

**EOTec**



**Resourcesat-1**



**Cartosat-1**

## Indian Remote Sensing Satellites

*- Current & Future Missions -*

Presented by:  
Timothy J. Puckorius  
Chairman & CEO  
EOTec

- India's Earth Observation Heritage
- Current IRS Satellite Missions
  - Resourcesat-1 (IRS-P6)
    - Multispectral broad area coverage
  - Cartosat-1 (IRS-P5)
    - Real-time Stereo mapping
  - Cartosat-2 (IRS-P7)
    - High-Resolution imaging at 0.81m
- Future IRS Satellite Missions
  - Current Status on Resourcesat-2
- Conclusions

**1995/1997**



IRS-1C/1D LISS-3 (23/70M,  
STEERABLE PAN (5.8 M);  
WiFS (188M)

**1999**



INSAT-2E CCD  
(1KM RESOLUTION;  
EVERY 30 MNUTESS)

**2003**



**RESOURCESAT-1**  
LISS3 - 23 M; 4 XS  
LISS4 - 5.8 M; 3-  
XS

**1996**



IRS-P3  
WiFS MOS  
X-Ray

**1994**



IRS-P2  
LISS-2

**1999**



IRS-P4  
OCEANSAT OCM, MSMR

**2005**



**CARTOSAT - 1**  
PAN - 2.5M, 30 KM,  
F/A

**1988/91**



IRS-1A/1B LISS-1&2 (72/36M,  
4 BANDS; VIS & NIR)

