
8	845-885	
•Spatial resolution: 360m x 236m		•Polarisation: V&H for all frequencies
•FOV: +/- 43 deg.		•Spatial resolution: 120,80,40 and 40 Km
•Swath: 1420 km		•Swath: 1360 km
•Radiometric Quantisation: 12 bits		•Radiometric Resolution: 12 bits
Along track steering +/-20 deg. in steps of 5 deg. to avoid sun glint		

Third Generation



- Resourcesat-1 & 2, Cartosat-1&2
 - 2003 to 2012

IRS Resourcesat (P6) Mission Objectives



- To provide continued remote sensing data services on an operational basis for integrated land and water resource management with enhanced multi-spectral / spatial coverage and stereo imaging.
- To further carry out studies in advanced areas of user applications such as improved urban planning, national security, crop discrimination, crop yield, forestry and disaster management.

Resourcesat-1 Salient Features

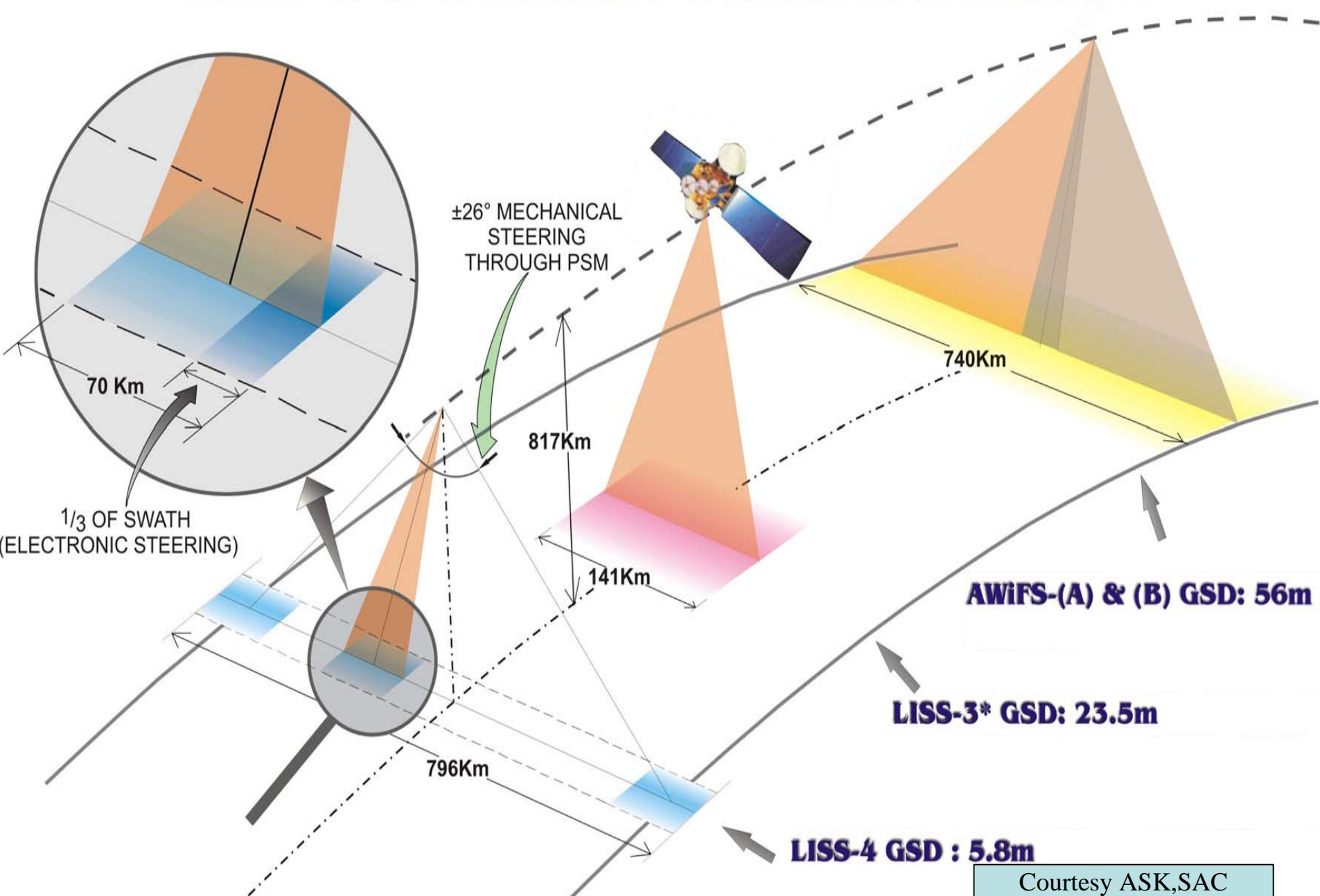
Orbit :	Circular Polar Sun Synchronous
Orbit height :	821 km
Orbit inclination :	98.76°
Orbit period :	101.35 min
Number of Orbits per day :	14
Local Time of Equator crossing :	10.30 a.m.
Repetivity (LISS-3) :	24 days (341 orbits)
Revisit (LISS-4) :	5 days
Lift-off Mass :	1,360 kg
Attitude and Orbit Control :	3-axis body stabilized using Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters
Power :	Solar Array generating 1250 W (at EOL), Two 24 Ah Ni-Cd batteries
Mission Life :	5 years (launched 10/17/03)

Resourcesat-1 Payloads



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
Quantisation (bits)	7	7	10
Square Wave Response (at Nyquist)	>0.20	B2 > 0.40 B3 > 0.40 B4 > 0.35 B5 > 0.20	B2 > 0.40 B3 > 0.40 B4 > 0.35 B5 > 0.20
Power (W)	216	70	114
Weight (kg)	169.5	106.1	103.6
Data Rate (MBPS)	105	52.5	52.5

IRS-P6 THREE TIER IMAGING



Courtesy ASK,SAC

Cartosat Mission Objectives



- To design and develop an advanced 3-axis body stabilized remote sensing satellite for providing enhanced spatial resolution with stereo imaging capability for cartographic applications.
- To further stimulate new areas of user applications in the areas of cartographic applications, urban management, national security, disaster assessment and relief planning and management, environmental assessment and other GIS applications.

