

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)

INDIAN IMAGING SYSTEMS



2007

CARTOSAT-2
PAN - 1M

1982



RS-D1

1979

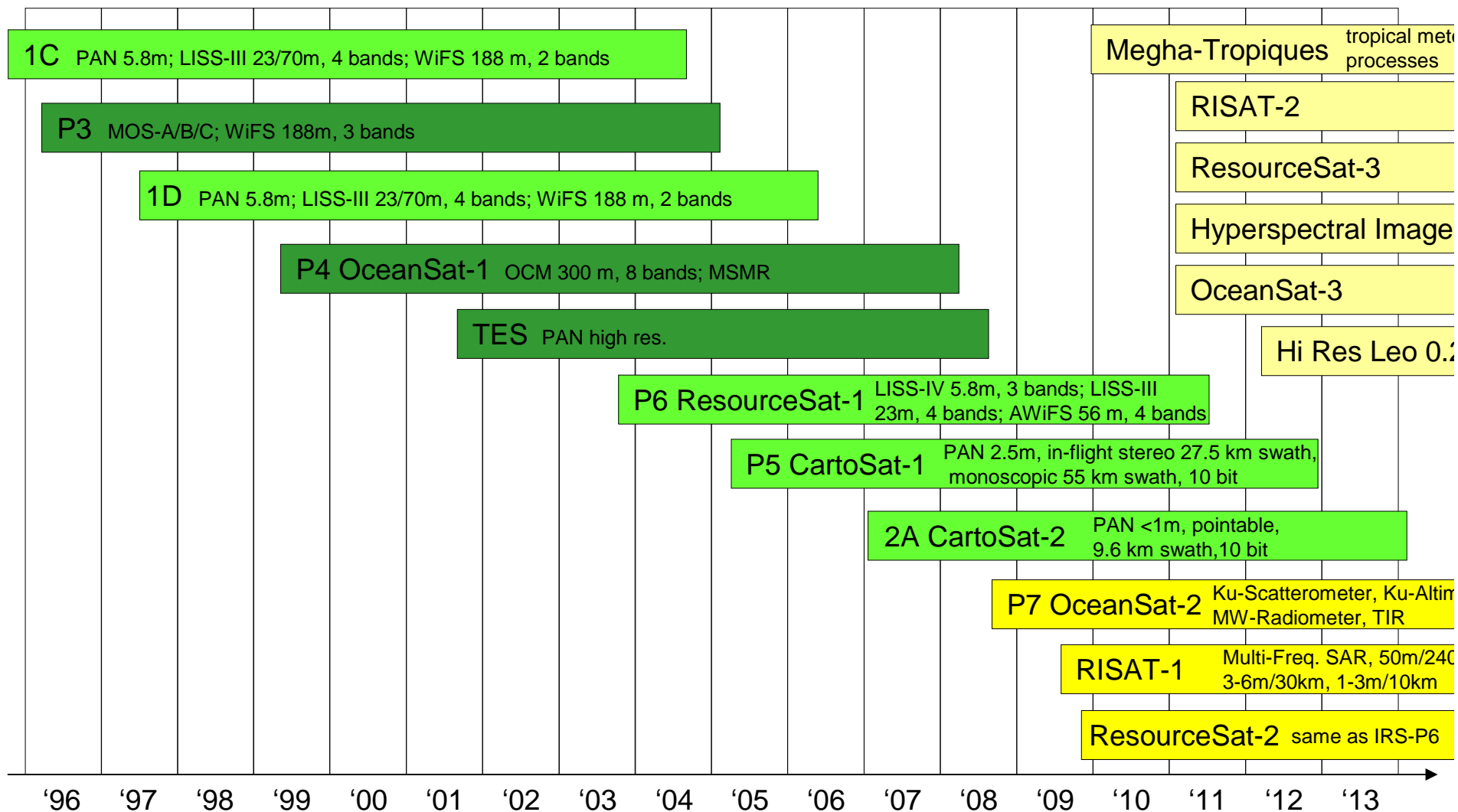


BHASKARA

IMAGING IMPROVEMENTS

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

MEGHA-TROPIQUES
SAPHIR
SCARAB & MADRAS



The logo for EO Tec features the text "EO Tec" in a bold, black, serif font. The letter "O" is stylized with a blue dot above it and a black orbital path that loops around it. The text is flanked by horizontal blue lines on both sides.

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Current IRS Missions

Resourcesat-1

Cartosat-1

Cartosat-2

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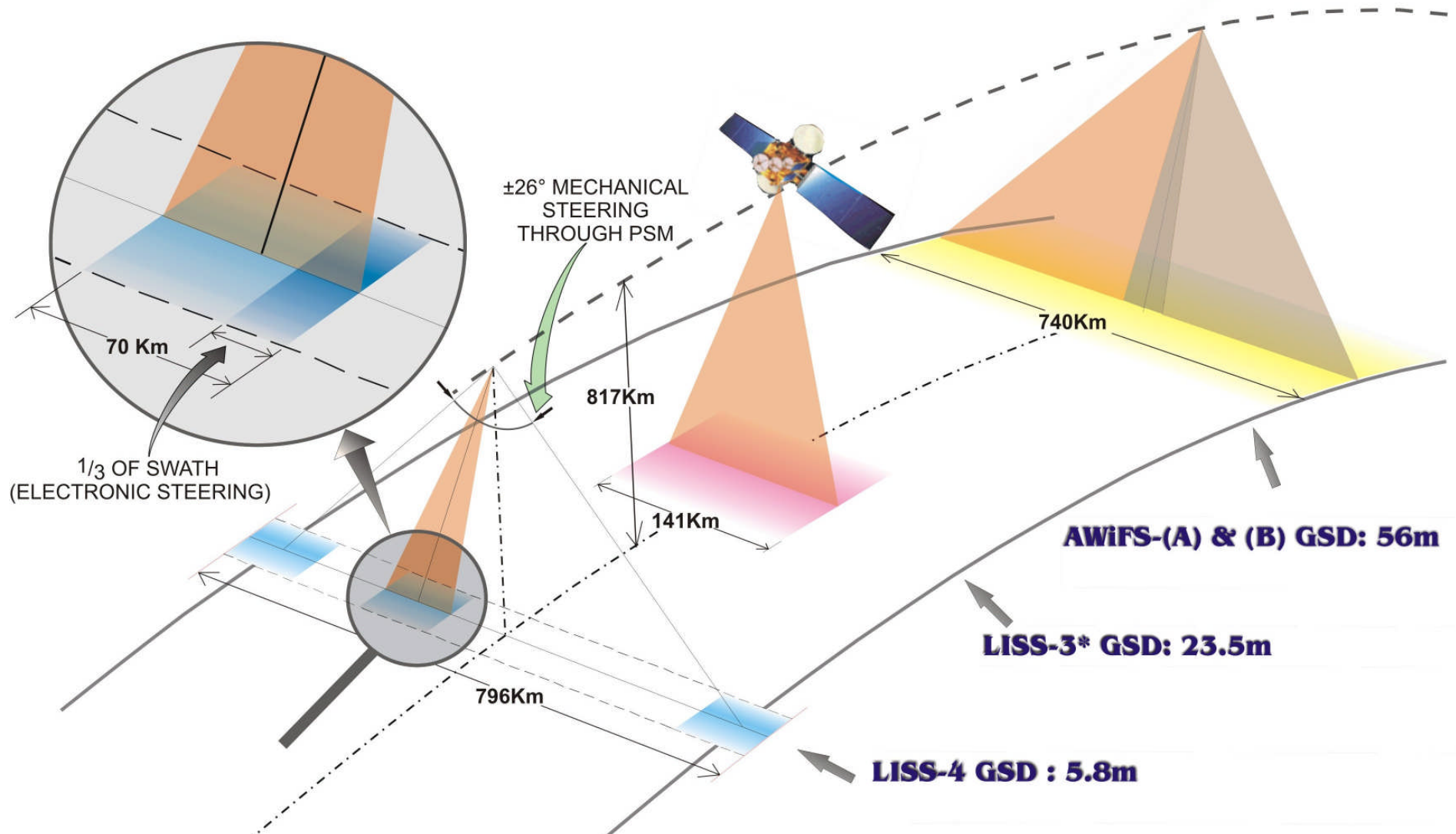
Resourcesat-1
(IRS-P6)