**1982**



RS-D1

**1979**



BHASKARA

## INDIAN IMAGING SYSTEMS

### IMAGING IMPROVEMENTS

- ◆ 1KM TO 0.81 M RESOLUTION
- ◆ GLOBAL COVERAGE
- ◆ APPLICATION-SPECIFIC

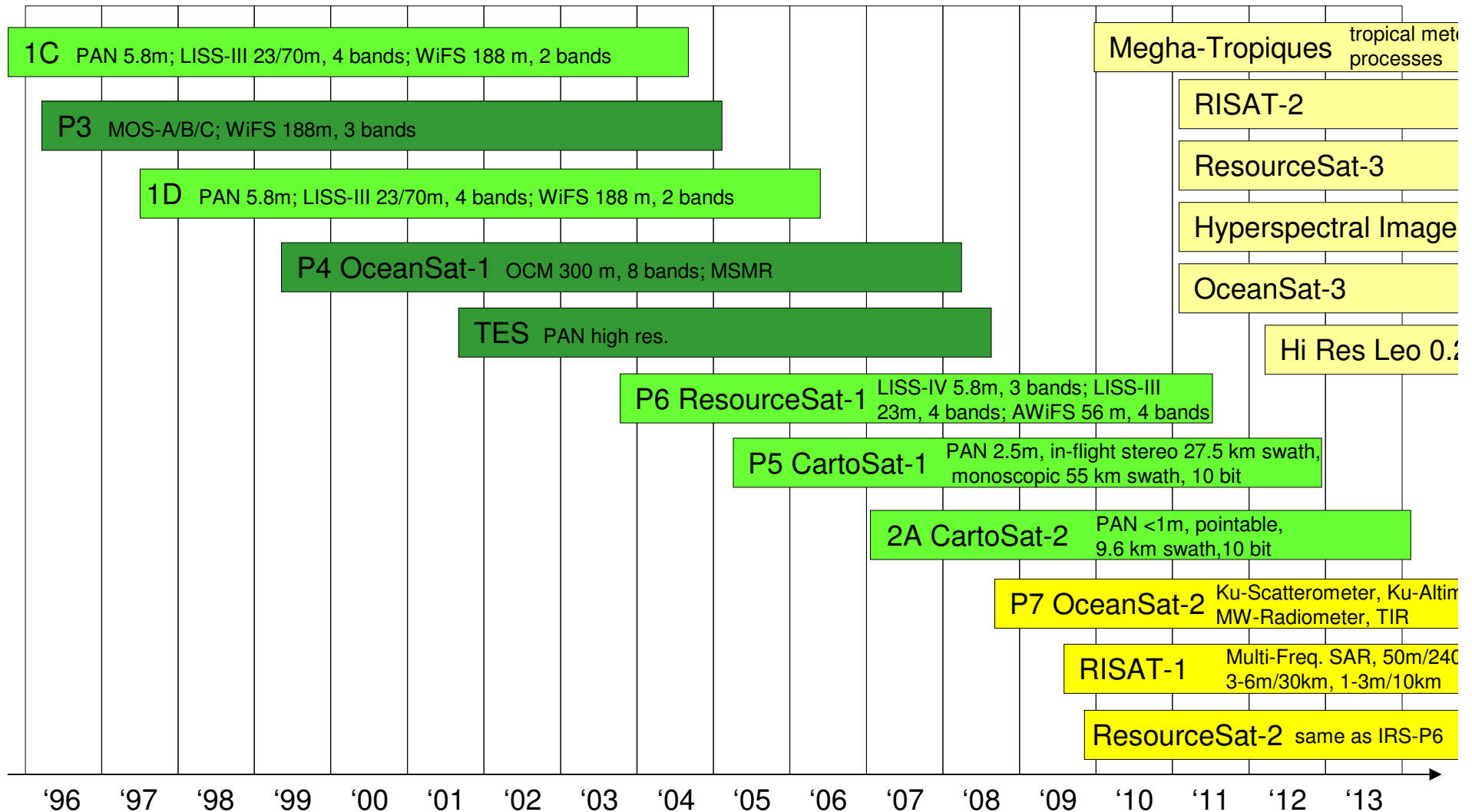
**2007**



**CARTOSAT-2**  
PAN - 1M



**MEGHA-  
TROPIQUES**  
**SAPHIR**  
**SCARAB &  
MADRAS**





## Current IRS Missions

Resourcesat-1

Cartosat-1

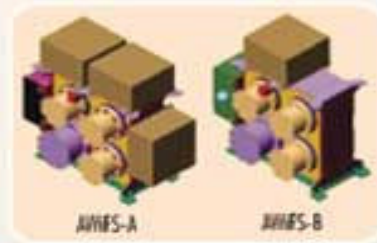
Cartosat-2

EO Tec

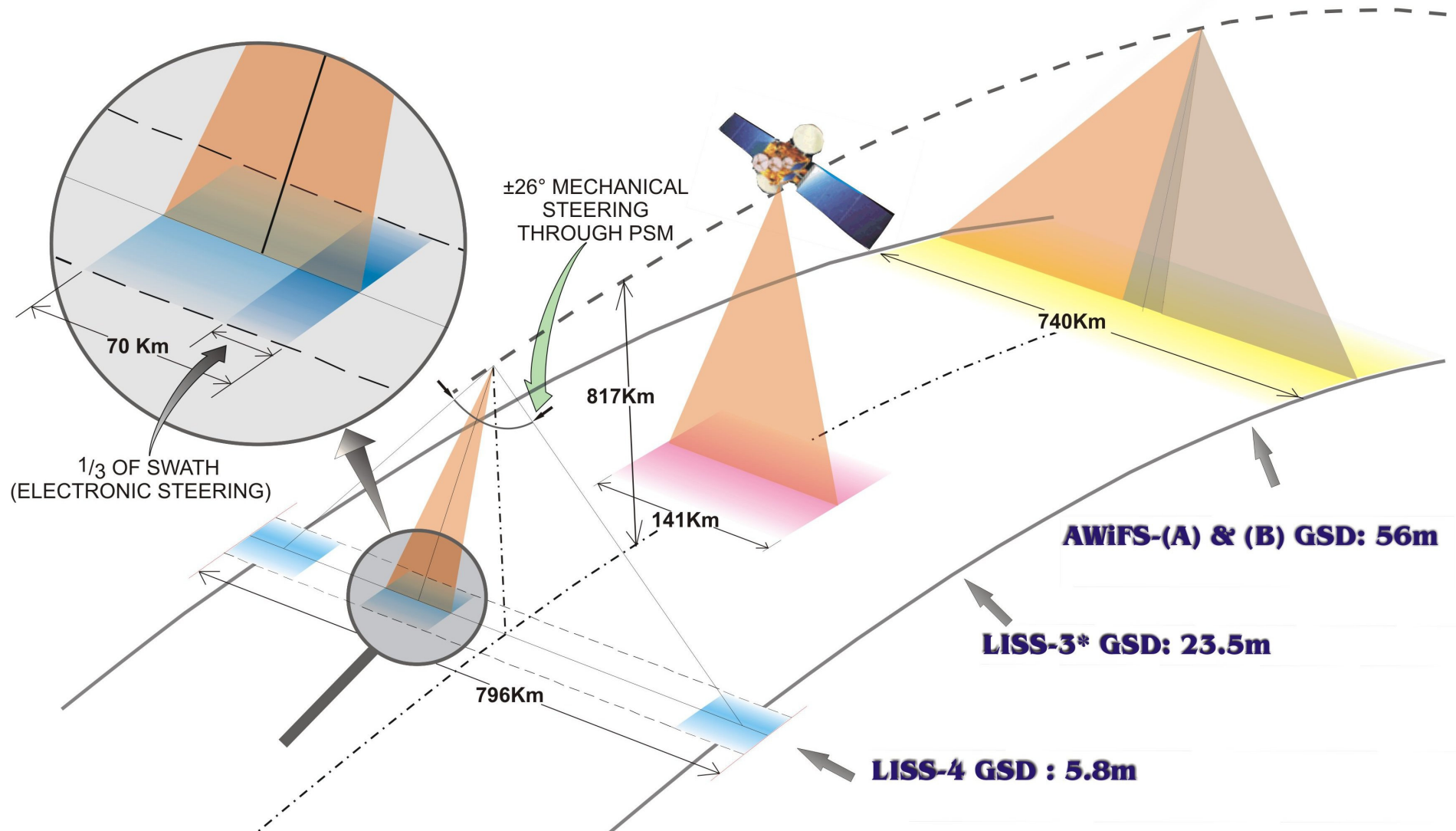


Resourcesat-1  
(IRS-P6)

|                                         |                                                                                                |
|-----------------------------------------|------------------------------------------------------------------------------------------------|
| <b>Orbit :</b>                          | <b>Circular Polar Sun Synchronous</b>                                                          |
| <b>Orbit height :</b>                   | <b>821 km</b>                                                                                  |
| <b>Orbit inclination :</b>              | <b>98.76°</b>                                                                                  |
| <b>Orbit period :</b>                   | <b>101.35 min</b>                                                                              |
| <b>Number of Orbits per day :</b>       | <b>14</b>                                                                                      |
| <b>Local Time of Equator crossing :</b> | <b>10.30 a.m.</b>                                                                              |
| <b>Repetivity (LISS-3) :</b>            | <b>24 days (341 orbits)</b>                                                                    |
| <b>Revisit (AWiFS) :</b>                | <b>5 days</b>                                                                                  |
| <b>Lift-off Mass :</b>                  | <b>1,360 kg</b>                                                                                |
| <b>Attitude and Orbit Control :</b>     | <b>3-axis body stabilized using Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters</b> |
| <b>Power :</b>                          | <b>Solar Array generating 1250 W (at EOL), Two 24 Ah Ni-Cd batteries</b>                       |
| <b>Mission Life :</b>                   | <b>5-7 years</b>                                                                               |
| <b>Launch Dates :</b>                   | <b>Resourcesat-1 launched on 10-17-03<br/>Resourcesat-2 scheduled for Q3 2009</b>              |

|                                   |  |  |  |
|-----------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| PAYLOADS                          | LISS-4                                                                             | LISS-3                                                                              | AWiFS                                                                               |
| Spatial Resolution (m)            | 5.8                                                                                | 23.5                                                                                | 56                                                                                  |
| Swath (km)                        | 23.9 (MX mode)<br>70.3 (PAN mode)                                                  | 141                                                                                 | 740                                                                                 |
| Spectral Bands (micron)           | 0.52-0.59<br>0.62-0.68<br>0.77-0.86                                                | 0.52-0.59<br>0.62-0.68<br>0.77-0.86<br>1.55-1.70                                    | 0.52-0.59<br>0.62-0.68<br>0.77-0.86<br>1.55-1.70                                    |
| Quantisation (bits)               | 7                                                                                  | 7                                                                                   | 10                                                                                  |
| Square Wave Response (at Nyquist) | $>0.20$                                                                            | B2 $>0.40$<br>B3 $>0.40$<br>B4 $>0.35$<br>B5 $>0.20$                                | B2 $>0.40$<br>B3 $>0.40$<br>B4 $>0.35$<br>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



| Satellite     | Sensor | Km <sup>2</sup><br>Per Second | Km <sup>2</sup><br>Per Minute | Scenes/Day<br>(@ 8 mins/day) |
|---------------|--------|-------------------------------|-------------------------------|------------------------------|
| Resourcesat-1 | LISS-4 | ~ 462 km <sup>2</sup>         | ~ 27,720 km <sup>2</sup>      | ~ 221,760 km <sup>2</sup>    |
|               | LISS-3 | ~ 931 km <sup>2</sup>         | ~ 55,836 km <sup>2</sup>      | ~ 446,688 km <sup>2</sup>    |
|               | AWiFS  | ~ 4,884 km <sup>2</sup>       | ~ 293,040 km <sup>2</sup>     | ~ 2,344,320 km <sup>2</sup>  |

| Sensor                                     | IRS-1C/1D<br>PAN | IRS-P6<br>LISS-IV |
|--------------------------------------------|------------------|-------------------|
| Mode                                       |                  | Mono              |
| Spatial<br>resolution                      | 5.8 m            | 5.8 m             |
| Swath-width                                | 70 km            | 70 km             |
| Radiometric<br>Resolution,<br>Quantisation | 6 bit            | 7 bit             |
| Spectral<br>coverage                       | 500 – 750 nm     | 620-680 nm        |
| Number of<br>CCD arrays                    | 3                | 1                 |