Cartosat-1 Salient Features

Orbit :	Circular Polar Sun Synchronous
Orbit height :	~618 km
Orbit inclination :	98.87°
Orbit period	97 min
Number of Orbits per day :	15
Local Time of Equator crossing :	10.30 a.m.
Orbital Repetivity Cycle	126 days
Nominal Wait Time to Acquire Adj.Path	11 days
Max. Wait Time for Revisit	5 days
Data Rate	105 Mb/s
Solid state storage	120GB
Lift-off Mass :	1,560 kg
Attitude and Orbit Control :	3-axis body stabilized using Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters
Power :	5 sq m Solar Array generating 1100W (End Of Life) Two 24 Ah Ni-Cd batteries
Mission Life :	5-6 years (launched 05/05/05)

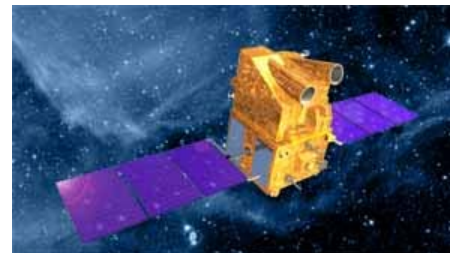
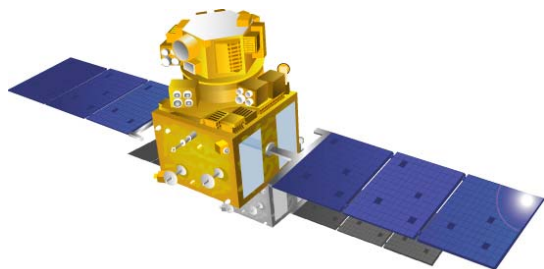
CARTOSAT-1 Payload

Payloads	: Two PAN Cameras (PAN fore mounted with a tilt of +26 deg and PAN aft mounted with a tilt of – 5 deg from the yaw axis to generate stereoscopic imagery)
Instantaneous Geometric Field of View (IGFOV)	: < 2.5 m
Swath	: 30 km
Spectral Band	: 0.50-0.85 Micron
Data rate	: 105 Mbps for each camera
Solid State Recorder	: 120 GB capacity for image data storage



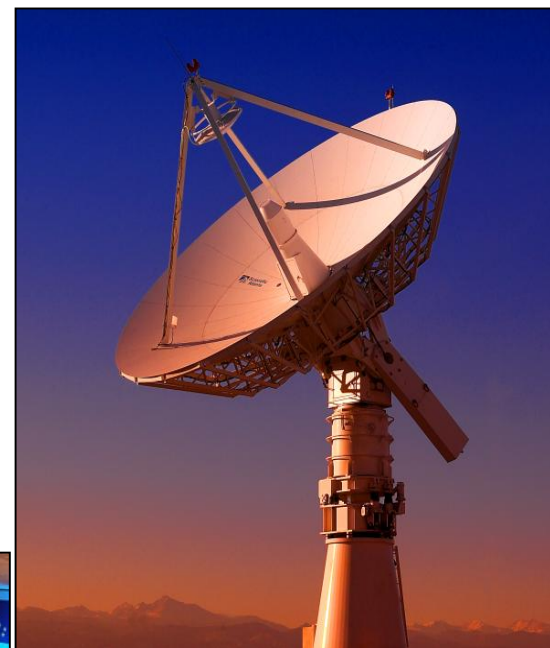
*CARTOSAT-1
PAN camera*

Direct International Access



Antrix and its authorized resellers are working with current IGS owners and new organizations to provide access to RESOURCESAT-1 and CARTOSAT-1

Upgrade options to existing IRS 1C & 1D, Landsat, SPOT, Radarsat, ERS, Ikonos, OrbView, and other Ground Stations



TOMORROW

Fourth Generation IRS Satellites



Fourth Generation

- Follow on concepts
 - 2009 to 2018
 - Many systems already under development
- Increased resolution and more bands for Resourcesat Series:
 - AWiFS (A & B) at 25m, 600km swath
 - Liss3 at 23.5m and 2 additional bands
 - Thermal at 70m resolution
 - Liss4 at 5.8m with 1 additional band, 25km swath
- Addition of new sensors with 25km swath
 - Liss5 at 2.5m (PAN)
 - Hyperspectral at 25m resolution (~200 Bands)
 - All with 5 day repeat cycles

Fourth Generation *(continued)*

- Addition of new sensors with 12.5km swath based on 500mm optics
 - Liss4*n* at 2.5m, 3-4 bands, 5 day revisit
 - Liss5*n* at 1.25m PAN, 5 day revisit
 - HSI*n* at 12.5m, 200 bands, 5 day revisit
- Increased resolution for Cartosat Series with 8-10km swath
 - PAN*n* at 1m
 - MSI at 2-4m, 4 bands
 - HSI at 8m, ~200 bands
- RISAT – First IRS SAR system
 - C-Band SAR
 - 10km Spot mode, 240km Scan mode
 - 1m to 50m resolution