| | |
|---|--|
| 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 (AWiFS) : | 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 : | 5-7 years |
| Launch Dates : | Resourcesat-1 launched on 10-17-03 Resourcesat-2 scheduled for Q2 2009 |



| 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



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

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

Better radiometric resolution

Red instead of pan-chromatic band

Only one array, leads to better internal geometry

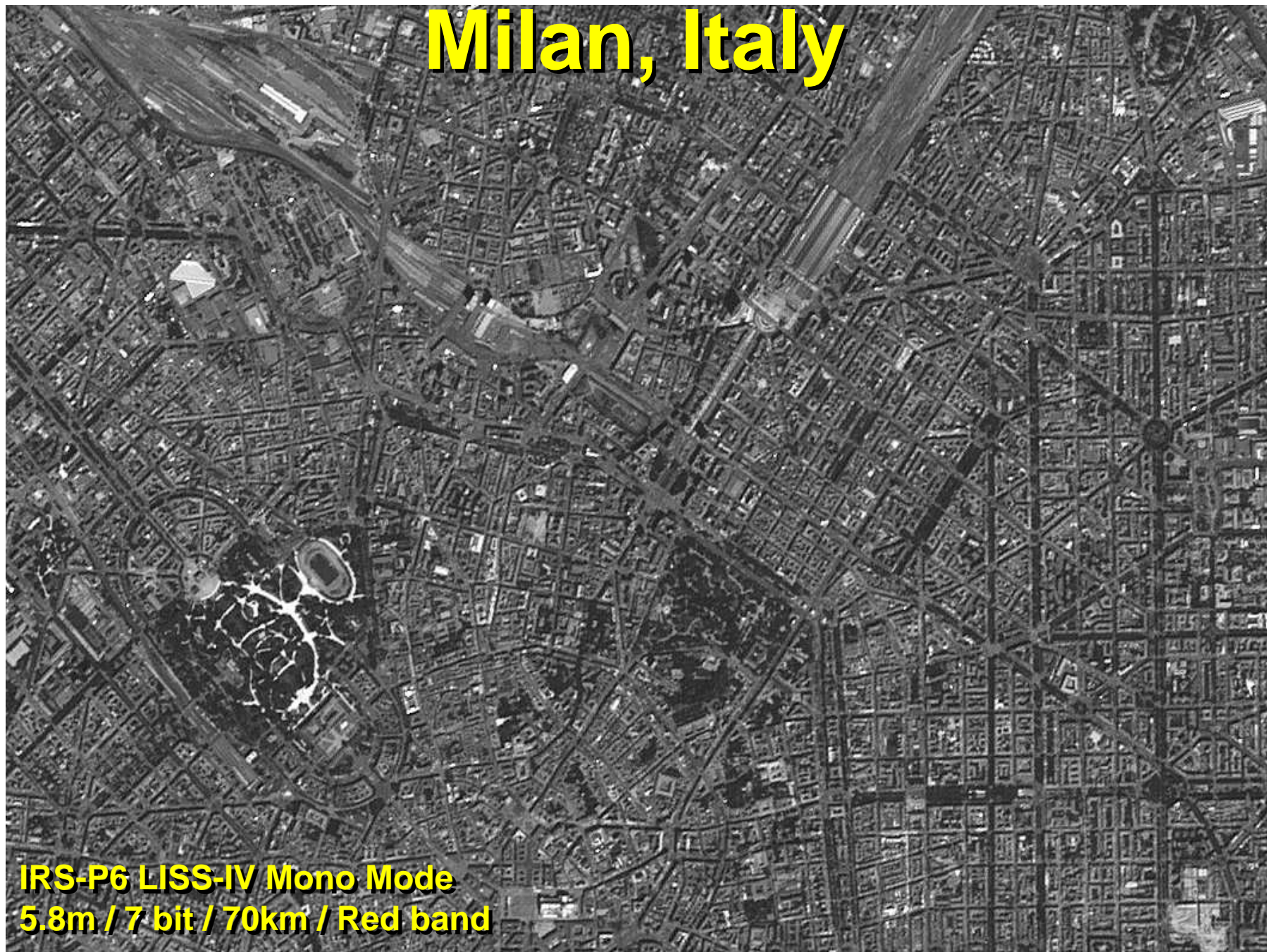
Suitable for mapping, mobile phone cell planning

