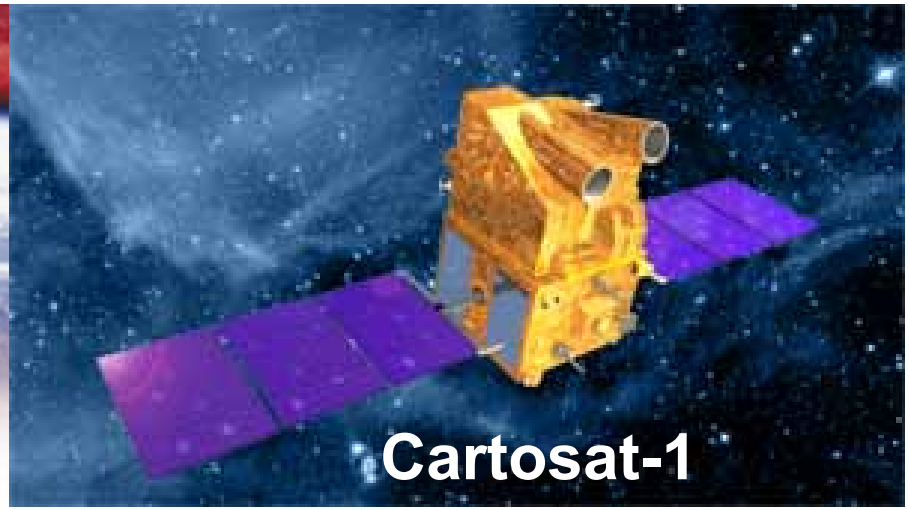

Indian Remote Sensing Satellites

-Current & Future Missions -

Presented by:
Timothy J. Puckorius
Chairman & CEO
EOTec

Presentation Topics

- Not much has changed since last year's presentation!
- EOTec's new role as Exclusive Distributors in USA
- India's Earth Observation Heritage
- Update and Status on 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
- Plans for Future IRS Satellite Missions
- Conclusions

Exclusive Distribution

- Effective 1 January 2009, EOTec became the exclusive distributors for Resourcesat Data in North America
  - GeoEye is our key partner
    - Provides reception, processing, archiving, customer service and catalog support
  - Cartosat-1 will likely be added to our capabilities later this year
    - Upgrade to GeoEye's ground station in Norman, OK
- Since January, EOTec has expanded the number of resellers in North America
  - GeoEye
  - eMap International (Florida)
  - IntraSearch / MapMart (Colorado)
  - Digital Environmental (Canada)
  - Soon to be added:
    - Harris Corp/ImageLinks
    - MDA (Canada)
    - MDA-Federal (USA)
    - HJW GeoSpatial (California)
    - Others

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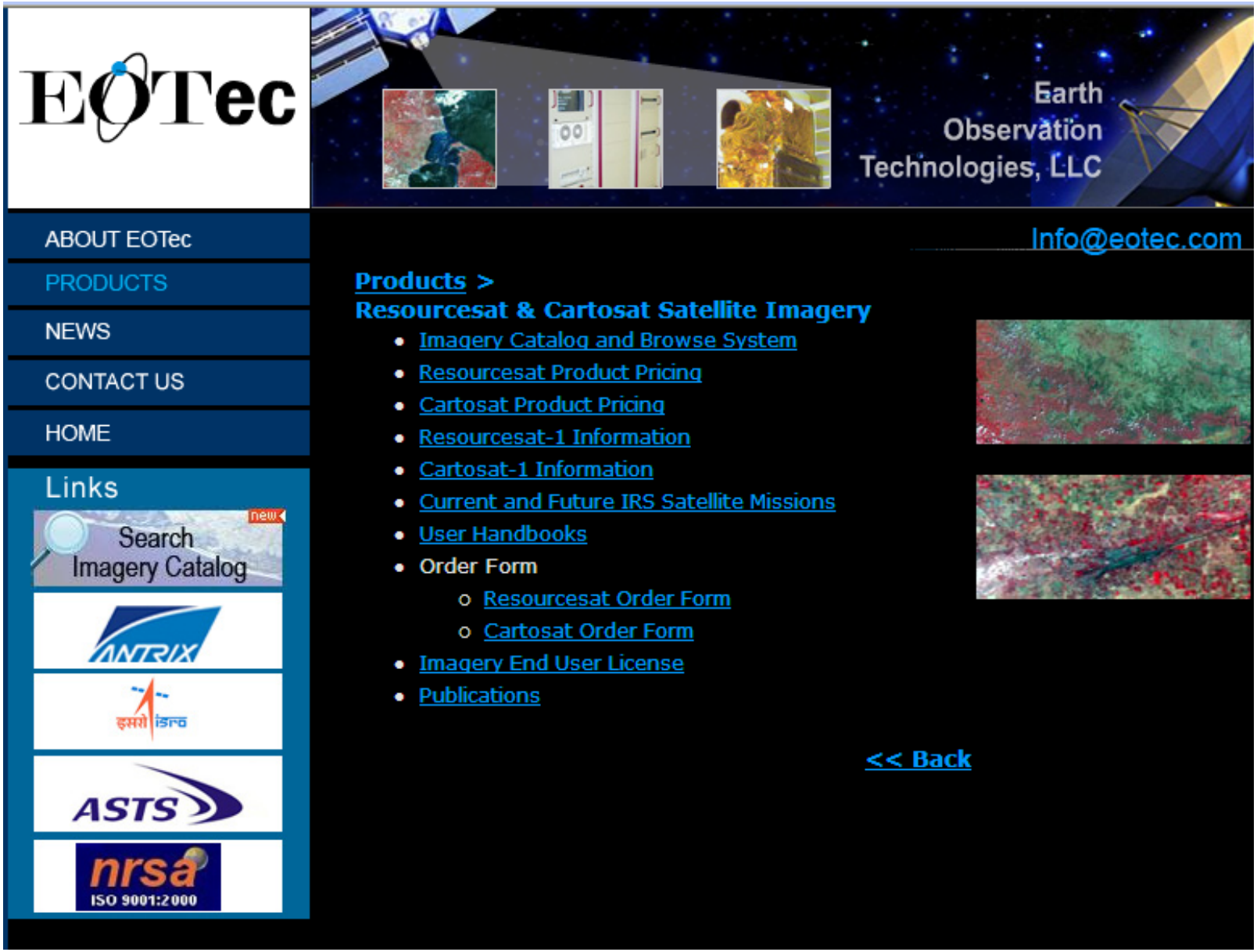
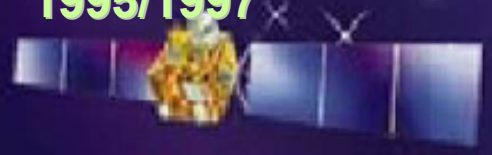
Product Information