Better radiometric  
resolution

Red instead of pan-  
chromatic band

Only one array, leads to  
better internal geometry

Suitable for mapping, mobile phone cell planning

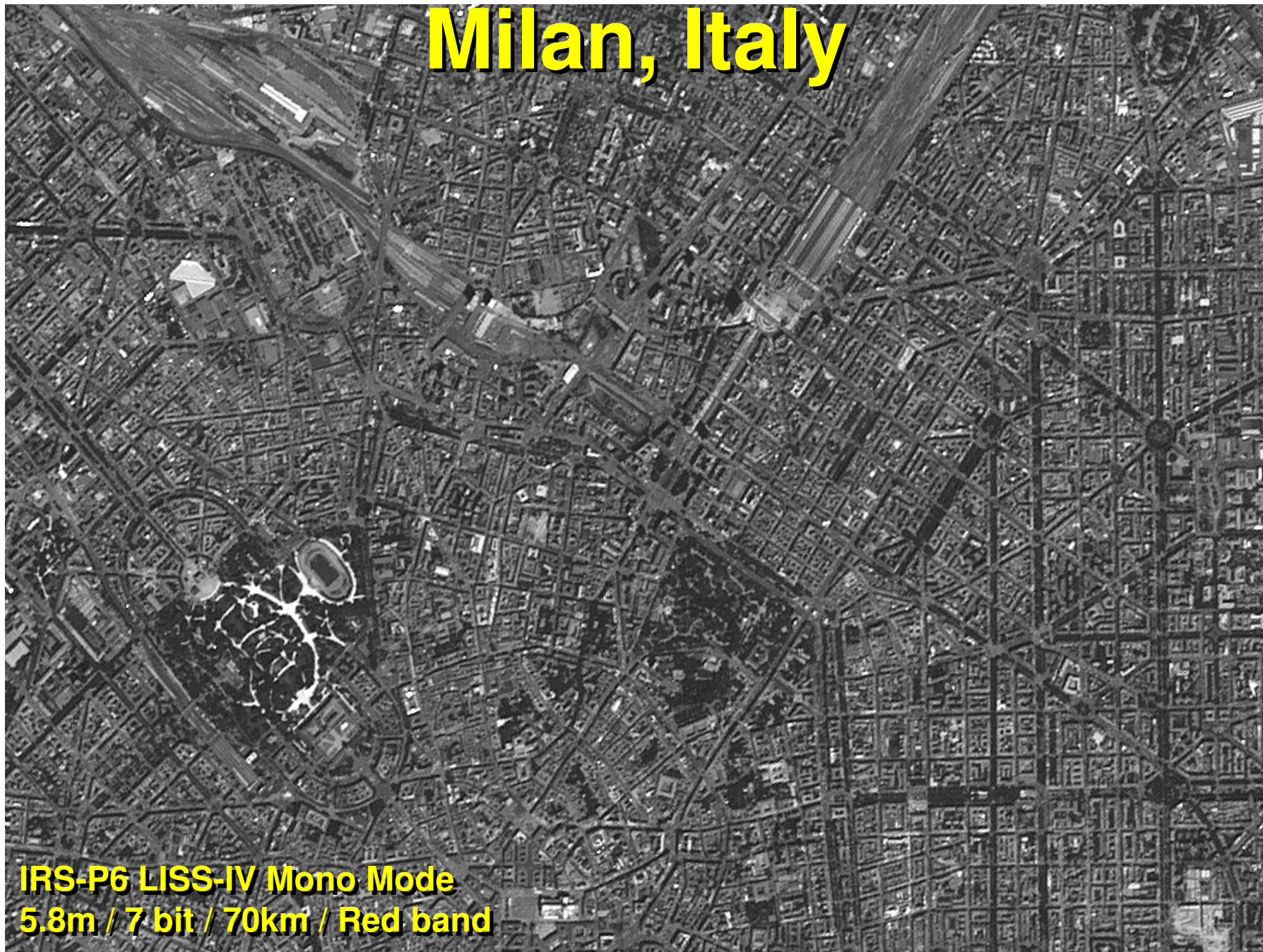
- The LISS-IV camera can be operated either in monochromatic or multi spectral mode.

| Sensor                                          |           |       | LISS-IV    |            | LISS-III     | AWiFS        |
|-------------------------------------------------|-----------|-------|------------|------------|--------------|--------------|
| Mode                                            |           |       | Mono       | MX         |              |              |
| Spatial resolution                              | B2        | green | 5.8 m      | 5.8 m      | 23.5 m       | 56 m .. 70 m |
|                                                 | B3        | red   |            | 5.8 m      | 23.5 m       | 56 m .. 70 m |
|                                                 | B4        | NIR   |            | 5.8 m      | 23.5 m       | 56 m .. 70 m |
|                                                 | B5        | SWIR  |            |            | 23.5 m       | 56 m .. 70 m |
| Swath-width                                     |           |       | 70 km      | 23.9 km    | 140 km       | 740 km       |
| Radiometric Resolution, Quantisation            | all Bands |       | 7 bit      | 7 bit      | 7 bit        | 10 bit       |
| Spectral coverage                               | B2        | green | 620-680 nm | 520-590 nm | 520-590 nm   | 520-590 nm   |
|                                                 | B3        | red   |            | 620-680 nm | 620-680 nm   | 620-680 nm   |
|                                                 | B4        | NIR   |            | 770-860 nm | 770-860 nm   | 770-860 nm   |
|                                                 | B5        | SWIR  |            |            | 1550-1700 nm | 1550-1700 nm |
| CCD arrays (number of arrays * No. of elements) | B2        | green | 1 * 12000  | 1 * 12000  | 1 * 6000     | 2 * 6000     |
|                                                 | B3        | red   |            | 1 * 12000  | 1 * 6000     | 2 * 6000     |
|                                                 | B4        | NIR   |            | 1 * 12000  | 1 * 6000     | 2 * 6000     |
|                                                 | B5        | SWIR  |            |            | 1 * 6000     | 2 * 6000     |

- **Agriculture**
  - Crop monitoring and condition assessment
  - Crop canopy water stress
  - Crop yield estimates
  - Damage assessment
- **Forestry**
  - Inventory and updating
  - Encroachment
  - Habitat analysis
  - Fire damage
- **Environmental Monitoring**
  - Land use
  - Soil contamination
  - Desertification analysis
  - Oil Spills and disaster monitoring
  - Environmental impact assessments
- **Geology and Exploration**
  - Rock type mapping
  - Mining pollution assessments
  - Coal fire analysis
  - Landslide vulnerability / risk
- **Infrastructure and Utilities**
  - Road networks
  - 3D city models
  - Structural and hydrological inventory
  - Utility corridor mapping
  - Change detection
- **Cartography / Mapping**
- **National Security**