- 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 |

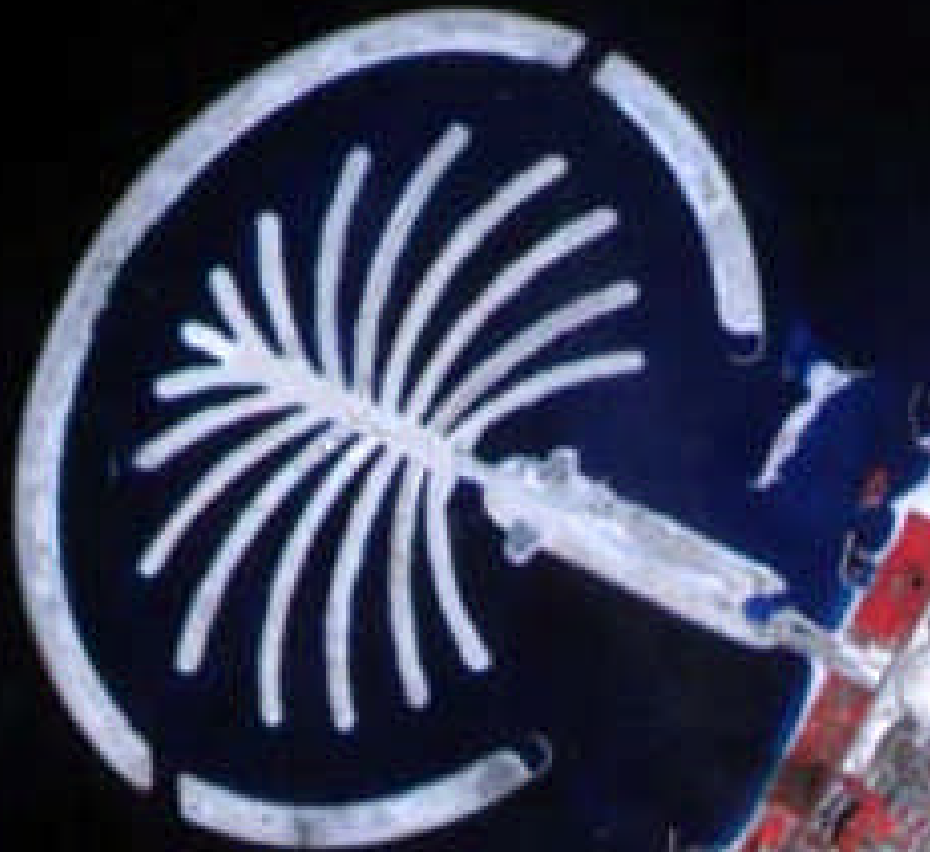
- **Agriculture**
 - Crop monitoring and condition assessment
 - Crop canopy water stress
 - Crop yield estimates
 - Damage assessment
- **Forestry**
 - Inventory and updating
 - Encroachment
 - Habitat analysis
 - Fire damage
- **Environmental Monitoring**
 - Land use
 - Soil contamination
 - Desertification 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



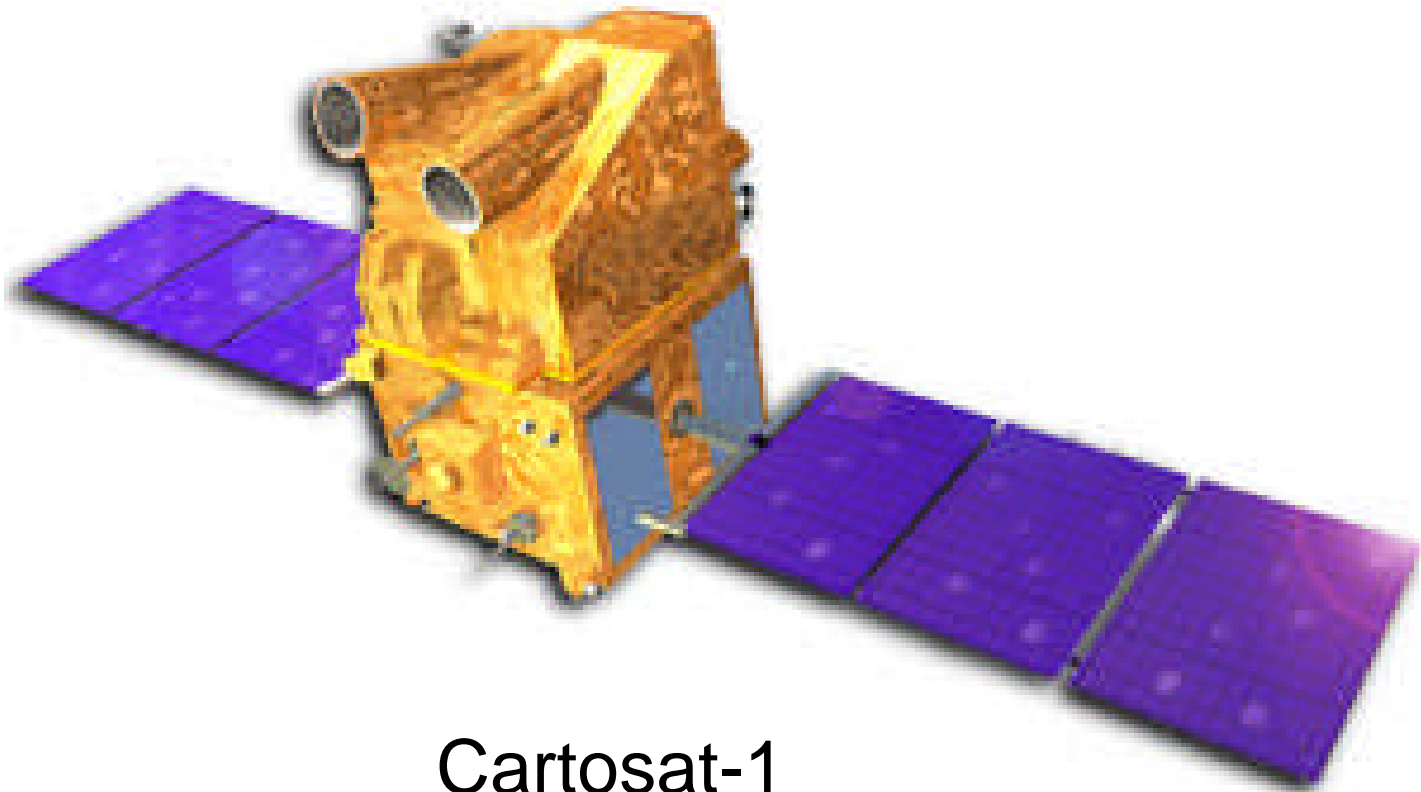
IRS-P6 AWiFS

Part of Myanmar coast



IRS-P6 LISS-III

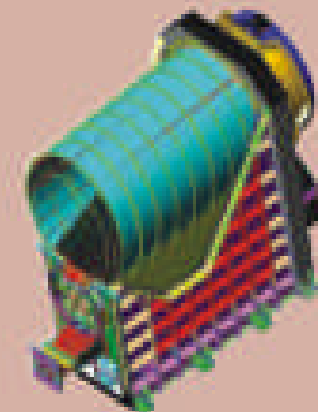
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Cartosat-1
(IRS-P5)