INDIAN IMAGING SYSTEMS

1995/1997



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

1994

IRS-P2
LISS-2

1996

IRS-P3
WiFS MOS
X-Ray

1988/91

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

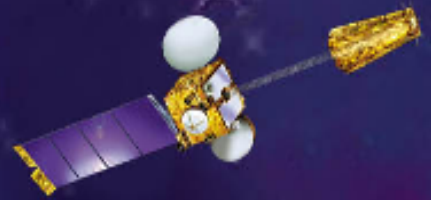
1982

RS-D1

1979

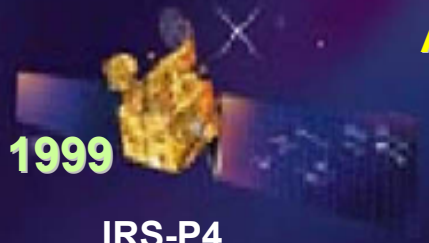
BHASKARA

1999



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

1999



IRS-P4
OCEANSAT OCM, MSMR

2003

RESOURCESAT-1
LISS3 - 23 M; 4 XS
LISS4 - 5.8 M; 3-XS
AWIFS - 70 M; 4-XS

2005

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

2007

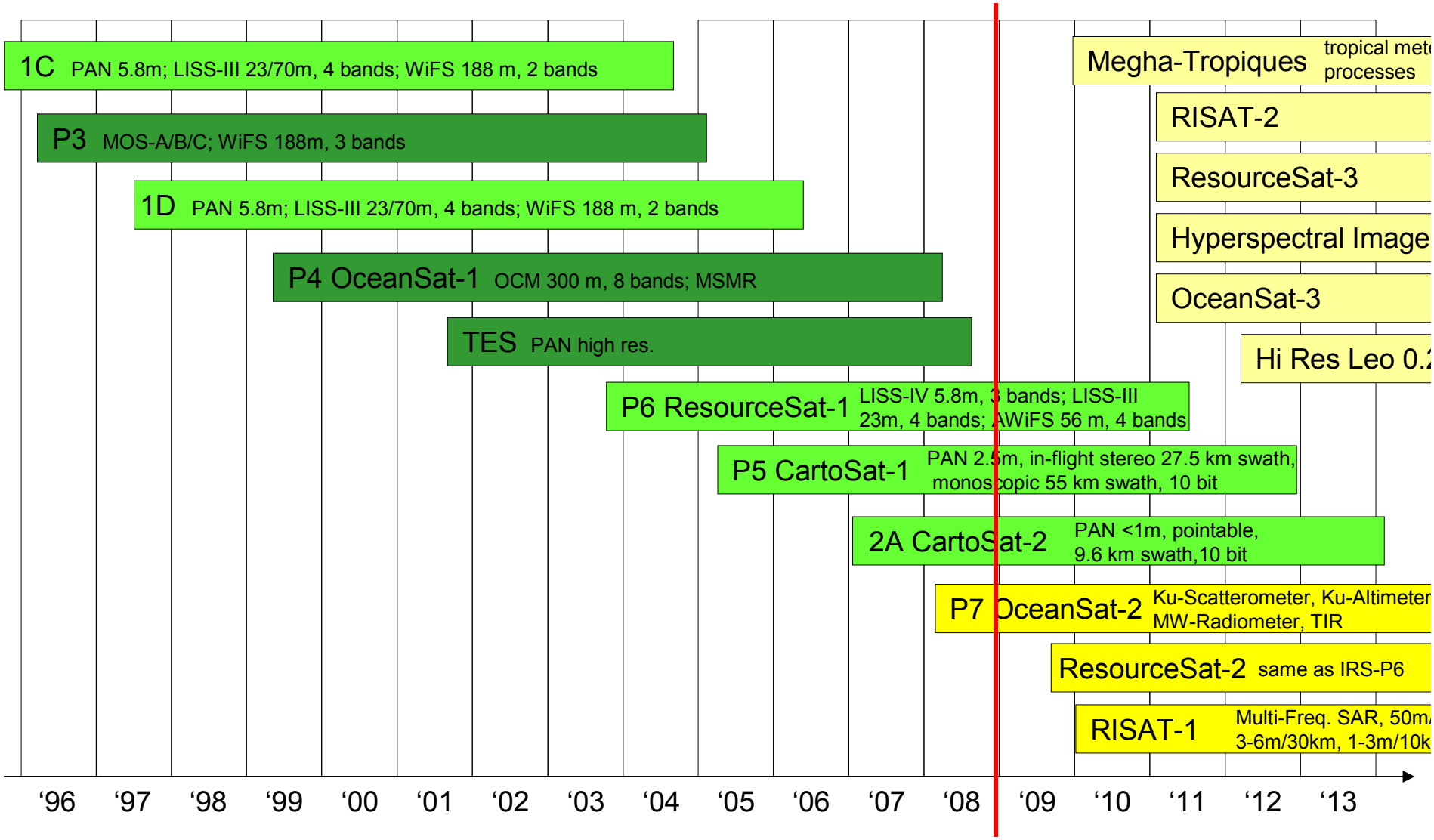
CARTOSAT-2
PAN - 1M

MEGHA-TROPIQUES
SAPHIR
SCARAB &
MADRAS

IMAGING IMPROVEMENTS

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

Indian Earth Observation Satellites



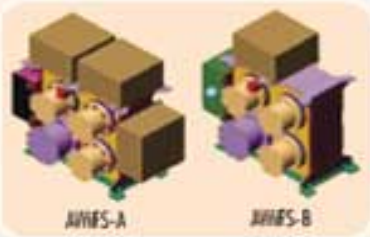
Status on Current IRS Missions

Resourcesat-1
Cartosat-1
Cartosat-2
(Experimental Missions not covered)