# Milan, Italy

**IRS-P6 LISS-IV Mono Mode**  
**5.8m / 7 bit / 70km / Red band**

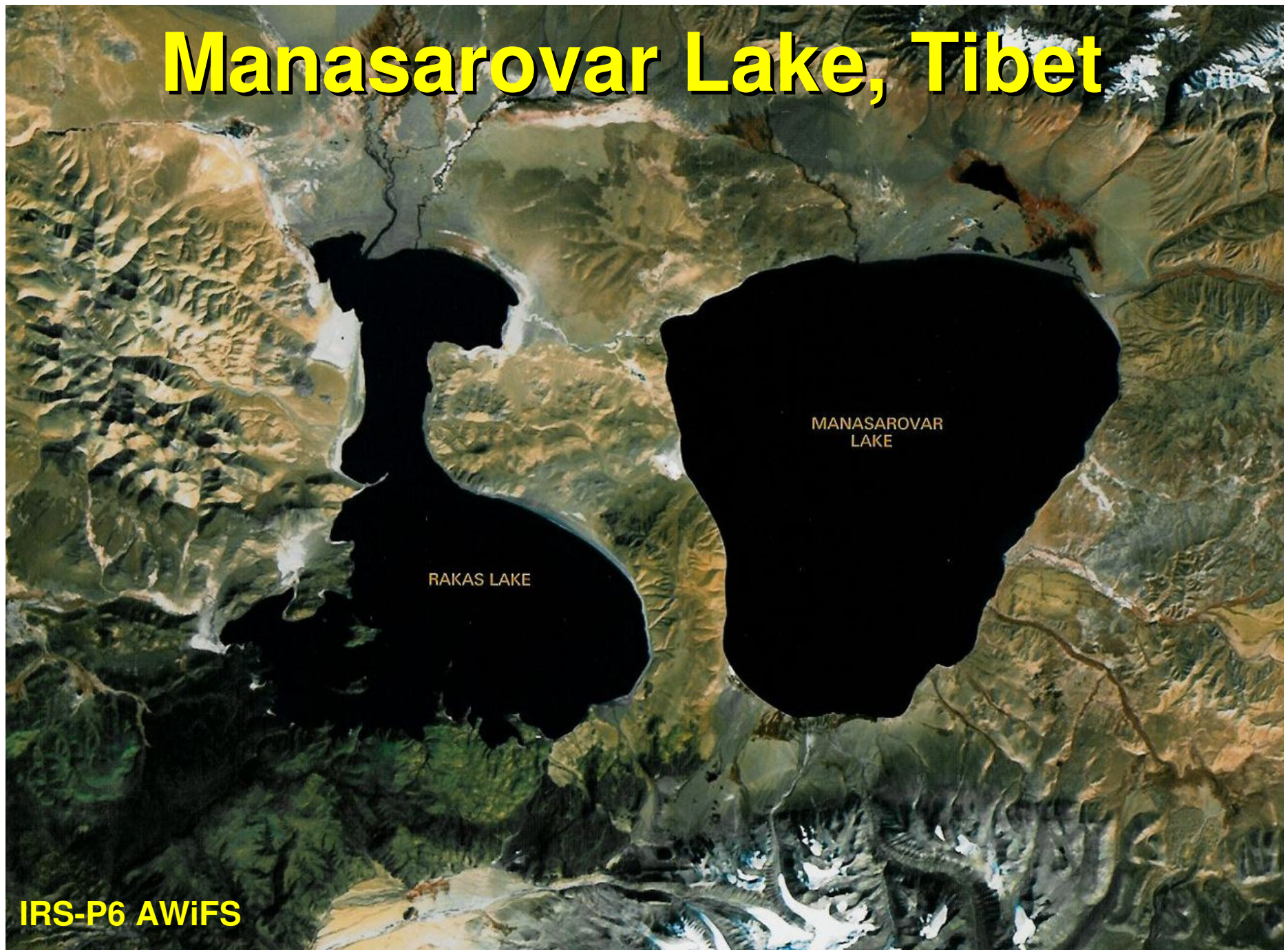


# Palm Island, Dubai



IRS-P6 LISS-IV  
5.8m / 7 bit / 70km

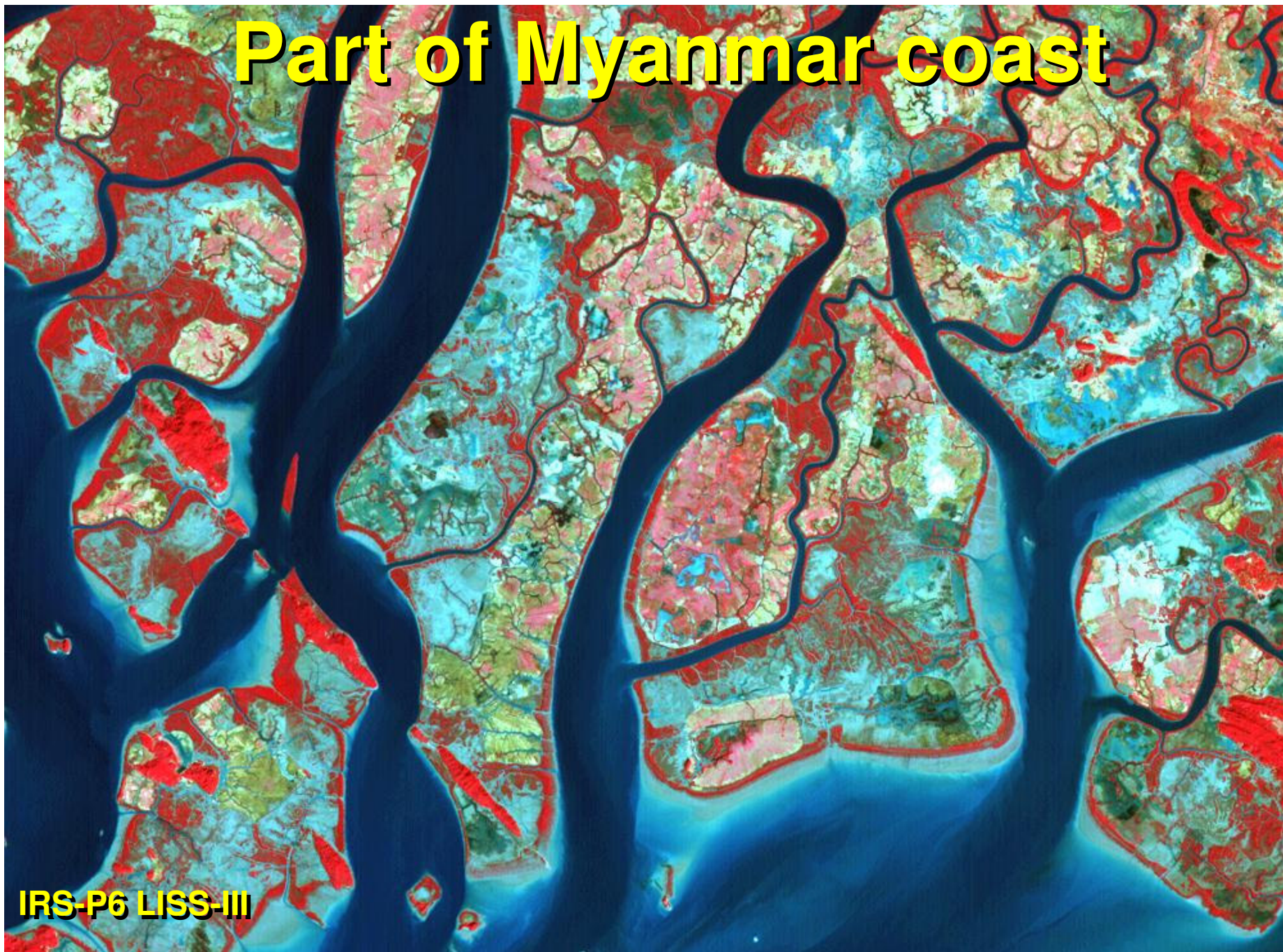
# Manasarovar Lake, Tibet



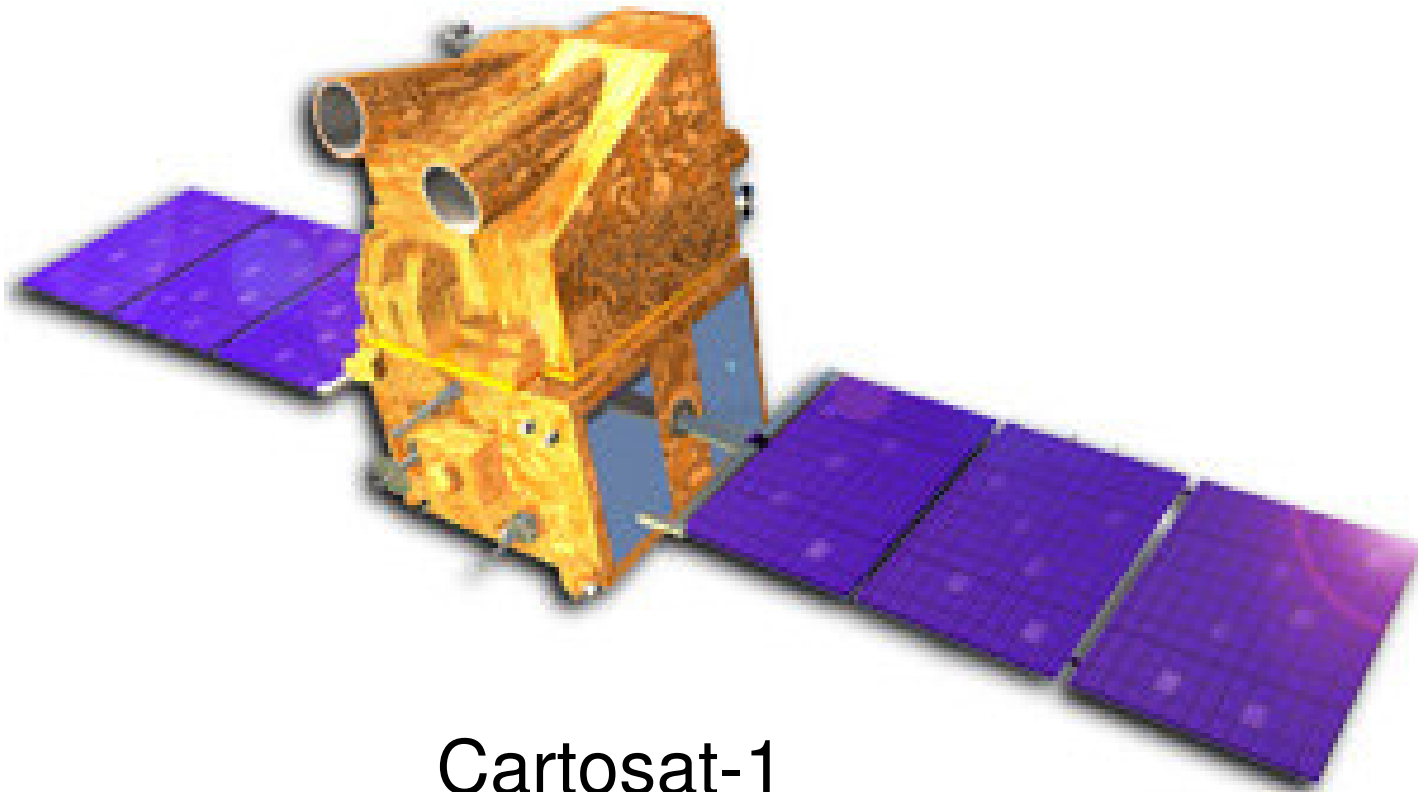
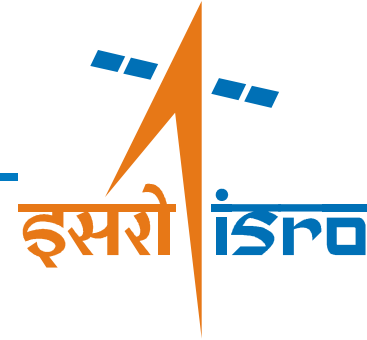
IRS-P6 AWiFS