| | |
|---|--|
| 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 Adjacent 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 – 7 years (launched 05/05/05) |

| | |
|--|---|
| 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*

EO Tec Cartosat-1 Additional Specs



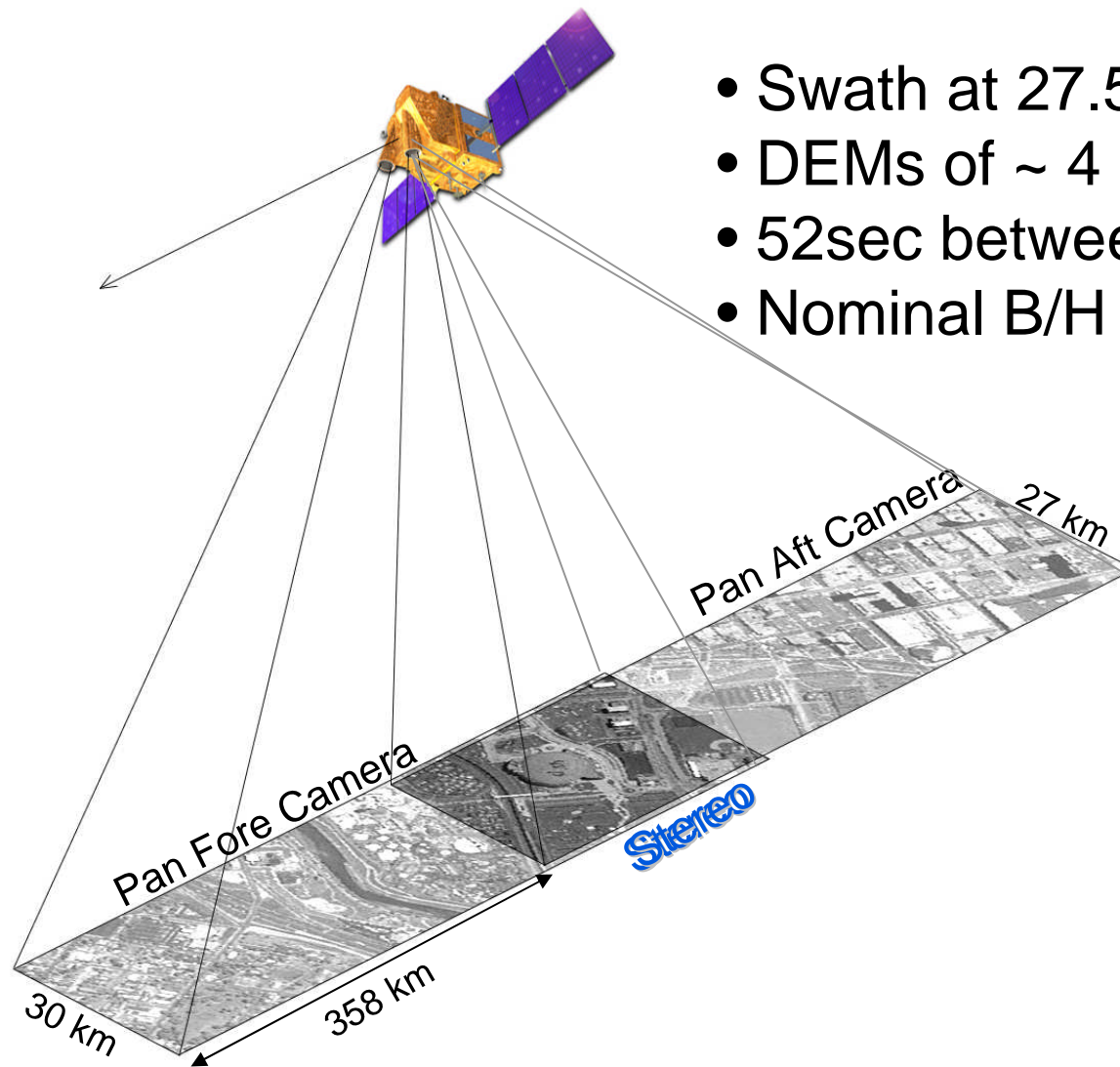
- Cartosat-1 has two (2) panchromatic cameras for in flight stereo viewing
- Stereo data is provide to ground stations in *Real-Time*

| 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, Quantisation | 10 bit | 10 bit |
| Spectral coverage | 500-850 nm | 500-850 nm |
| CCD arrays (number of arrays * No. of 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 ² Per Second | Km ² Per Minute | Scenes/Day (@ 8 mins/day) |
|-------------------|----------------------|-------------------------------|-------------------------------|------------------------------|
| Cartosat-1 | PAN Camera (Fore) | ~ 190 km ² | ~ 11,385 km ² | ~ 91,080 km ² |
| | PAN Camera (Aft) | ~ 190 km ² | ~ 11,385 km ² | ~ 91,080 km ² |