Resourcesat-1

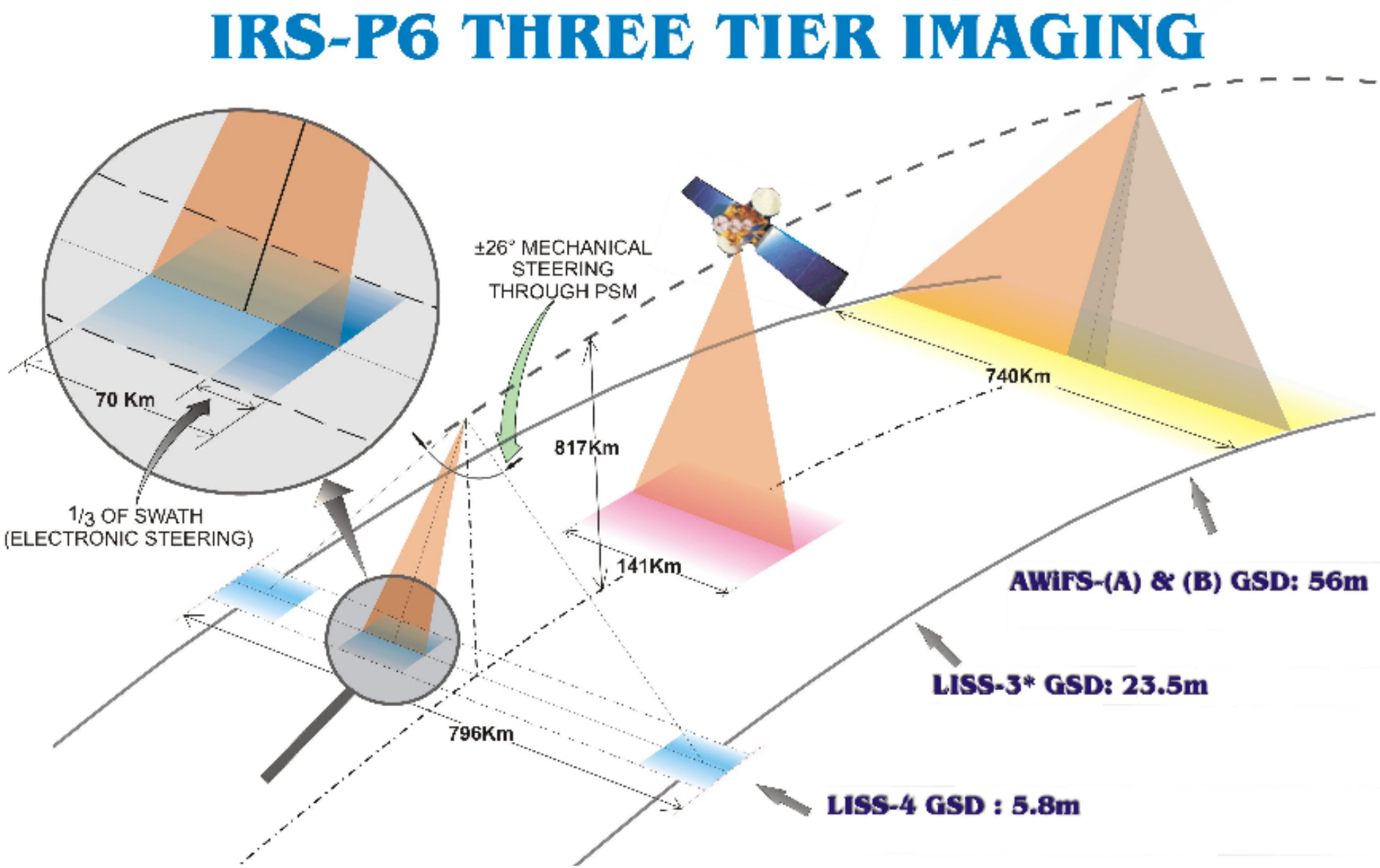
(IRS-P6)

Resourcesat-1 Payload



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

Resourcesat-1 Acquisition Modes



Resourcesat-1 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 (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 (solar array power problems now exist)
Launch Dates :	Resourcesat-1 launched on 10-17-03 Resourcesat-2 scheduled for end of Q3 - 2009

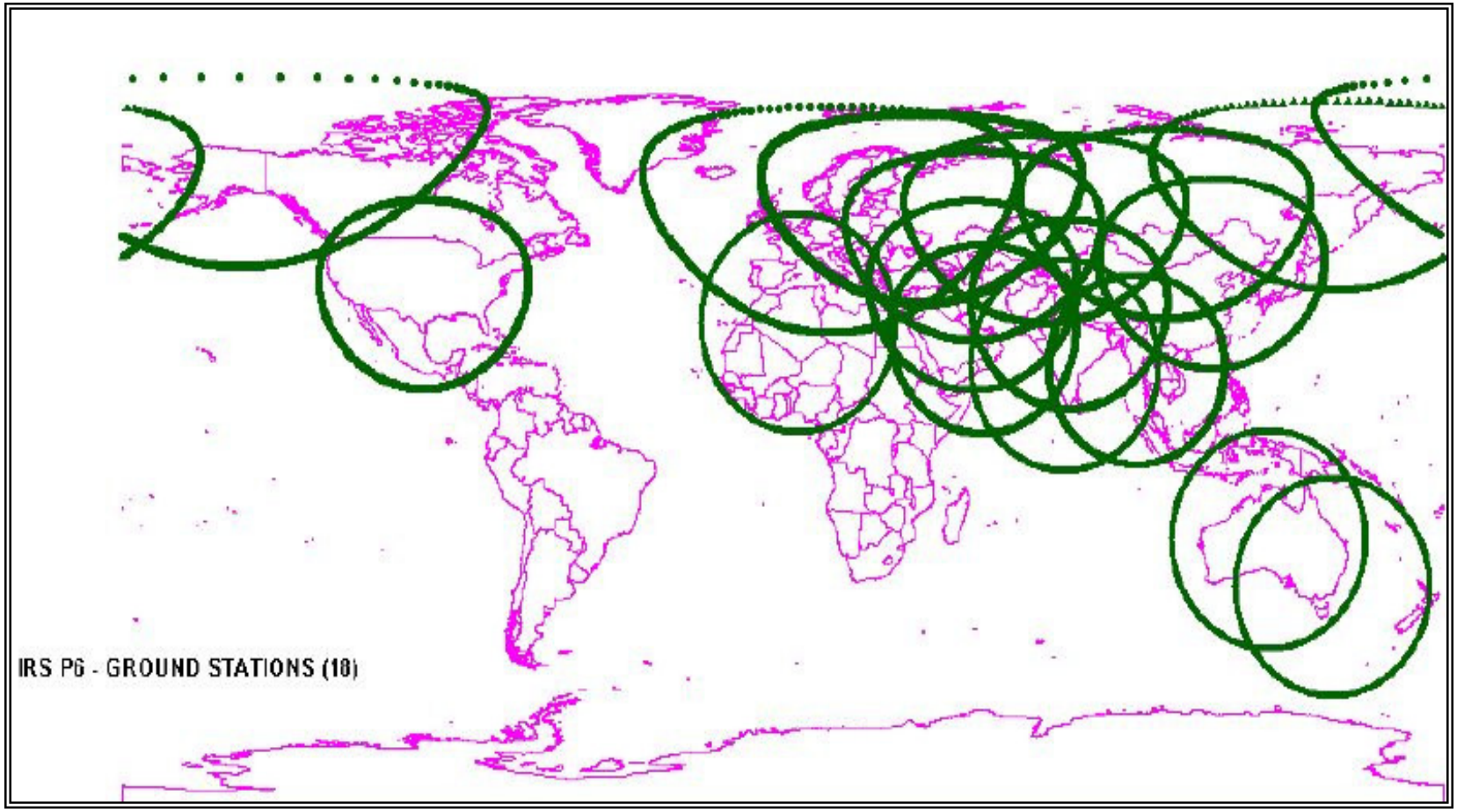
Data Collection Rates

Image Collection Rates at full power:

Satellite	Sensor	Km^2 Per Second	Km^2 Per Minute	Scenes/Day (@ 8 mins/day)
Resourcesat-1	LISS-IV	~ 462 km2	~ 27,720 km2	~ 221,760 km2
	LISS-III	~ 931 km2	~ 55,836 km2	~ 446,688 km2
	AWiFS	~ 4,884 km2	~ 293,040 km2	~ 2,344,320 km2