# Part of Myanmar coast

IRS-P6 LISS-III



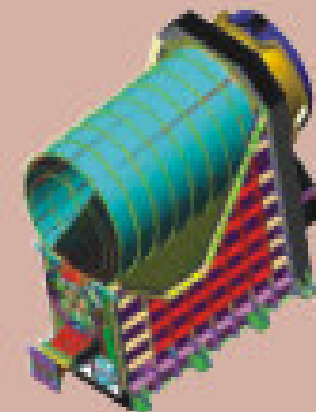
EO Tec



Cartosat-1  
(IRS-P5)

|                                                     |                                                                                                |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------|
| <b>Orbit :</b>                                      | <b>Circular Polar Sun Synchronous</b>                                                          |
| <b>Orbit height :</b>                               | <b>~618 km</b>                                                                                 |
| <b>Orbit inclination :</b>                          | <b>98.87°</b>                                                                                  |
| <b>Orbit period :</b>                               | <b>97 min</b>                                                                                  |
| <b>Number of Orbits per day :</b>                   | <b>15</b>                                                                                      |
| <b>Local Time of Equator crossing :</b>             | <b>10.30 a.m.</b>                                                                              |
| <b>Orbital Repetivity Cycle :</b>                   | <b>126 days</b>                                                                                |
| <b>Nominal Wait Time to Acquire Adjacent Path :</b> | <b>11 days</b>                                                                                 |
| <b>Max. Wait Time for Revisit :</b>                 | <b>5 days</b>                                                                                  |
| <b>Data Rate :</b>                                  | <b>105 Mb/s</b>                                                                                |
| <b>Solid state storage:</b>                         | <b>120GB</b>                                                                                   |
| <b>Lift-off Mass :</b>                              | <b>1,560 kg</b>                                                                                |
| <b>Attitude and Orbit Control :</b>                 | <b>3-axis body stabilized using Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters</b> |
| <b>Power :</b>                                      | <b>5 sq m Solar Array generating 1100W (End Of Life)<br/>Two 24 Ah Ni-Cd batteries</b>         |
| <b>Mission Life :</b>                               | <b>5 – 7 years (launched 05/05/05)</b>                                                         |

|                                                  |                                                                                                                                                                       |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Payloads                                         | : Two PAN Cameras<br>(PAN fore mounted with a tilt of +26 deg<br>and PAN aft mounted with a tilt of<br>– 5 deg from the yaw axis to generate<br>stereoscopic imagery) |
| Instantaneous Geometric Field<br>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*

# EOTec Cartosat-1 Additional Specs



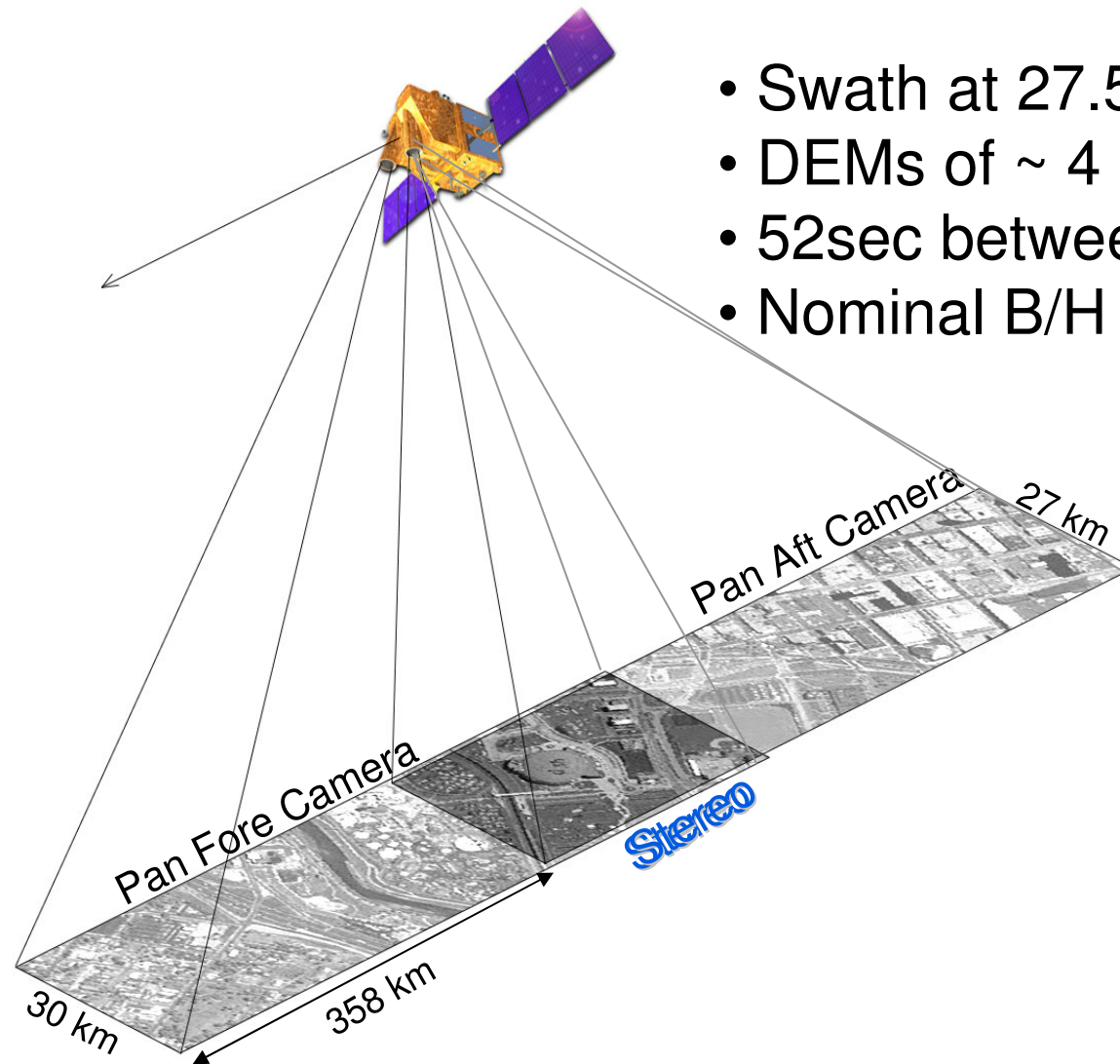
- Cartosat-1 has two (2) panchromatic cameras for in flight stereo viewing
- Stereo data is provide to ground stations in *Real-Time*

