Remote Sensing
Exercises for Practical Work

Course Content and Credit Scheme

Unit	Topic	Allotted Time (Hours)		
		L	T	P
I.	Remote Sensing: Definition, Development, Platforms and Types	3	0	10(5)*
II.	Aerial Photography: Definitions, Principles, Types and Geometry	4	0	20(10)*
III.	Satellite Remote Sensing: Principles, EMR Interaction with Atmosphere and Earth Surface; Satellites (Landsat and IRS) and Sensors.	4	0	30(15)*
IV.	Bases of Visual Interpretation of Remote Sensing images: Land use/ Land Cover, Fundamentals of Global Positioning System (GPS) – Principles and Uses	4	0	30(20)*
	Total Hours	**15**	**0**	**90(45)***

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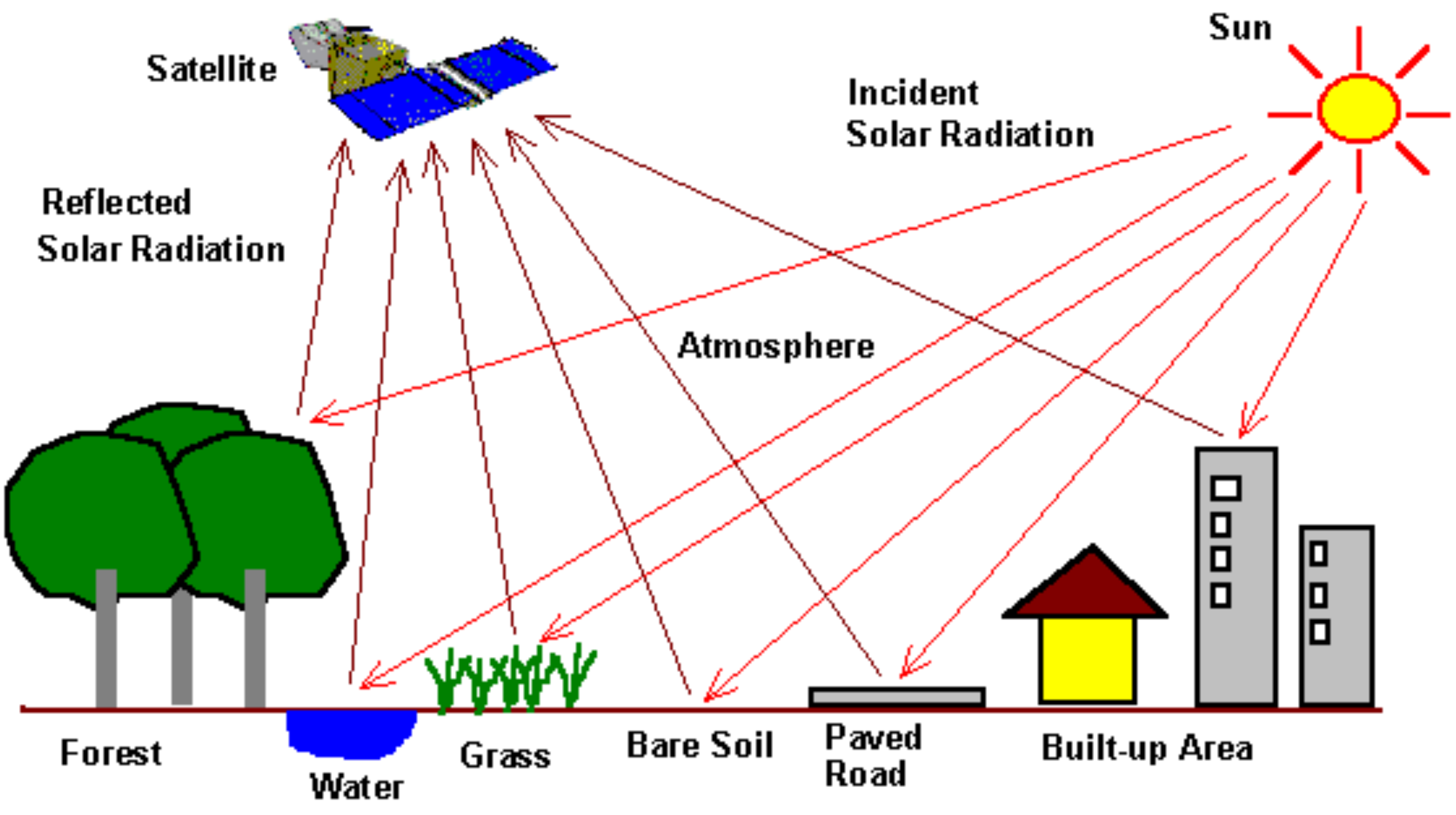
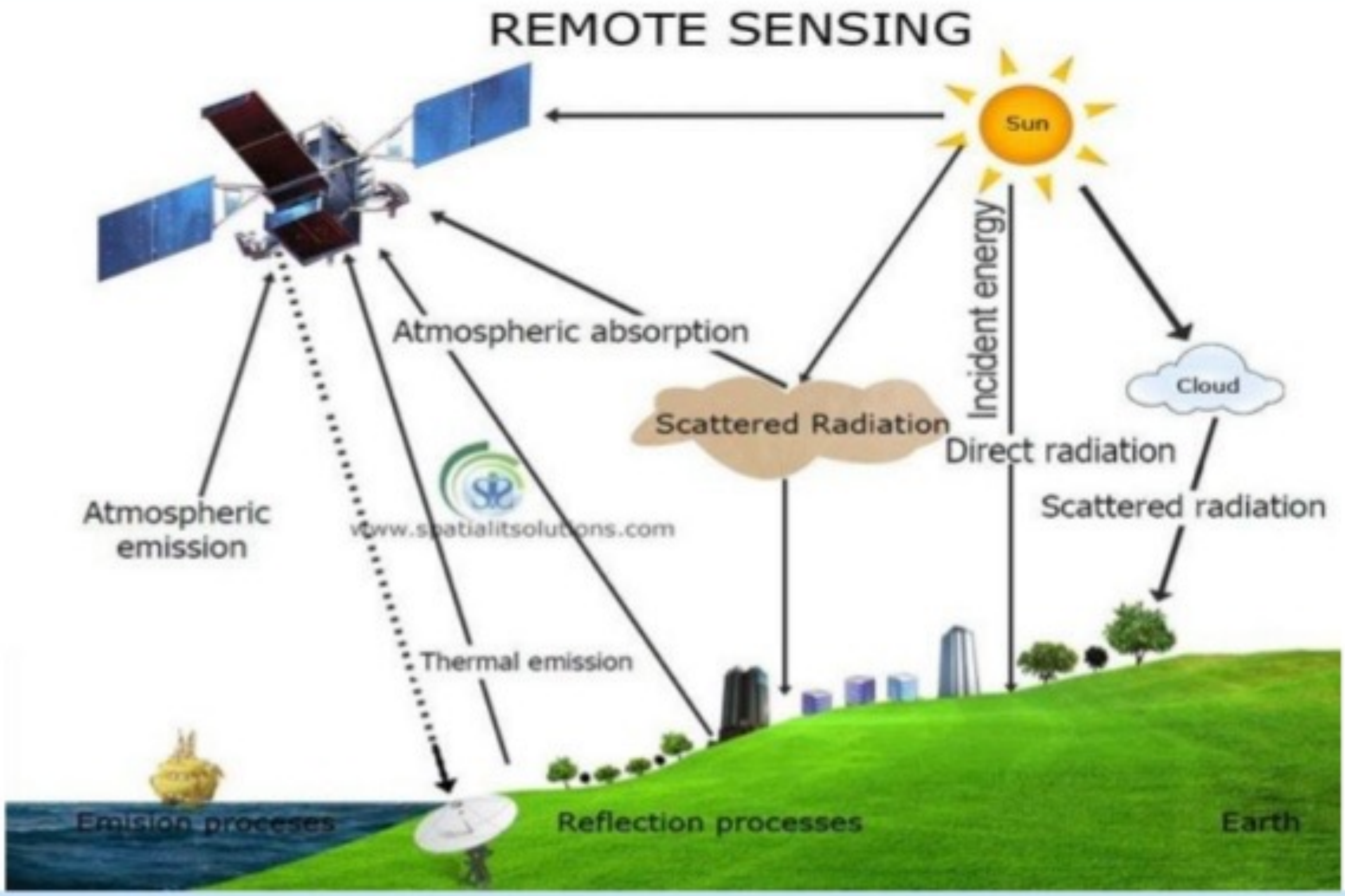
Remote Sensing