- Solar array power limitations now limit collections to 7 mins/orbit
  - No imaging activities every 5th orbit (recharging)
  - 14 orbits per day
- Despite power limitations, we're still meeting about 90% of all requirements
  - Direct downlinks are provided to the international ground station network
    - 15 active stations
  - Collections via the OBSSR

Ground Station Network

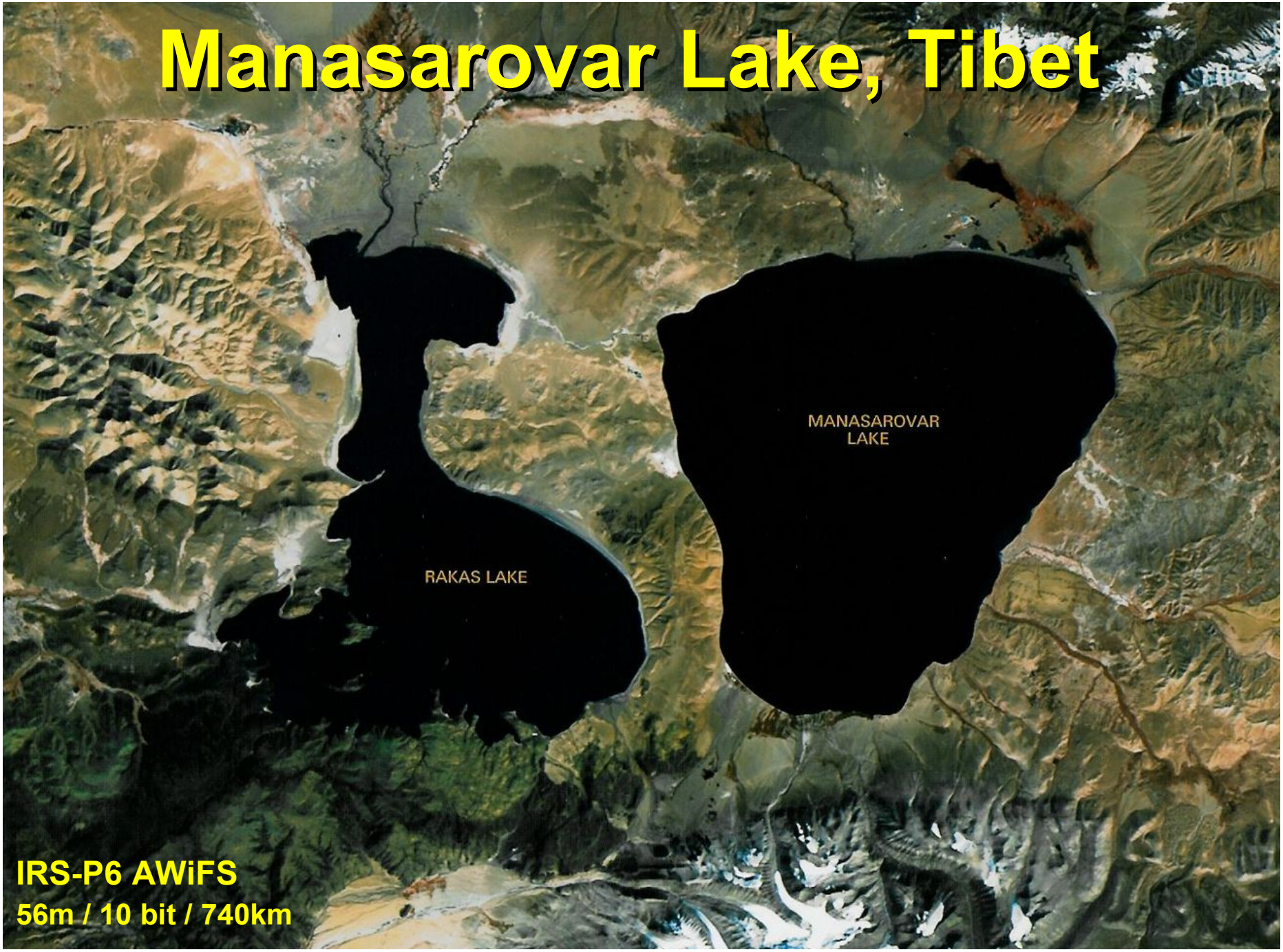


- 15 active stations now collect Resourcesat data
- Not all stations have a license to collect outside their country
- We must resolve conflicts for each orbit (for tilt, duration, mode, gain setting, etc.)