CONCLUSIONS

Questions and Answers



Conclusions

- Like other long-term remote sensing programs, ISRO and Antrix are dedicated to providing IRS data through 2018
 - Current systems will be operational thru 2012
 - Fourth Generation systems will carry into 2018
- Availability of key components (e.g., optics) was previously a limiting factor
 - ISRO is no longer constrained by DoS
 - Advanced international cooperative programs are now underway between ISRO and NASA, DLR and others
- Large data users, like USDA, have an opportunity to provide input to ISRO and Antrix
 - Let your voice be heard so the future systems will acquire the remote sensing data sets you require

Thank You !



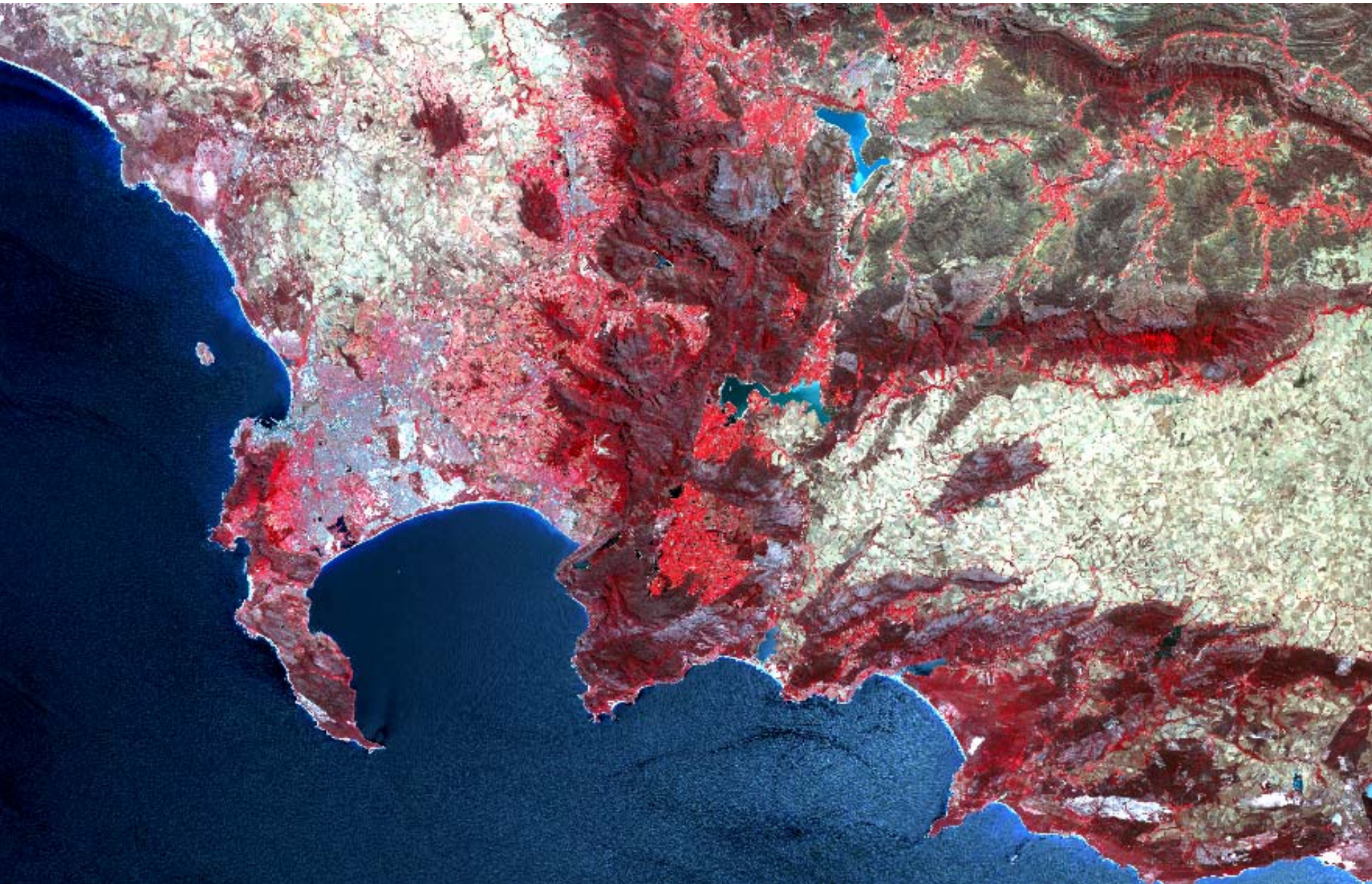
Back Up Slides



Advanced WiFS Camera (AWiFS)

- **Sensor:** 6 K CCD
- **Spectral bands:** 4bands (0.52 - 0.59, 0.62 - 0.68, 0.77 - 0.86 and 1.5 - 1.7 μ)
- **Swath:** 740 Km
- **Ground Resolution:** 56 m at Nadir, 70 m at edge (Average 60m).
- **Radiometric Resolution:** 10 Bits
- **SNR:** > 512
- **BBR:** < 0.25 pixel
- **Repetivity:** 5 days