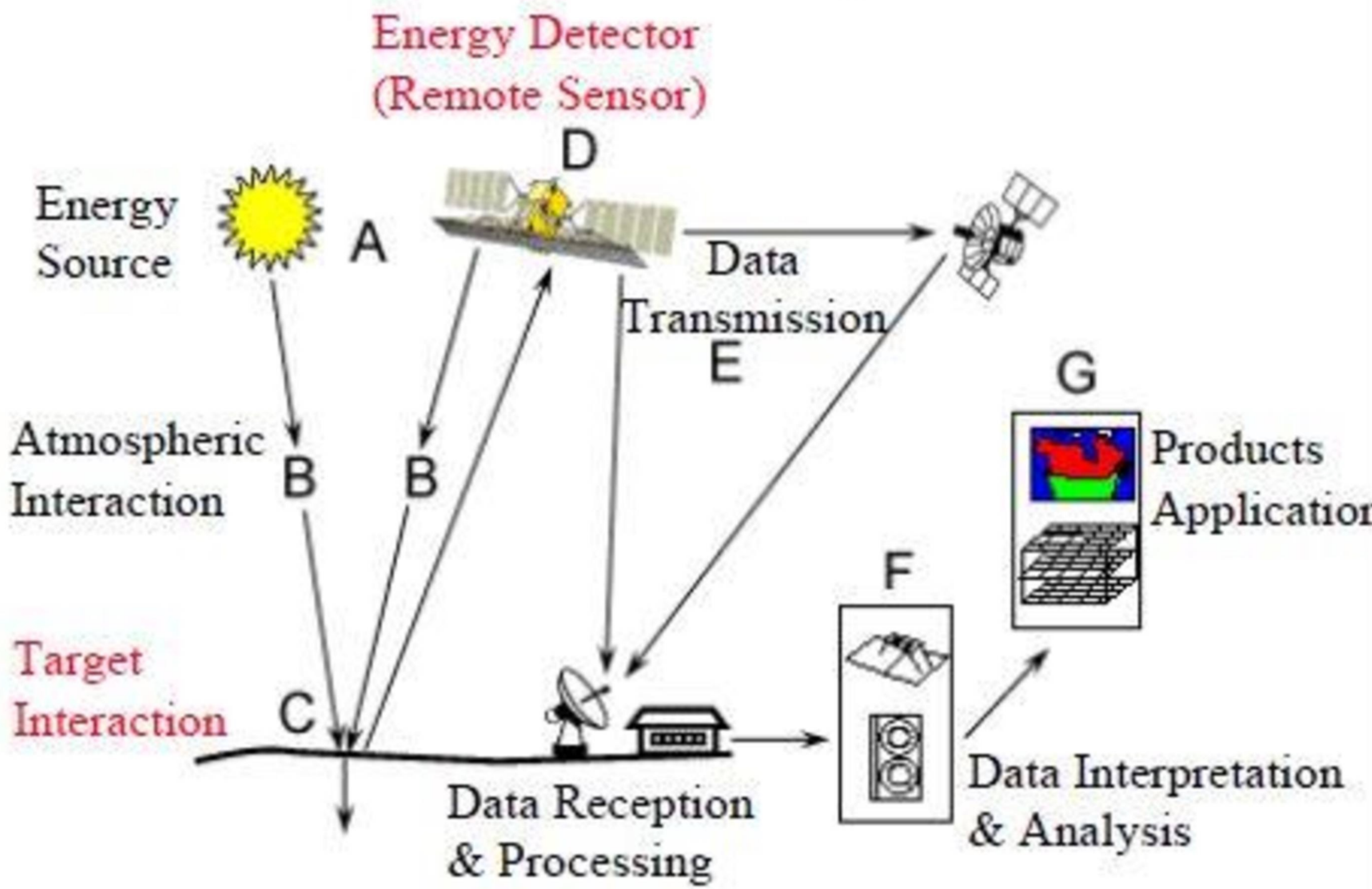


WHAT IS REMOTE SENSING?