Possible Applications

- 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

Manasarovar Lake, Tibet



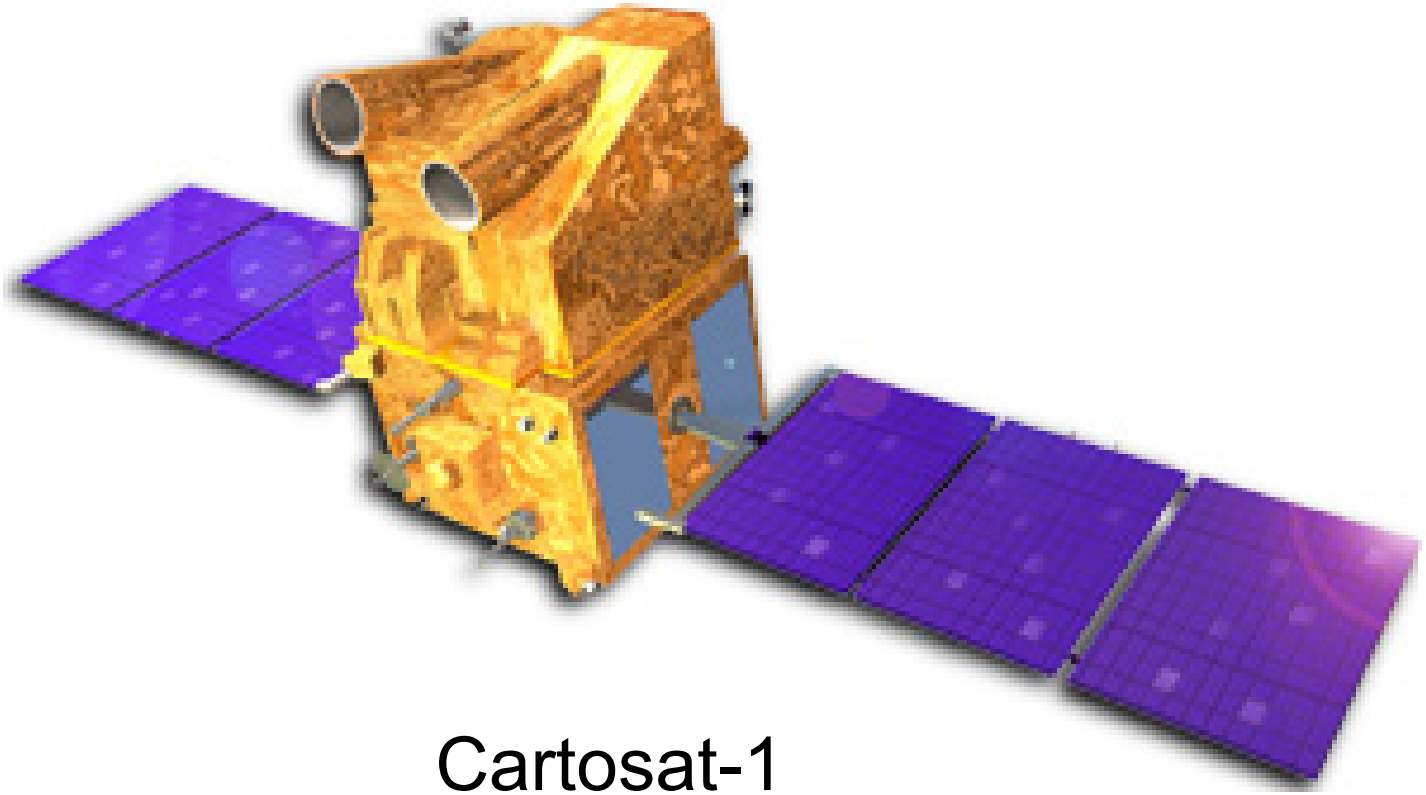
IRS-P6 AWiFS
56m / 10 bit / 740km

Palm Island, Dubai

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

Part of Myanmar coast
IRS-P6 LISS-III
23.5m / 7 bit / 141km

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



Cartosat-1

(IRS-P5)

Cartosat-1 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 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 (no power issues)
Mission Life :	5 – 7 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

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*

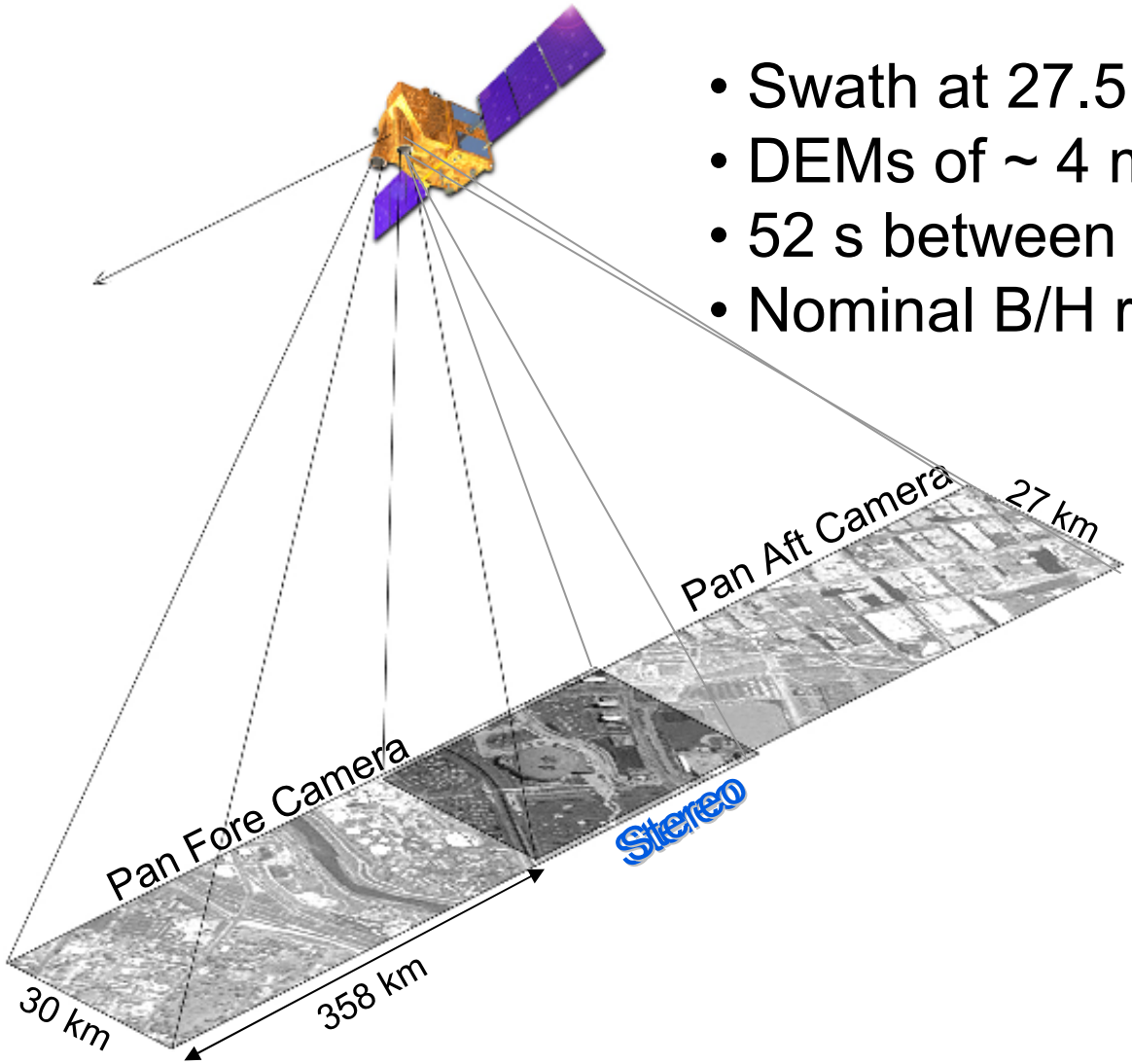
Sensor	**PAN Fore**	**PAN Aft**
Tilt Along Track	+26°	-5°
Spatial Resolution	2.5 m	2.5 m
Swath-width	30 km	27 km
Radiometric Resolution, Quantization	10 bit	10 bit
Spectral coverage	500-850 nm	500-850 nm
CCD arrays (number of arrays * No. of elements)	1 * 12000	1 * 12000

- Revisit capability is 5 days (by rolling on axis ± 23º)