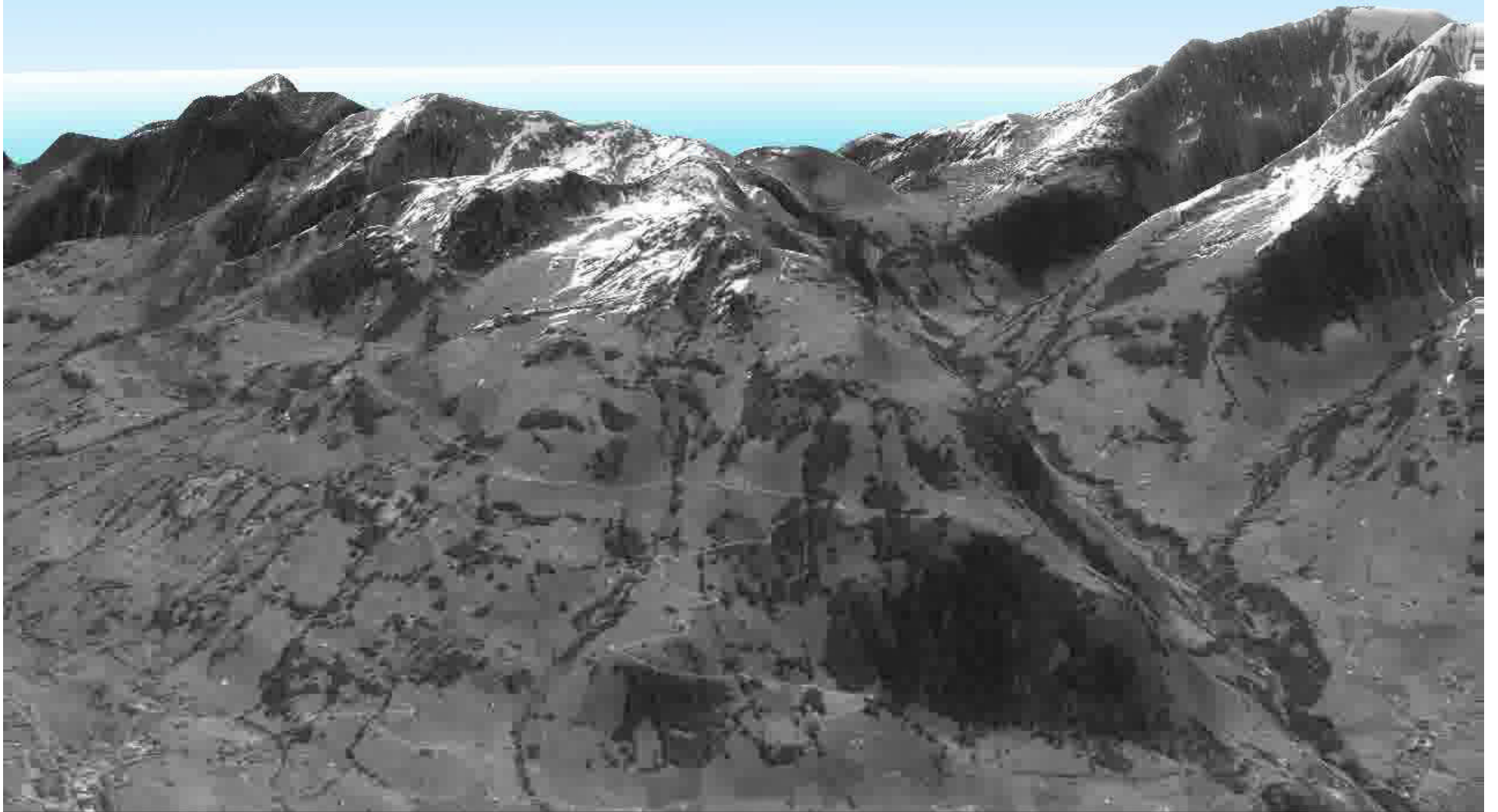
- Swath at 27.5 km
- DEMs of ~ 4 m elevation accuracy
- 52sec between cameras ~ 358 km
- Nominal B/H ratio 0.62

Denver, CO



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

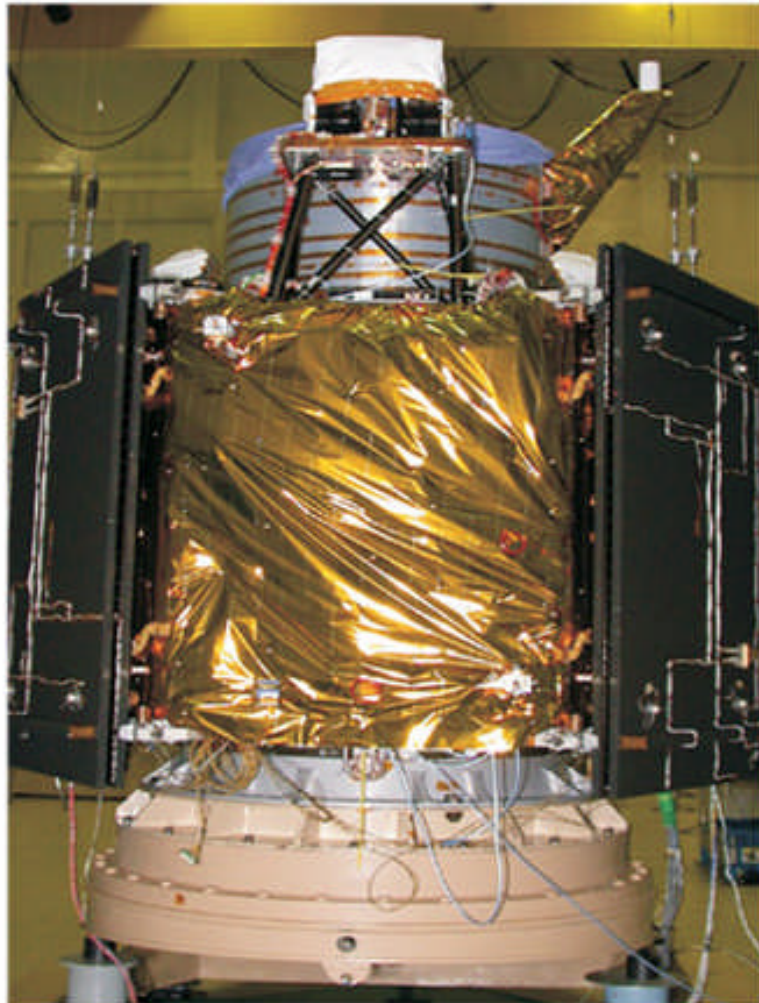
FPS : 28.561057



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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 using high torque Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters |
| Power | : Solar Array Generating 900 W, Two 18 Ah Ni-Cd batteries |
| Payload | : Panchromatic camera (PAN) |
| Operational Life | : 5 years |
| PAN specifications | |
| Resolution | : 0.81m |
| Swath | : About 9.6 km |
| Spectral Band | : 0.5 – 0.85 micrometre |
| Data rate | : 336 MBPS |
| Solid State Recorder | : 64 GB capacity for 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 km²