| Sensor                                                | PAN Fore   | PAN Aft    |
|-------------------------------------------------------|------------|------------|
| Tilt Along Track                                      | +26°       | -5°        |
| Spatial Resolution                                    | 2.5 m      | 2.5 m      |
| Swath-width                                           | 30 km      | 27 km      |
| Radiometric Resolution,<br>Quantisation               | 10 bit     | 10 bit     |
| Spectral coverage                                     | 500-850 nm | 500-850 nm |
| CCD arrays<br>(number of arrays * No. of<br>elements) | 1 * 12000  | 1 * 12000  |

- Revisit capability is 5 days (by rolling on axis  $\pm 23^\circ$ )

**NOTE:** See the accuracy assessment study of DEMs produced from Cartosat-1 Data done by the USGS (The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. 34, Part XXX)

| Satellite         | Sensor               | Km <sup>2</sup><br>Per Second | Km <sup>2</sup><br>Per Minute | Scenes/Day<br>(@ 8 mins/day) |
|-------------------|----------------------|-------------------------------|-------------------------------|------------------------------|
| <b>Cartosat-1</b> | PAN Camera<br>(Fore) | ~ 190 km <sup>2</sup>         | ~ 11,385 km <sup>2</sup>      | ~ 91,080 km <sup>2</sup>     |
|                   | PAN Camera<br>(Aft)  | ~ 190 km <sup>2</sup>         | ~ 11,385 km <sup>2</sup>      | ~ 91,080 km <sup>2</sup>     |



- Swath at 27.5 km
- DEMs of ~ 4 m elevation accuracy
- 52sec between cameras ~ 358 km
- Nominal B/H ratio 0.62

# Denver, CO

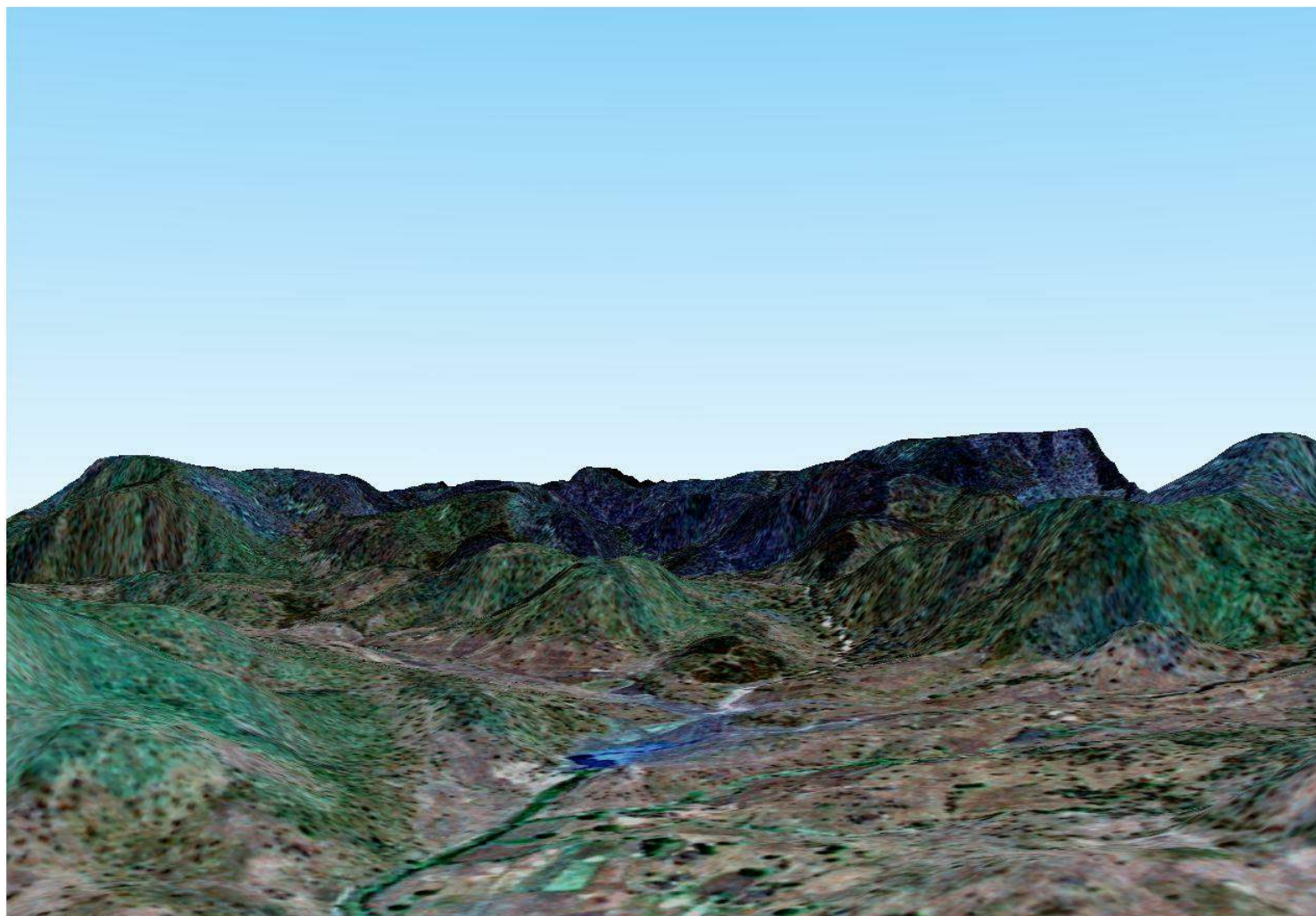


IRS-P5 / PAN-A / 2.5m / 10 bit



# INITIAL IMAGE OF CARTOSAT-1

## 3D PERSPECTIVE VIEWS OF KHED BRAHMA, GUJARAT



NATURAL COLOR COMPOSITE IMAGE OF  
CARTOSAT-1 PAN-AFT + IRS-P6 LISS-IV MX

ACQUIRED ON:

CARTOSAT-1 PAN : 08-MAY-2005  
IRS-P6 LISS-IV MX : 27-MAR-2004

BEST COMPLIMENTS FROM  
NRSA / DOS

EO Tec



Cartosat-2



*CARTOSAT-2 Spacecraft with its solar panels in stowed condition*

Launched 1/10/07

|                               |                                                                                                                   |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Altitude                      | : 630 km                                                                                                          |
| Inclination                   | : 97.91 deg                                                                                                       |
| Period                        | : 97.4 min                                                                                                        |
| Local time at descending node | : 9.30 am                                                                                                         |
| Orbits/day                    | : 14                                                                                                              |
| Revisit                       | : 4 days                                                                                                          |
| Repetivity                    | : 310 days                                                                                                        |
| Lift-off Mass                 | : 680 kg                                                                                                          |
| Attitude and Orbit Control    | : 3-axis body stabilised<br>using high torque<br>Reaction Wheels,<br>Magnetic Torquers and<br>Hydrazine Thrusters |
| Power                         | : Solar Array Generating<br>900 W, Two 18 Ah<br>Ni-Cd batteries                                                   |
| Payload                       | : Panchromatic<br>camera (PAN)                                                                                    |
| Operational Life              | : 5 years                                                                                                         |
| <b>PAN specifications</b>     |                                                                                                                   |
| Resolution                    | : <b>0.81m</b>                                                                                                    |
| Swath                         | : About 9.6 km                                                                                                    |
| Spectral Band                 | : 0.5 – 0.85 micrometre                                                                                           |
| Data rate                     | : 336 MBPS                                                                                                        |
| Solid State Recorder          | : 64 GB capacity for<br>image data storage                                                                        |