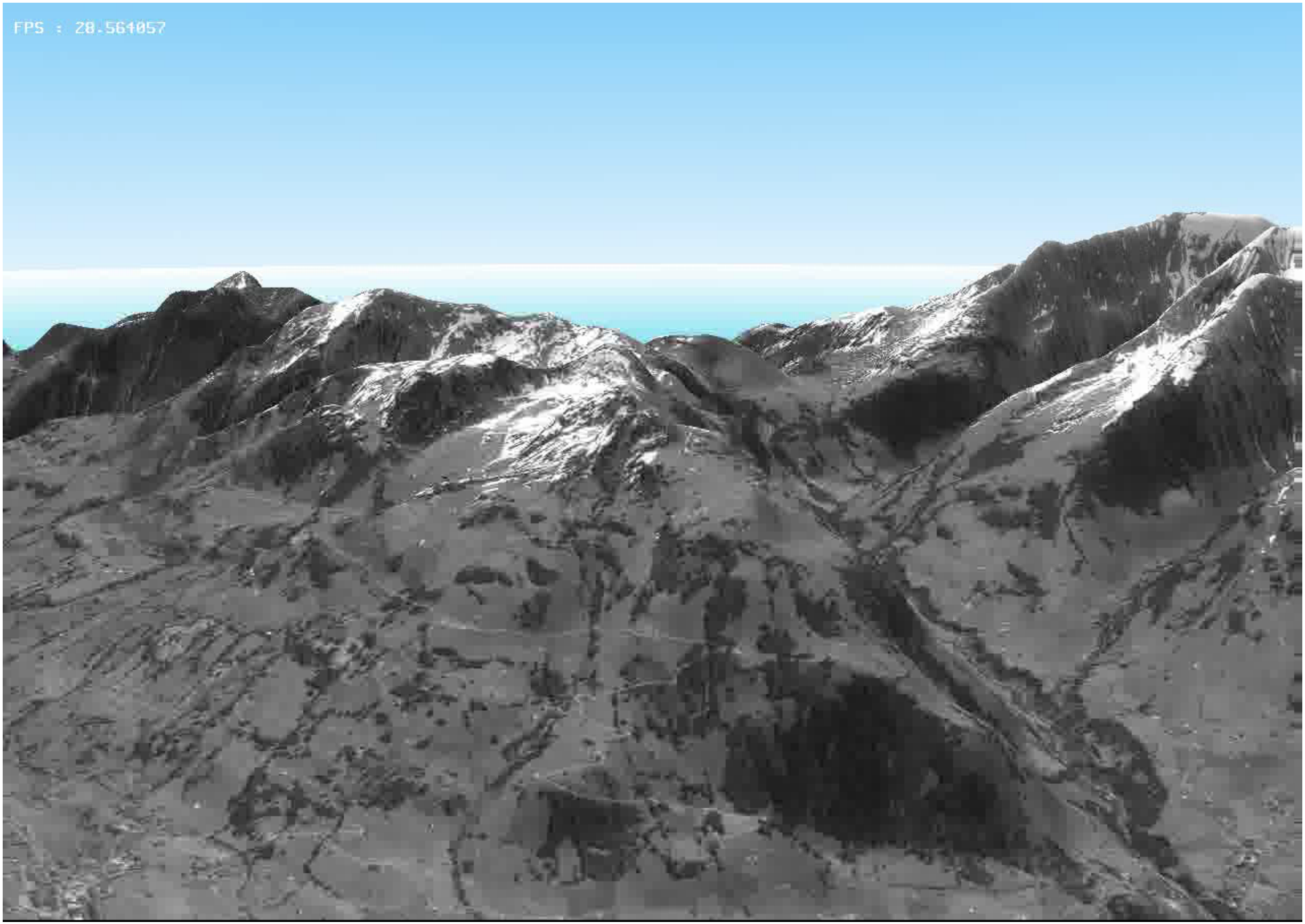
Data Collection Rates

Satellite	Sensor	Km^2 Per Second	Km^2 Per Minute	Scenes/Day (@ 8 mins/day)
Cartosat-1	PAN Camera (Fore)	~ 190 km2	~ 11,385 km2	~ 91,080 km2
	PAN Camera (Aft)	~ 190 km2	~ 11,385 km2	~ 91,080 km2

IRS-P5 Stereo Collection Mode



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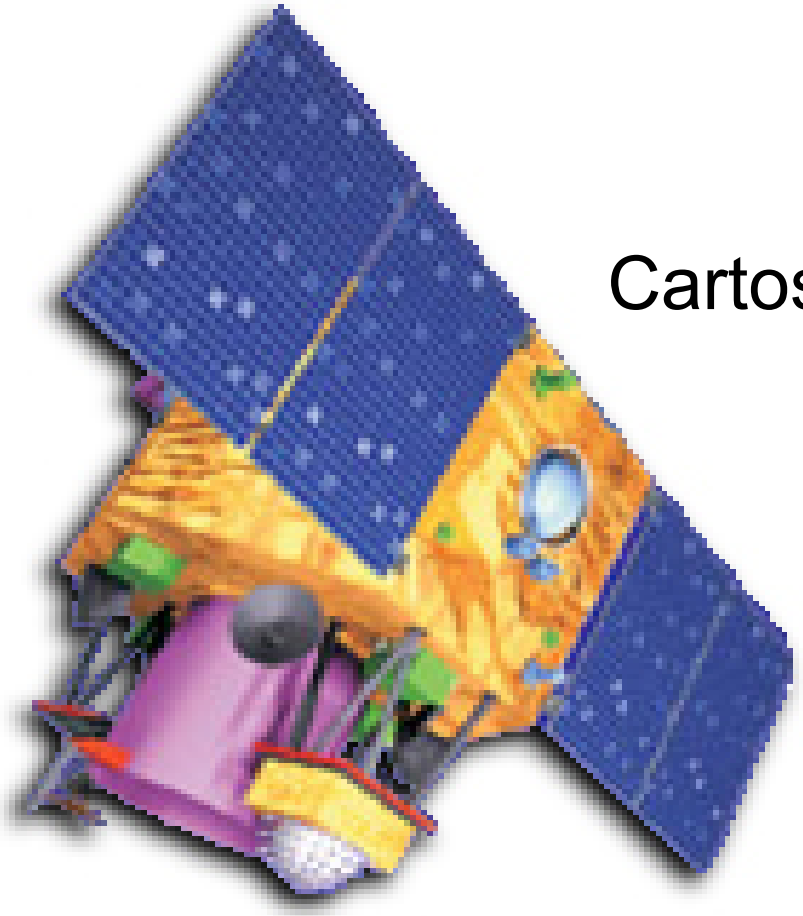