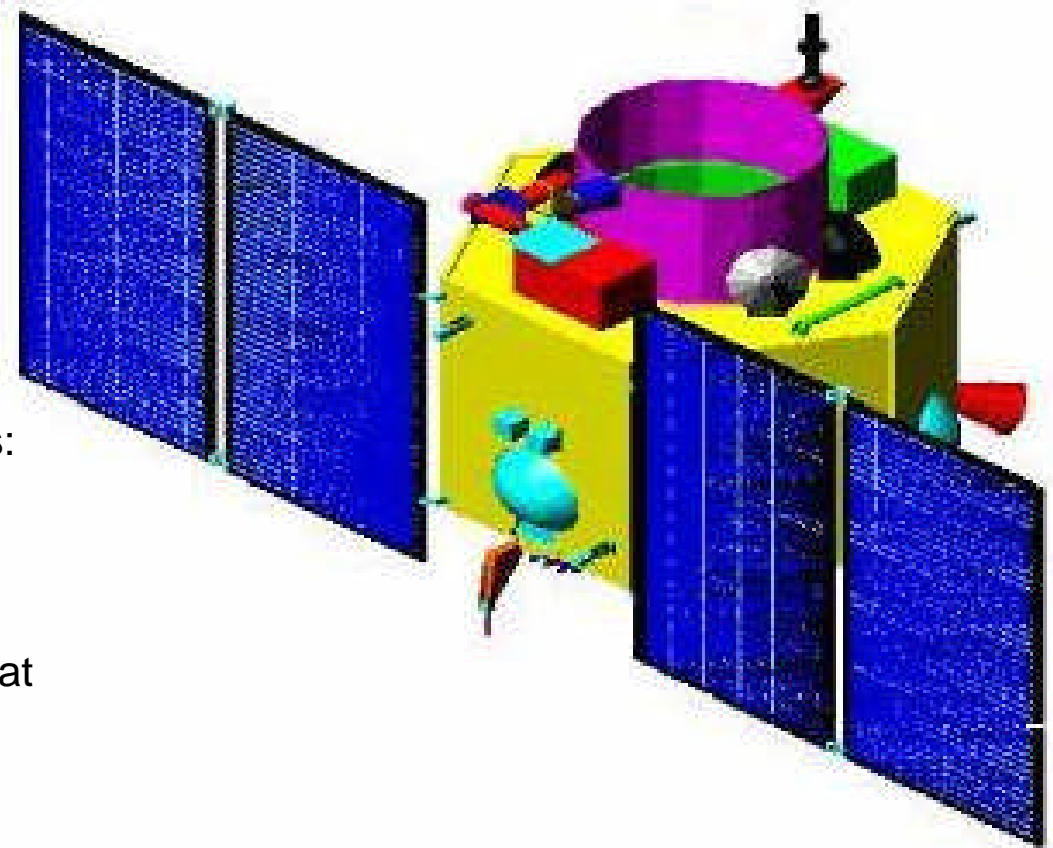
Revisit Time: 4/5 days at equator

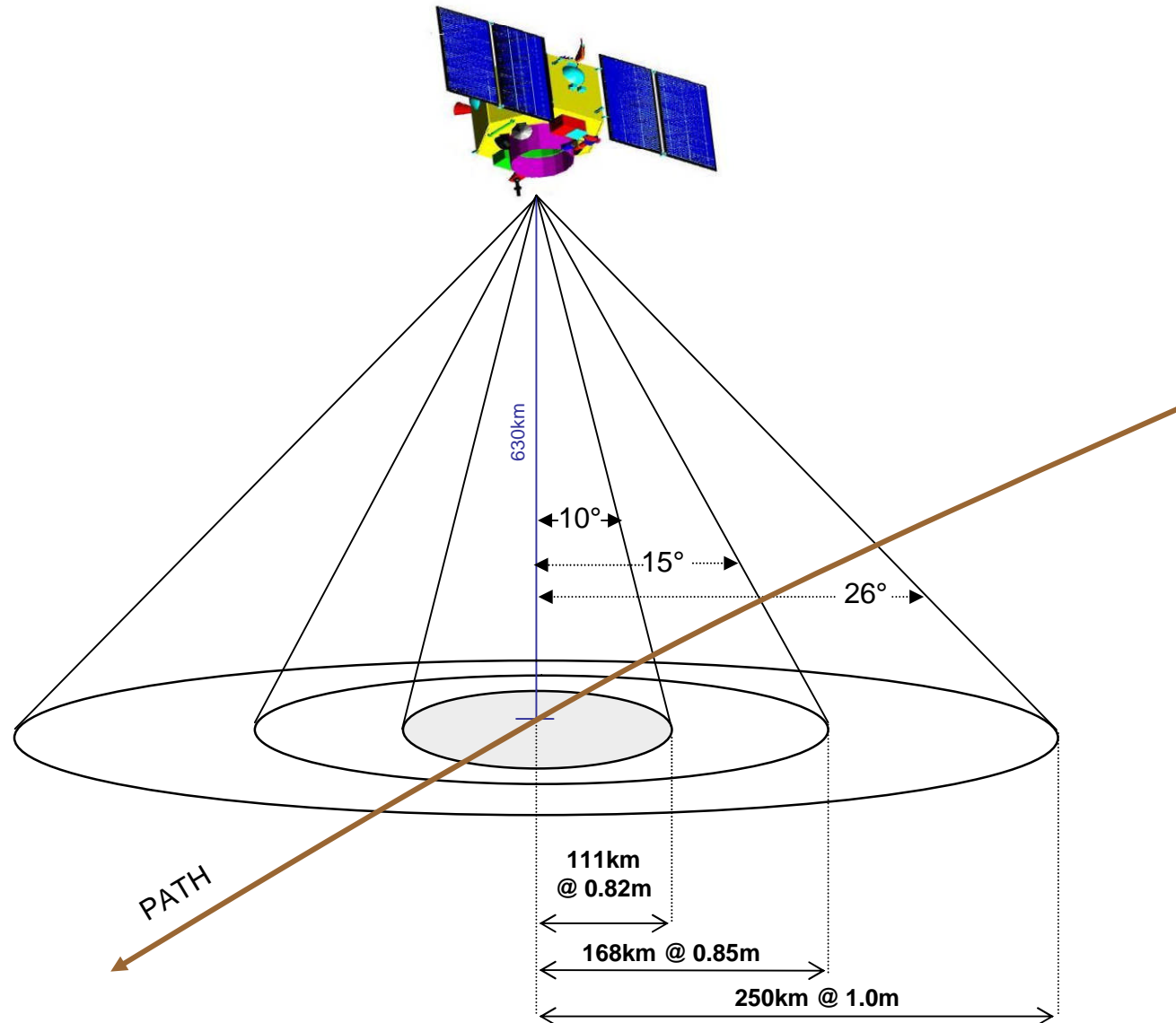
Orbit: 630km / 97.922° Sun Synchronous at
9.30 A.M Local time