**Resolution/Swath:**

Panchromatic: 0.80m at 9.6km

**Solid Stage Recorder:**

64 GB; 138 Images of 9.6km X 9.6km

**10 Bit Detector Dynamic Range****Max Data Rate:**

105 MBPS / X-Band Downlink

**Maximum Area Imaged per 12 min Pass:**

0.82m GSD (Mono): 8832 km<sup>2</sup>

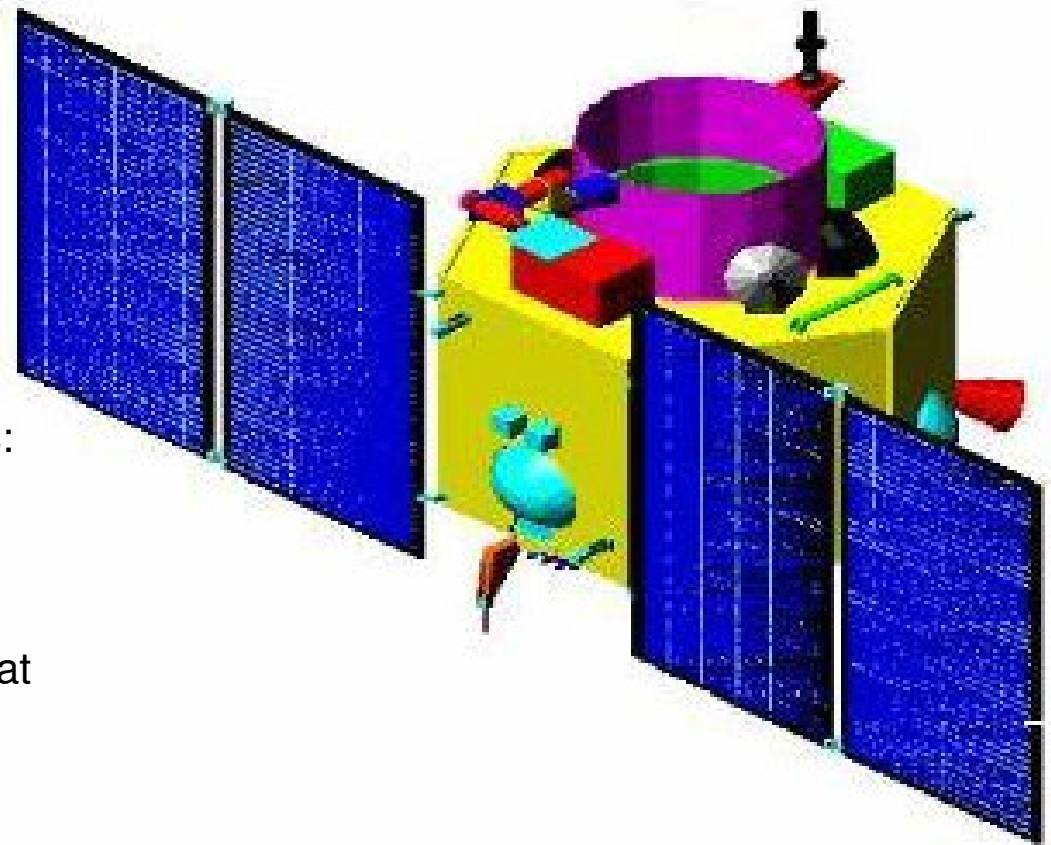
**Revisit Time:** 4/5 days at equator

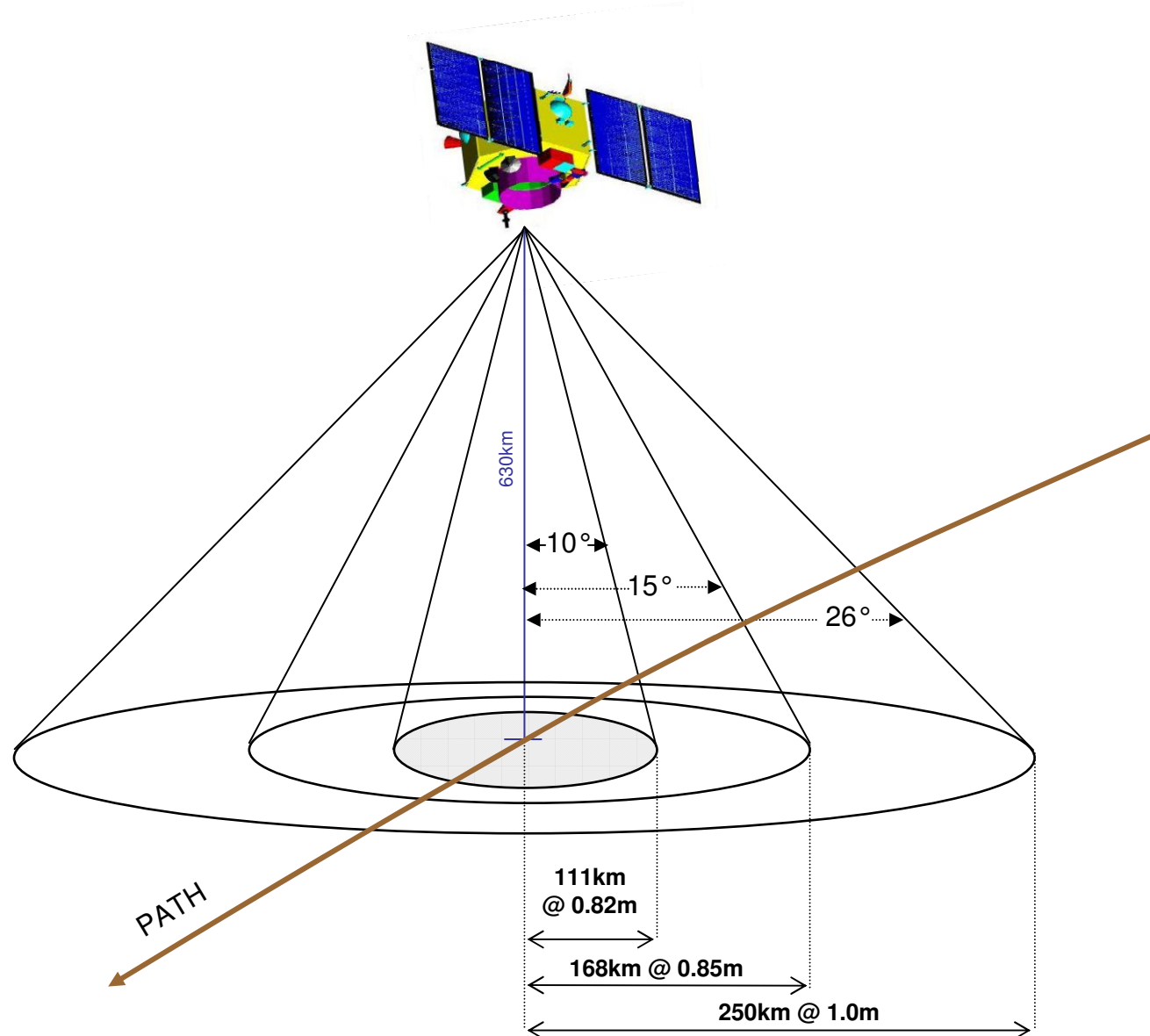
**Orbit:** 630km / 97.922° Sun Synchronous at  
9.30 A.M Local time