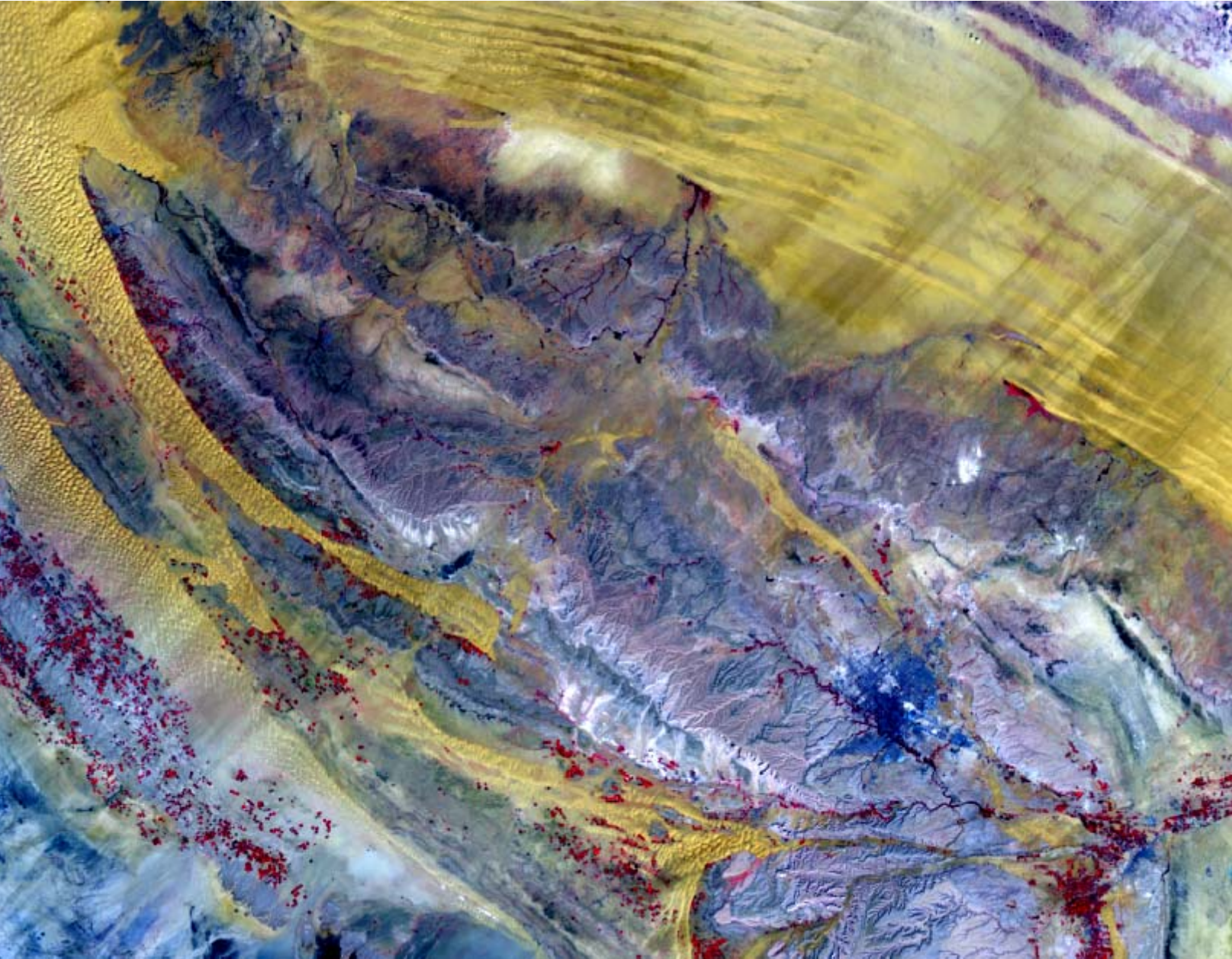
Cape Town, S. Africa- AWiFs



Cape Town, S. Africa-AWiFs

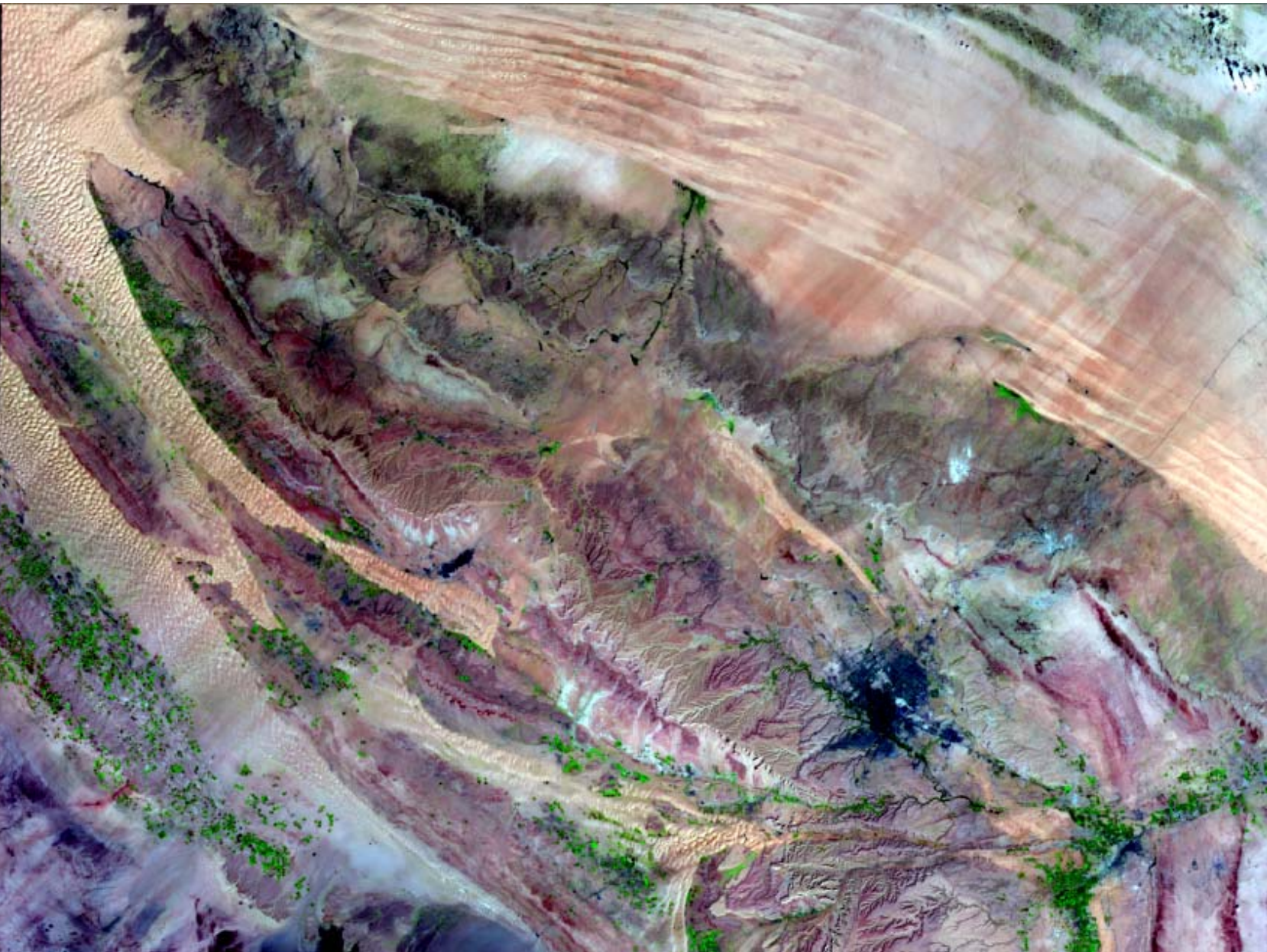


AWiFs Imagery of Saudi Arabia



FCC
Bands
234

AWiFs Imagery of Saudi Arabia



FCC
Bands
345

LISS-3 Sensor

- **Sensor:** 6 K CCD per band
- **Spectral bands:** 4 bands (0.52 - 0.59, 0.62 - 0.68, 0.77 - 0.86 and 1.5 - 1.7 μ)
- **Swath:** 140 Km
- **Ground Resolution:** 23.5 meter pixel in all 4 Bands
- **Radiometric Resolution:** 7 bits selected over 10 bits
- **BBR:** < 0.25 pixel
- **Repetivity:** 24 days

LISS-III 23 meter Multi-spectral

Southern
California



LISS-4 Sensor

- **Sensor:** 12 K CCD per band
- **Spectral bands:** 3 bands (0.52- 0.59, 0.62- 0.68 and 0.77- 0.86 μ)
- **Swath, MSS Mode:** 23.9 km, selectable over 70 Km
- **Swath, Pan Mode:** 70 km in red band
- **Ground Resolution:** 5.8 meter pixel in all 3 bands
- **Radiometric Resolution:** 7 Bits selectable over 10bits
- **Steering Capability:** \pm 26 degrees
- **Revisit Capability:** 5 days