Launch Mass: 680 Kgs

Launched Date: January 10, 2007

Design Life: Minimum 5 years

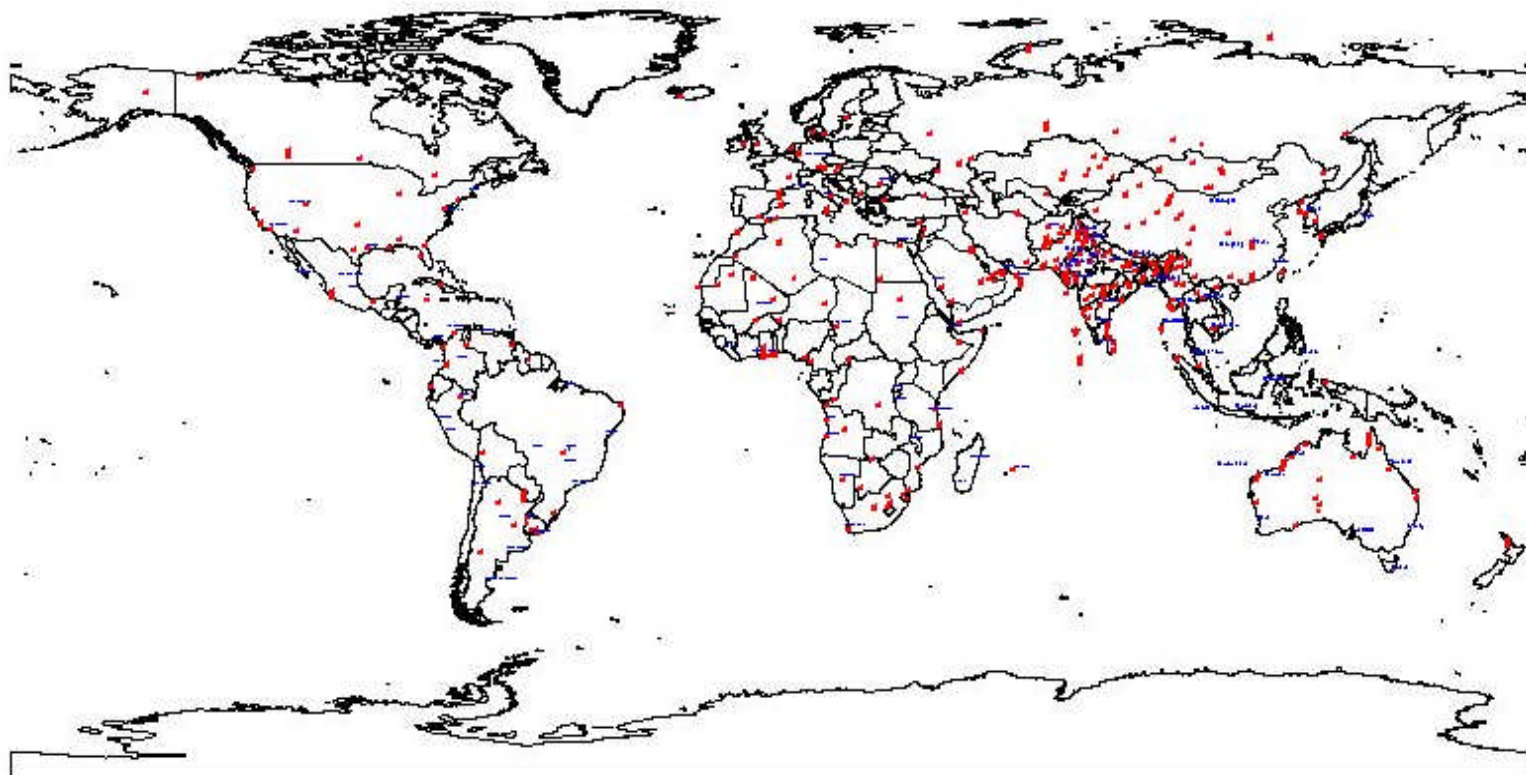








CARTOSAT 2 - GLOBAL COVERAGE



Catalog Updates available at www.nrsa.org.in



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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



| PAYLOADS | LISS-4 | LISS-3 | AWiFS |
|-----------------------------------|-------------------------------------|--|--|
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| Swath (km) | 23.9 (MX mode) 70.3 (PAN mode) | 141 | 740 |
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| Quantisation (bits) | 10 | 10 | 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 |

- 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 n at 2.5m, 3-4 bands, 5 day revisit
 - Liss-V n at 1.25m PAN, 5 day revisit
 - HSI n at 12.5m, 200 bands, 5 day revisit