Cartosat-2

Cartosat-2 at a Glance

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

Cartosat-2 Baseline

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

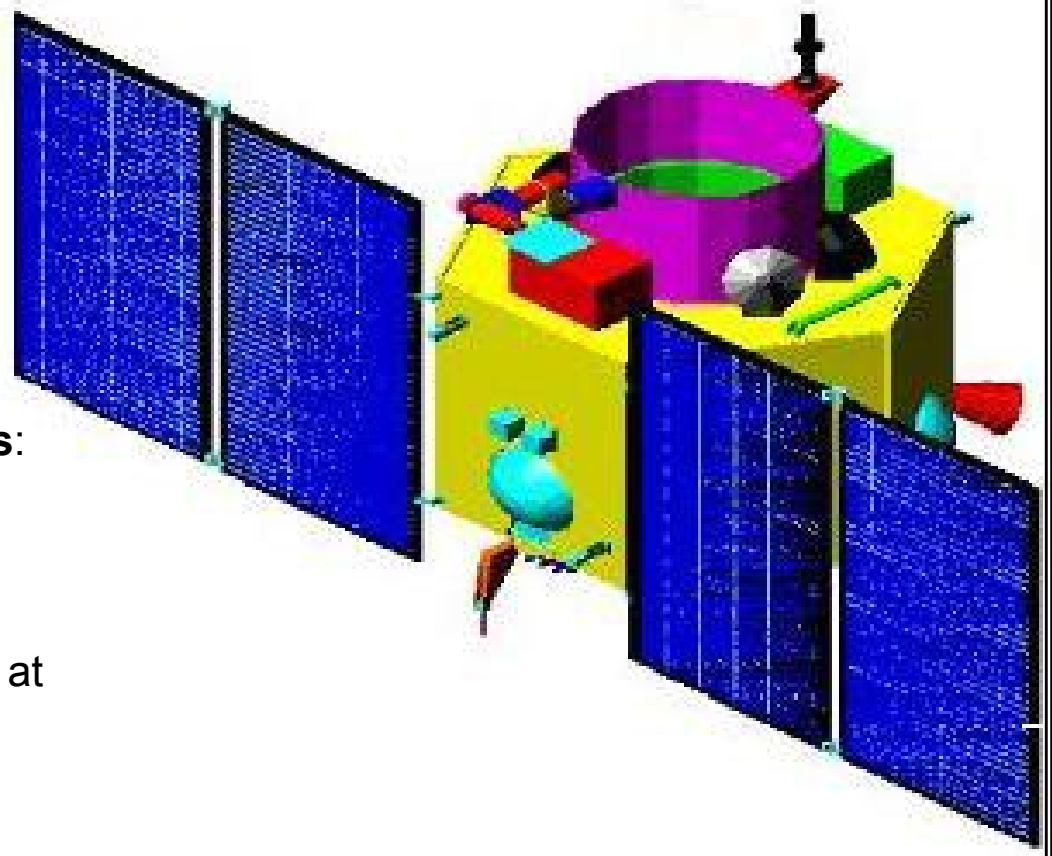
Revisit Time: 4/5 days at equator

Orbit: 630km / 97.922^{o} Sun Synchronous at 9.30 A.M Local time

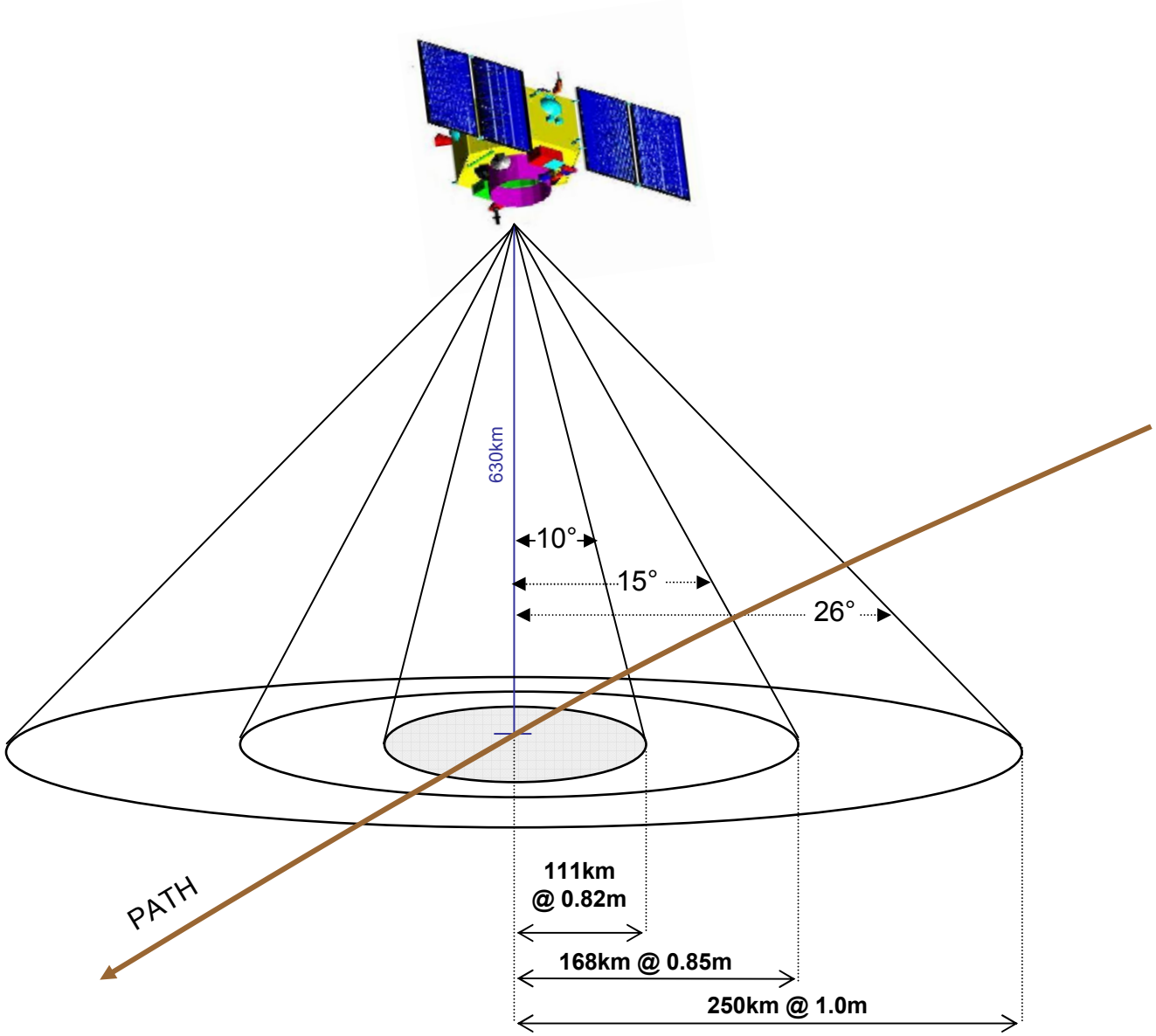
Launch Mass: 680 Kgs

Launched Date: January 10, 2007

Design Life: Minimum 5 years



Cartosat-2 Field of Regard



C2 Sample Imagery (Bangalore)

C2 Sample Imagery
(Bangalore)

Future
IRS Missions

Resourcesat-*n*

Cartosat-*n*

Radar

HSI

Future IRS Missions

- **Resourcesat-2**
  - Launch currently scheduled for end of Q3 to early Q4 - 2009
  - Virtually identical to Resourcesat-1 (with miniaturization)
    - Improved solar array and power handling system
    - Radiometric resolution of LISS-III and LISS-IV will be improved from 7 bits to 10 bits
    - AWiFS will have improved multi-linear gains
    - OBSSR will be increased in size (2 each at 200 GB)
  - Resourcesat-2 has a 7-10 year design life which assures data continuity through at least 2016
- **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

Future Missions (continued)

- Resourcesat-3 series
  - Increased resolution and more spectral bands to existing sensors:
    - AWiFS (A & B) improved to 25m resolution, 600km swath
    - Liss-III will remain at 23.5m resolution with 2 additional bands
      - Thermal at 70m resolution under consideration
    - Liss-IV will remain at 5.8m resolution, but swath will be increased
  - Possible addition of new sensors with 25km swath:
    - Liss-V (PAN) at 2.5m resolution
    - Hyperspectral at 25m resolution (~200 Bands)
- 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