**Launch Mass:** 680 Kgs

**Launched Date:** January 10, 2007

**Design Life:** Minimum 5 years











## Future IRS Missions

Resourcesat-2 thru  $n$

Cartosat-3 thru  $n$

Radar

HSI

- **Resourcesat-2**

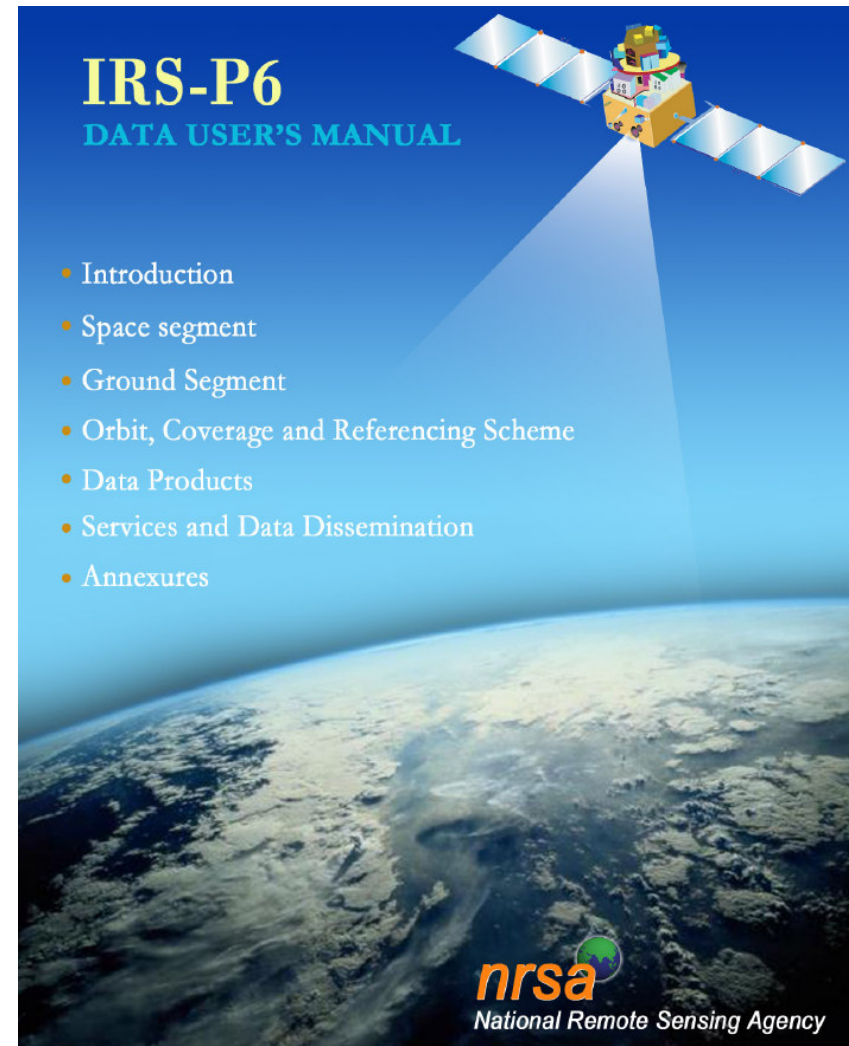
- Virtually identical to Resourcesat-1 (with a few sensor enhancements)
- Assures data continuity through 2015
- Resourcesat-2 Enhancements include:
  - Miniaturization of some structures and payload electronics
  - 10 Bit quantization for all data sets/sensors
  - OBSSR enlarged to 400 GB
- Current status:
  - All mainframe systems in advance stages of completion
  - AWiFS and LISS-3 optics fabrication in process
  - LISS-4 electronics and telescope mirror delivered
- Launch scheduled for Q3-2009

|                                   |                                                                                    |                                                                                     |                                                                                     |
|-----------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                                   |  |  |  |
| <b>PAYLOADS</b>                   | <b>LISS-4</b>                                                                      | <b>LISS-3</b>                                                                       | <b>AWiFS</b>                                                                        |
| Spatial Resolution (m)            | 5.8                                                                                | 23.5                                                                                | 56                                                                                  |
| Swath (km)                        | 23.9 (MX mode)<br>70.3 (PAN mode)                                                  | 141                                                                                 | 740                                                                                 |
| Spectral Bands (micron)           | 0.52-0.59<br>0.62-0.68<br>0.77-0.86                                                | 0.52-0.59<br>0.62-0.68<br>0.77-0.86<br>1.55-1.70                                    | 0.52-0.59<br>0.62-0.68<br>0.77-0.86<br>1.55-1.70                                    |
| Quantisation (bits)               | 10                                                                                 | 10                                                                                  | 10                                                                                  |
| Square Wave Response (at Nyquist) | >0.20                                                                              | B2>0.40<br>B3>0.40<br>B4>0.35<br>B5>0.20                                            | B2>0.40<br>B3>0.40<br>B4>0.35<br>B5>0.20                                            |
| Power (W)                         | 216                                                                                | 70                                                                                  | 114                                                                                 |
| Weight (kg)                       | 169.5                                                                              | 106.1                                                                               | 103.6                                                                               |
| Data Rate (MBPS)                  | 105                                                                                | 52.5                                                                                | 52.5                                                                                |

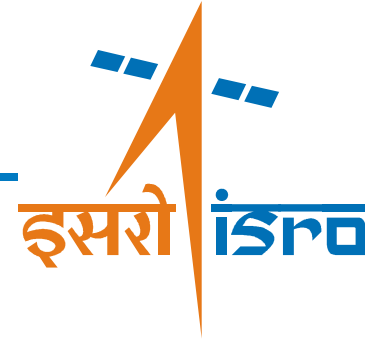
- Resourcesat-3 series
  - Increased resolution and more spectral bands:
    - AWiFS (A & B) at 25m resolution, 600km swath
    - Liss-III at 23.5m resolution and 2 additional bands
      - Thermal at 70m resolution under consideration
    - Liss-IV at 5.8m with 1 additional band, 25km swath
  - Addition of new sensors with 25km swath:
    - Liss-V (PAN) at 2.5m resolution
    - Hyperspectral at 25m resolution (~200 Bands)
    - 5 day revisit cycle
- Resourcesat-4 series
  - Addition of new sensors with 12.5km swath based on 500mm optics:
    - Liss-IV<sub>n</sub> at 2.5m, 3-4 bands, 5 day revisit
    - Liss-V<sub>n</sub> at 1.25m PAN, 5 day revisit
    - HSI<sub>n</sub> at 12.5m, 200 bands, 5 day revisit

- **Cartosat Series:**
  - Increased resolution and more spectral bands:
    - PAN at 0.5m resolution
    - MSI at 2-4m, 4 bands
    - HSI at 8m, ~200 bands
      - Swath at 8-10km
- **RISAT – First IRS SAR system**
  - C-Band SAR
  - 10km swath in Spot mode, 240km swath in Scan mode
  - Resolution at 1m to 50m
  - Single/Dual polarization

- ISRO and Antrix are dedicated to providing IRS data through 2018
  - Current systems will be operational thru 2012
  - Next generation systems will carry into 2018
  - Data continuity is assured
- Resourcesat-2 assures data continuity and improved collection rates while R-1 remains operational
  - Tandem collection potential is under evaluation
- Cartosat-1 provides high-resolution stereo data in real time
  - Competitors do not downlink their stereo data to any ground stations
  - Economically provides **millions** of km<sup>2</sup> of data per day
- Follow on systems are already under development



Available at NRSA's web site: [www.nrса.org.in](http://www.nrса.org.in)



# Thank you!



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