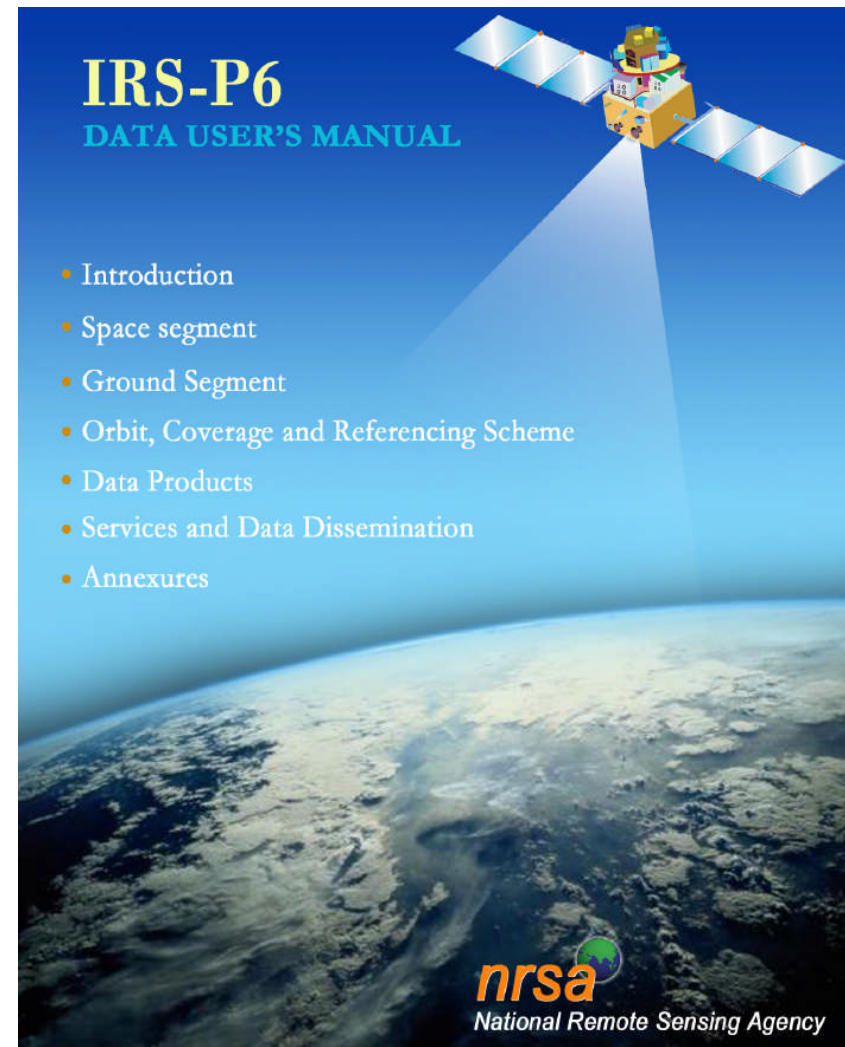
- **Cartosat Series:**

- 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 km² of data per day
- Follow on systems are already under development



Available at NRSA's web site: www.nrsa.org.in

The logo for EOTec features the letters 'EOTec' in a bold, black, serif font. The letter 'O' is stylized with a blue dot above it and a blue orbital ring around it. The letters 'E' and 'T' are connected to the 'O' by thin blue lines. Horizontal blue lines extend from the left and right sides of the 'E' and 'T' respectively.

EOTec



Thank you!

The logo for EOTec features the letters 'EOTec' in a bold, black, serif font. The letter 'O' is stylized with a blue dot above it and a blue orbital ring around it. The letters 'E' and 'T' are connected to the 'O' by thin blue lines.

EOTec

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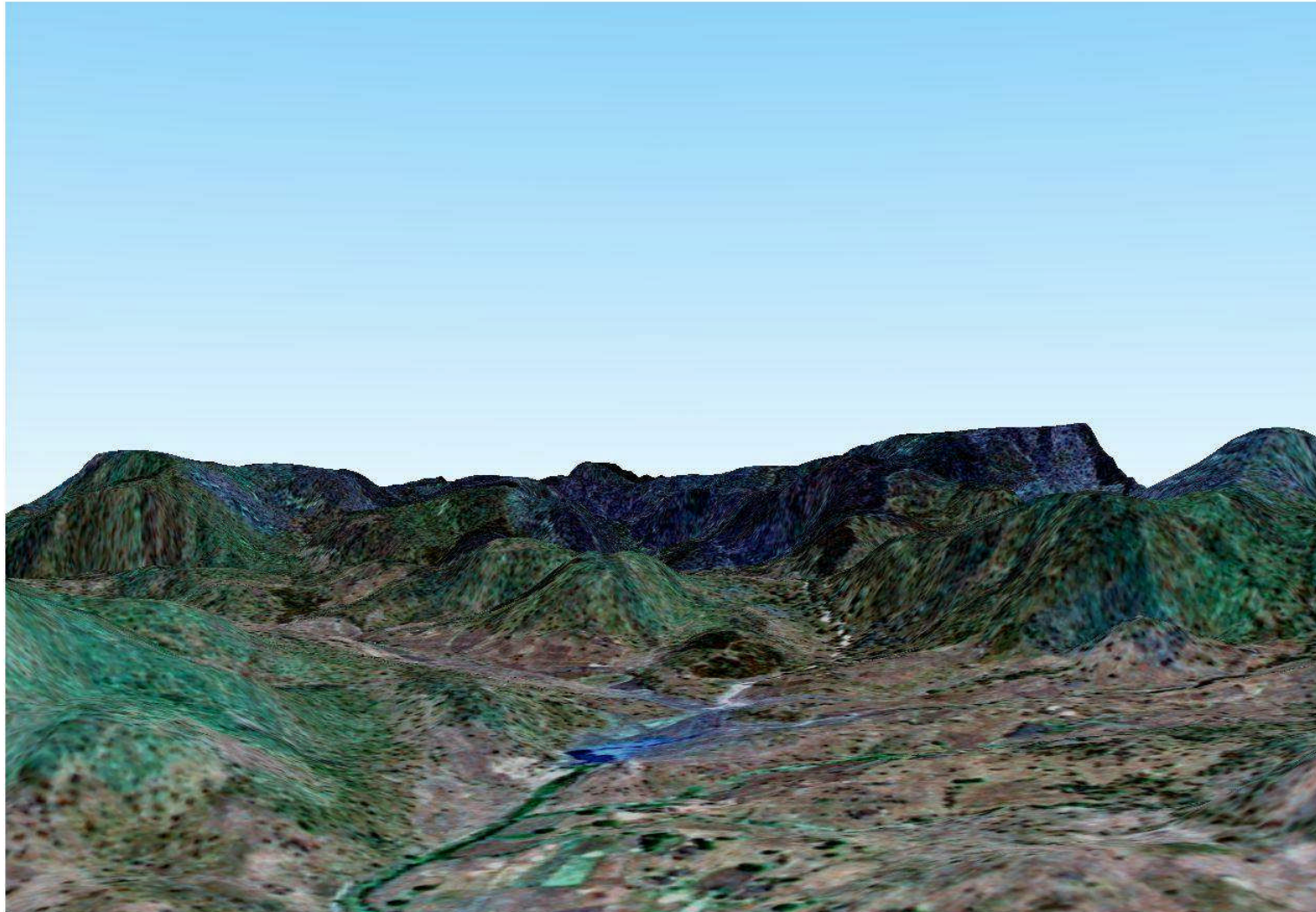
The logo for ISRO (Indian Space Research Organisation) features a stylized orange and blue arrow pointing upwards and to the right. The word 'इसरो' is written in orange Devanagari script, and 'ISRO' is written in blue capital letters below it.

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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