Kuwait City, LISS 4 MX



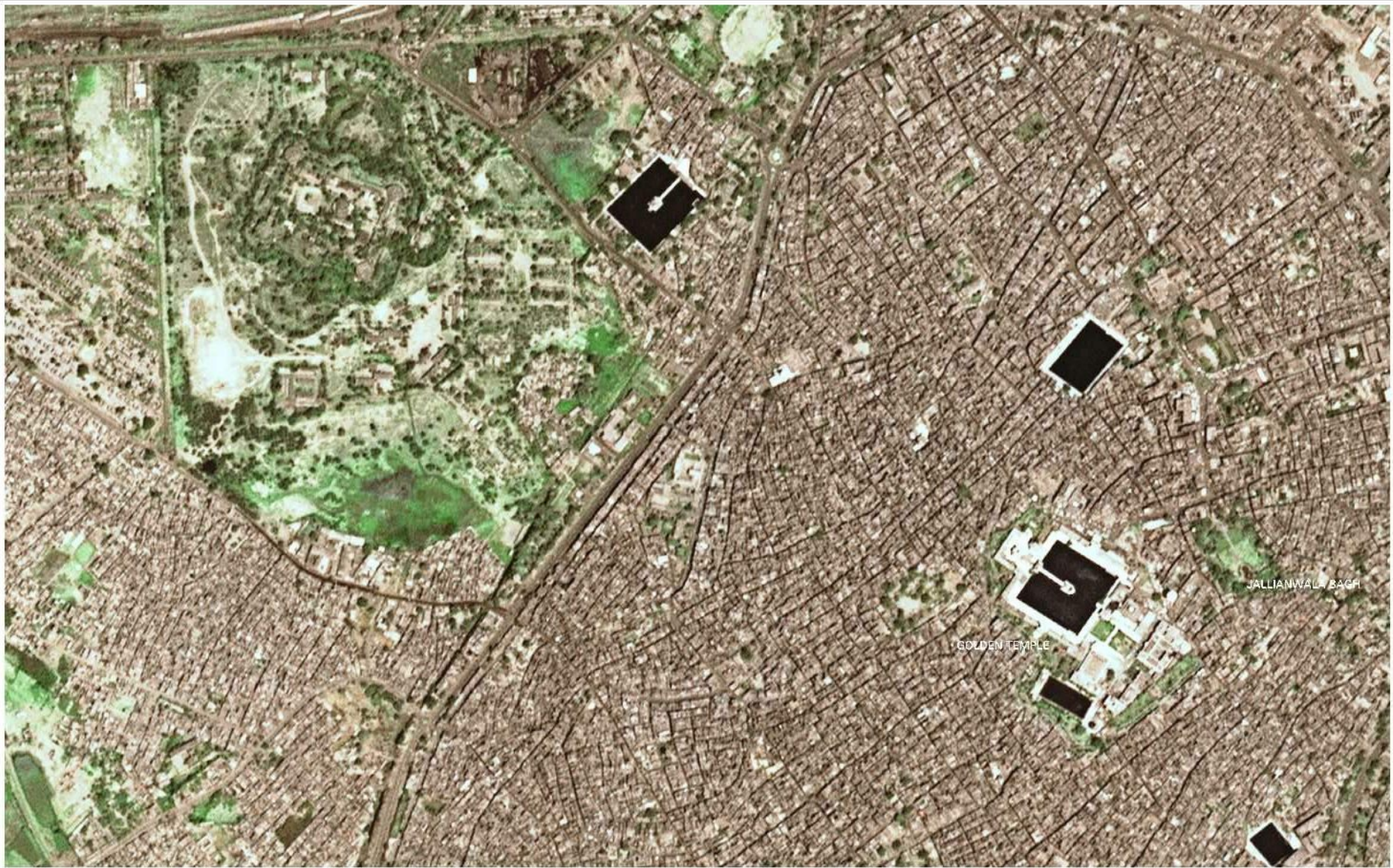
Palm Island Dubai, L4 MX



Tiananmen Square, Beijing, China



INITIAL IMAGE OF CARTOSAT-1 GOLDEN TEMPLE, AMRITSAR



JALLIANWALA BACH

GOLDEN TEMPLE

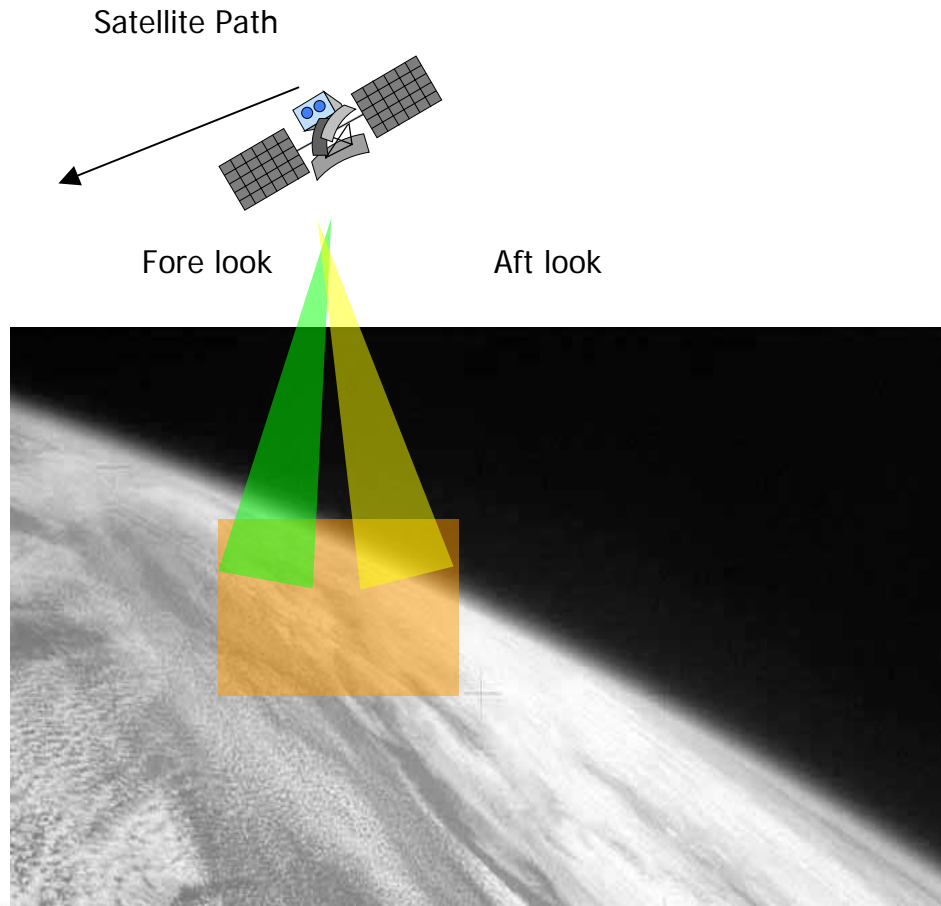
SENSOR : PAN-AFT + IRSP6-L4MX MERGED
ACQUIRED ON : PAN-AFT : 08-MAY-2005
L4-MX : 03-MAR-2004