Future Missions (continued)

- **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
  - Schedule for launch late 2009 or early 2010

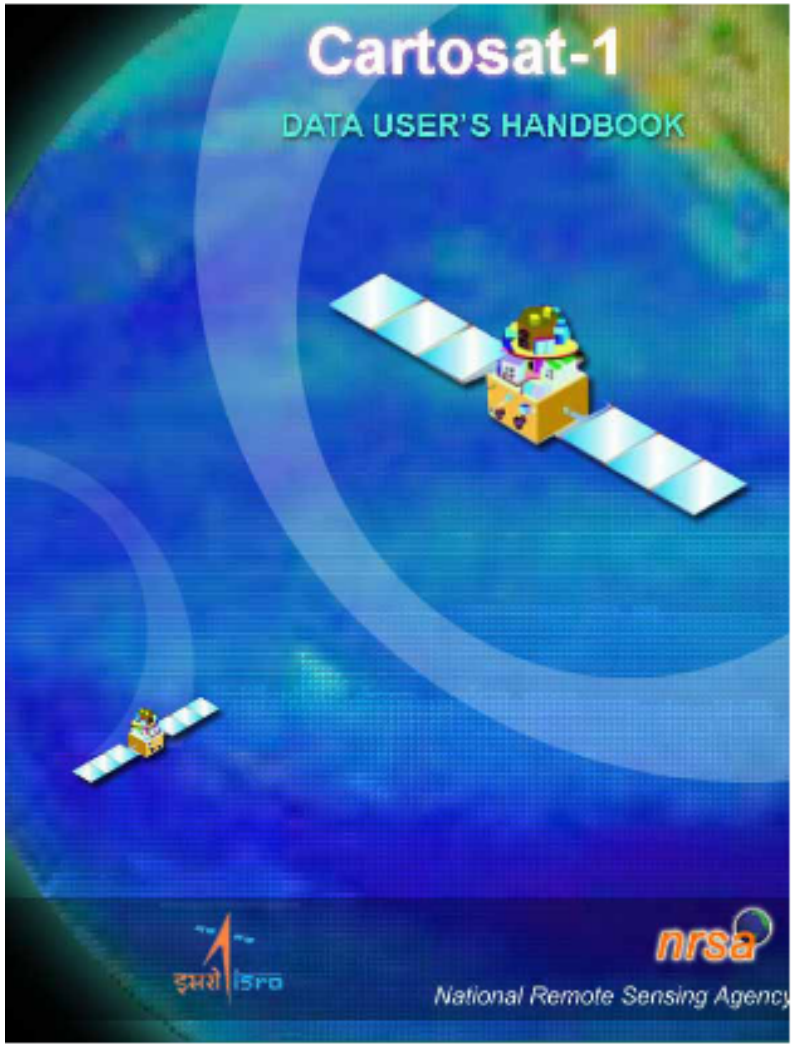
Mode	Look	Resolution	Swath	Polarization
Coarse Resolution Mode	2-4	50m	240km	Single or Dual
Medium Resolution Mode (MRS)	1-2	25m	120km	Single or Dual
Fine Resolution Striping Single Mode (FRS-2)	9-12	30m	Quad	
Fine Resolution Strip Map (FRS-1)	Single	3-6m	30km	Single or Dual
High Resolution Spot Mode (HRS)	Single	1-2	10 x 10km	Single or Dual

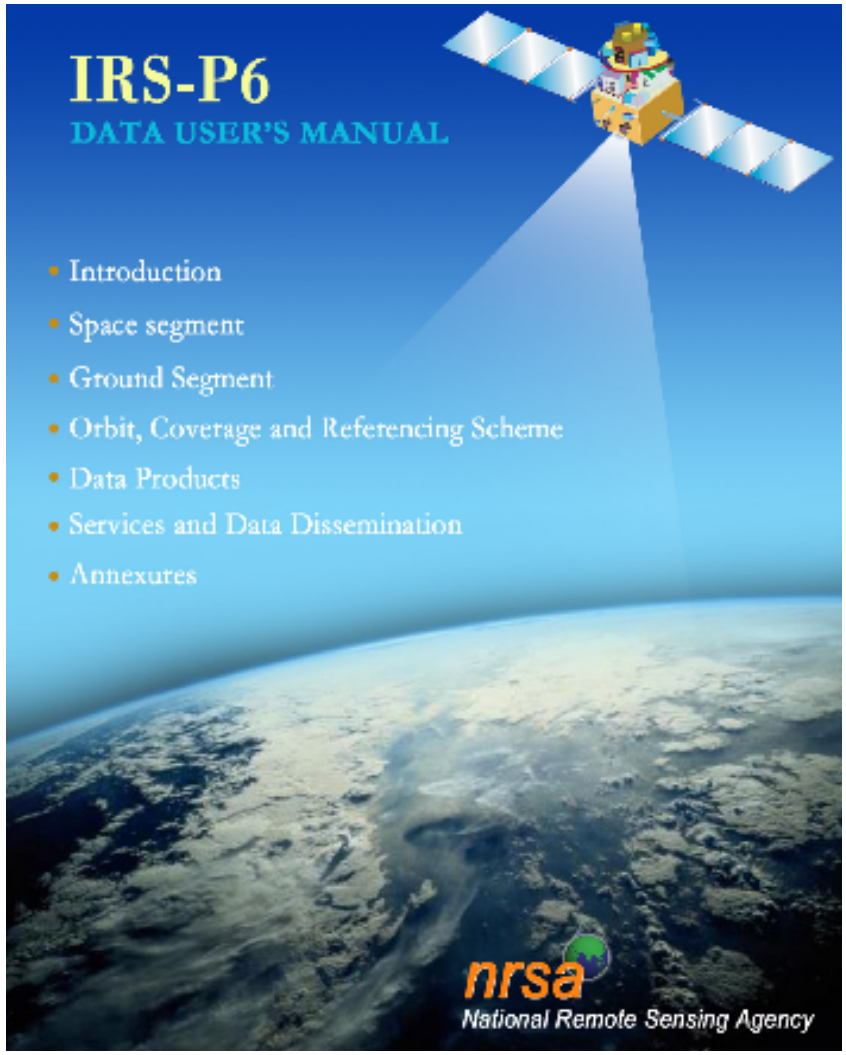
Single Polarization	VV/HH/HV/VH
Dual Polarization	HH & VV/VV & VH
Polarimetric	HH & VV & HV & VH

Conclusions

- Little has changed and the IRS program remains strong and viable
  - Distribution channels may be further refined from time to time
- India remains dedicated to providing IRS data
  - Funding is not an issue. Follow on missions are fully funded.
- Resourcesat-2 remains on track for late Q3 launch
  - Assures data continuity for at least next 7-10 years
- Follow on systems are already under development and radar data will soon be available
  - We welcome inputs and suggestions!
  - USDA and USGS have already submitted their IRS “wish list” and recommendations which were well received and are under consideration

Data User's Handbooks





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

Thank you!

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