BEST COMPLIMENTS FROM
NRSA / DOS

Cartosat-1 PAN Sensor

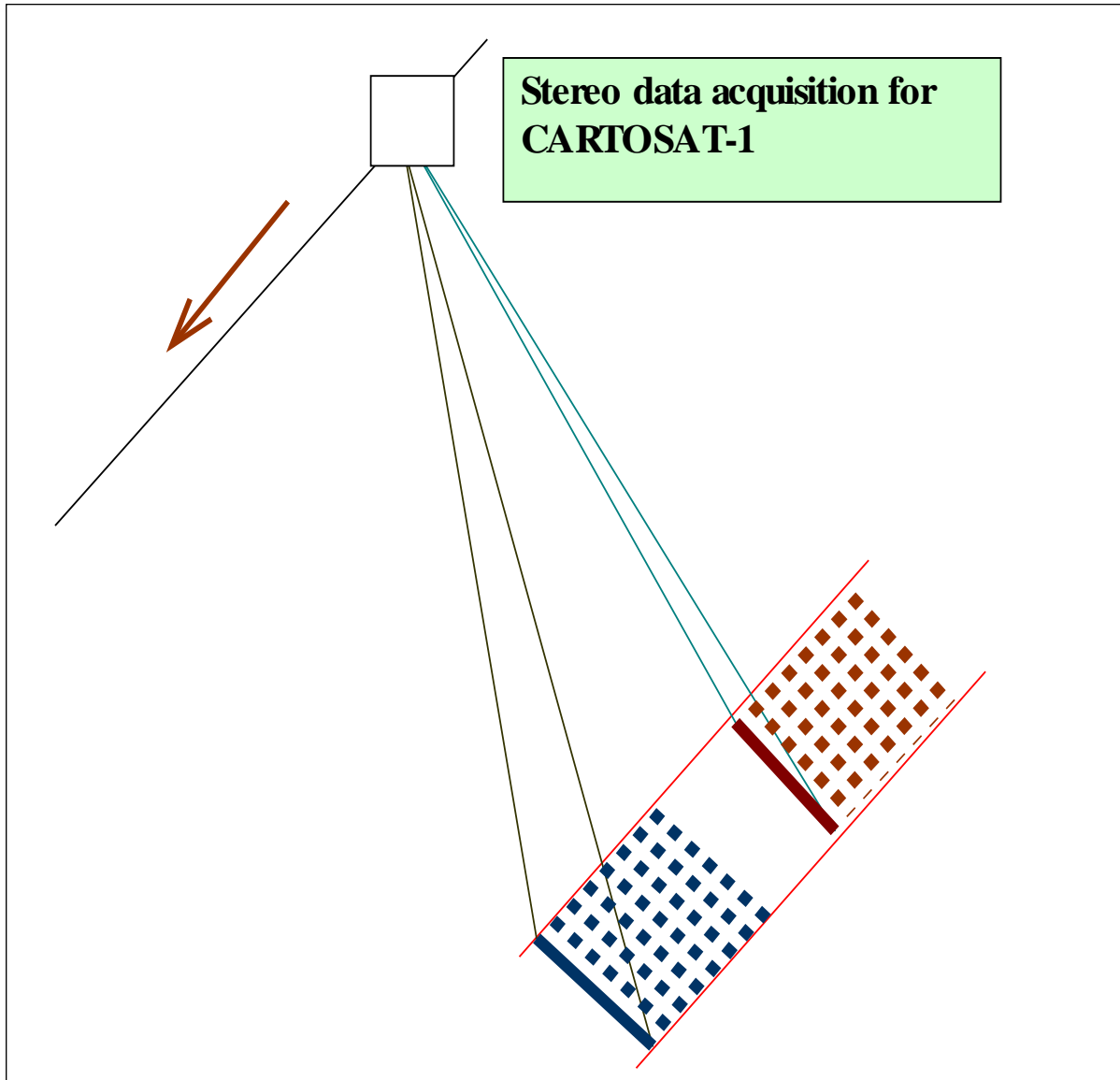
Real time stereo viewing



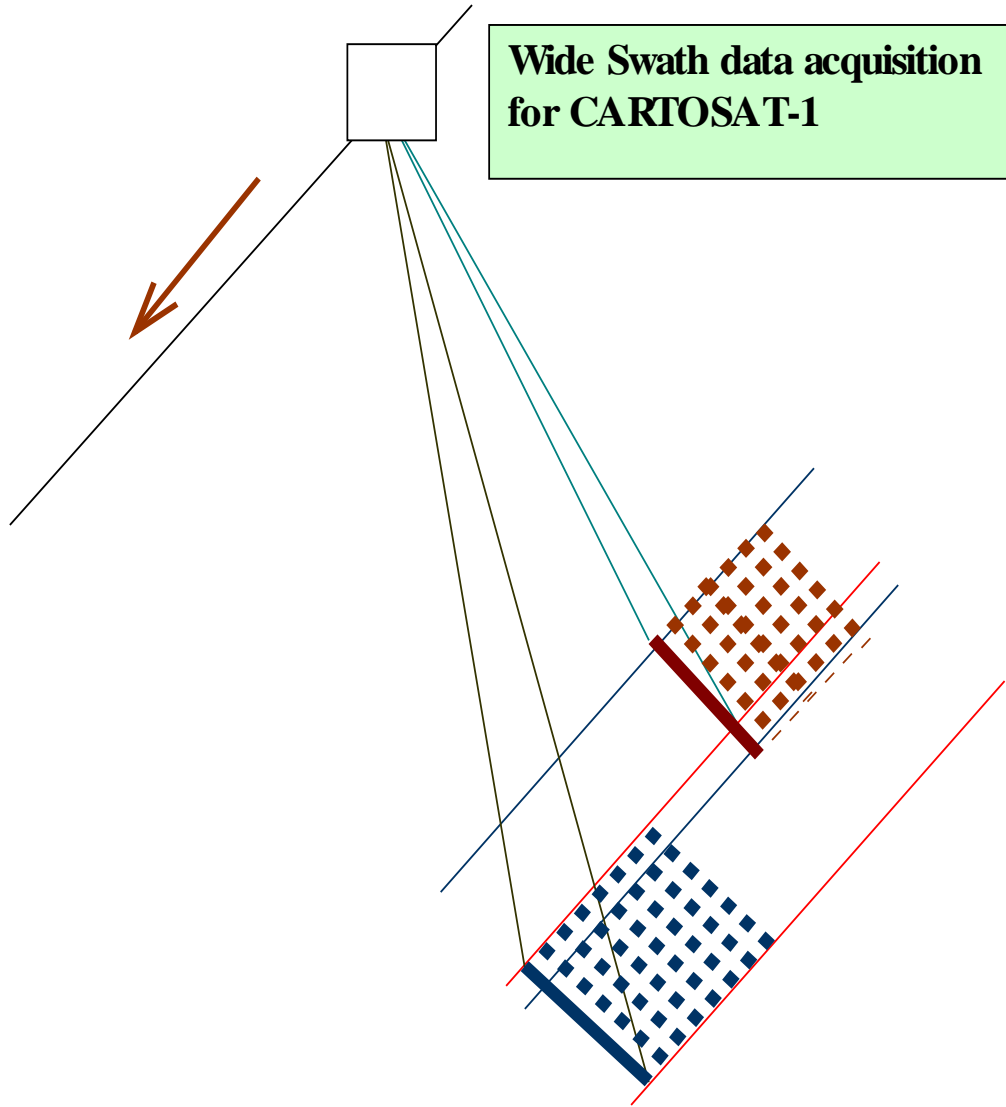
- Better than 2.5 m resolution
- Two Pan cameras - fore with 26 deg. and aft with -5 deg. Tilt(500 nm- 850 nm)
- Swath 27.5 km for stereo and 55 km for monoscopic mode.
- 8 km overlap between adjacent paths
- 10 bits
- Facility for across track tilt to give better revisit

MODES OF ACQUISITION

- STEREO MODE- The two cameras with +26 and -5 deg tilted to image the area along the track to generate the stereoscopic images
- MONO MODE- (Wide Swath)- Wide swath is covered by using both the For and Aft cameras in mono mode



**Wide Swath data acquisition
for CARTOSAT-1**



NEW ELEMENTS – In Data products

- AOI BASED DATA PRODUCTS
- PRODUCTS COMPATIBLE TO LARGE SCALE MAPPING
- LOCATION ACCURACY WILL BE BETTER THAN 250 m
- LOCATION ACCURACY FOR PRODUCTS GENERATED WITH SST WILL BE BETTER THAN 25 m.
- PRECISION PRODUCTS WITH HIGH ACCURACY
- DIGITAL ELEVATION MODEL PRODUCTS ARE ALSO PLANNED
- DEFAULT OPTION OF WGS-84 DATUM
- CASSINENI PROJECTION FOR LARGER SCALES
- DATA DISSEMINATION IN NEAR REAL TIME THROUGH COMMERCIALY AVAILABLE NETWORK

Cartosat-1 Data Products Available from NRSA, India

AOI Based products (MONO and Stereo) - Digital data

- User Area Of Interest is given as multiple scenes - different dates of acquisitions,
-which are tiled but not Radiometrically matched
- Minimum area of 25*25 Sq Km.
- Location accuracy will be better than 250m.
- These products are supplied as :
 - Radiometrically Corrected- LGSOWG format- CD-ROM/DVD (MONO & Stereo) with RPC File
 - Systematic - GEOTIFF format- CD-ROM/DVD (MONO)
 - Ortho Kit – With Systematic corrections and RPC file- Fast Format- CD-ROM/DVD(MONO)

Cartosat-1 Data Products(Contd.,)

Precision Georeferenced Products

- These are mosaiced Ortho rectified products best Radiometric match is attempted
- Location Accuracy will be better than 25 m

Area Coverage <u>Map sheet based /Float</u>	Level of processing	Photoprints Scale	Digital Data Format/Media
7.5' * 7.5' (14 Km * 14 Km) <u>Float</u>	Ortho	1:25,000	GEOTIFF(RGB)/CDROM
5' * 5' (9 Km * 9 Km)	Ortho	1:12,500	GEOTIFF/CDROM
2.25' * 2.25' (4 Km * 4 Km)	Ortho	1:5,000	GEOTIFF/CDROM
3.75' * 3.75'	Ortho	1:10,000	GEOTIFF/CDROM



Cartosat-1 Data Products (Contd.,)

Merged Georeferenced Products

Sensors: IRS-P6(L-IV MX)+ IRS-P5 (2.5 m color)

Area Coverage	Level of processing	Photoprints Scale	Digital Data Format/Media
<u>Float</u> 5' * 5' (9 Km * 9 Km)	Ortho	1:12,500	GEOTIFF/CDROM
2.25' * 2.25' (4 Km * 4 Km)	Ortho	1:5,000	GEOTIFF/CDROM
3.75' * 3.75'	Ortho	1:10,000	GEOTIFF/CDROM

San Diego, Airport, USA



San Diego, USA



Denver, Downtown, USA