Read More: Geospatial Training Services

The Remote Sensing Process



History of Remote Sensing

- 1929–1939: Economic depression generates environmental crises that lead to governmental applications of aerial photography
- 1930–1940: Development of radars in Germany, US, and UK
- 1939–1945: World War II: applications of nonvisible portions of electromagnetic spectrum; training of persons in acquisition and interpretation of airphotos
- 1950–1960: Military research and development
- 1956 Colwell's research on plant disease detection with infrared photography
- 1960–1970: First use of term *remote sensing* TIROS weather satellite Skylab remote sensing observations from space
- 1972: Launch of Landsat 1
- 1970–1980: Rapid advances in digital image processing
- 1980–1990: Landsat 4: new generation of Landsat sensors
- 1986: SPOT French Earth observation satellite
- 1980s: Development of hyperspectral sensors
- 1990s: Global remote sensing systems, lidars

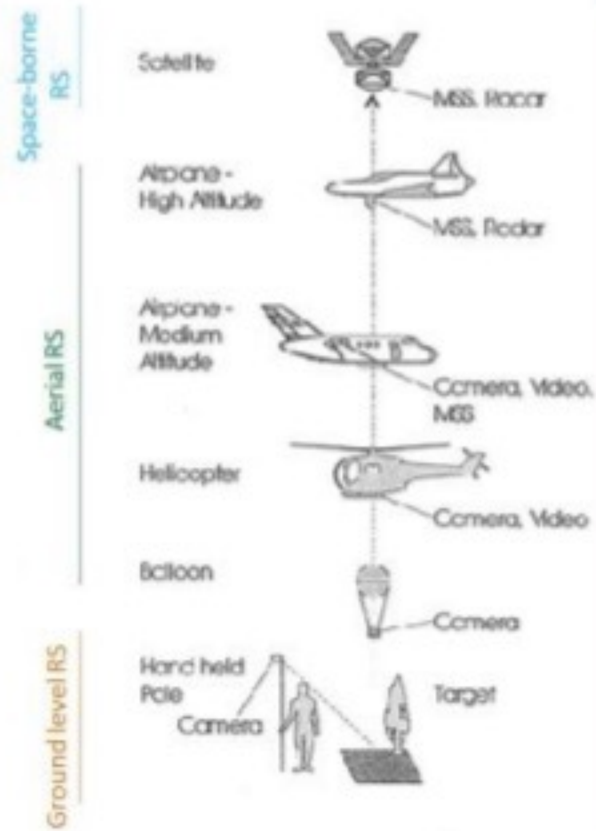
History of remote sensing

- 1783: The Marquis d'Arlandes and Pilatre made a voyage near Paris using a balloon.
- Photography using balloon, pigeon
- 1860: Aerial photos in Russia and the USA
- 1914-19: The first World War and the second World War (1939-45) had seen tremendous development in photography
- 1927: Robert Goddard launched the first liquid-fueled rocket.
- 1955: Work began on the Baikonur launch site in central Asia.
- 1957: Sputnik 1 launched from Baikonur (first satellite)
- 1961: Yuri Gagarin launched in the Vostok 1 capsule, becoming the first human in space.
- 1969: Neil Armstrong and Buzz Aldrin became the first humans to walk on the Moon.
- 1971: The first Space Station in history, the Russian Salyut 1
- 1972: (US Landsat1) the concept of imaging from satellites is introduced
- 1986: France launched the first stereo-image satellite (SPOT1)
- 1992: The space year (the maturity of remote sensing - 20 years of operation)
- 1995 The Shuttle-Mir Program (1st phase of the International Space Station (ISS).
- 2000 The first 3 astronauts (2 Russian and one American) start to live in the ISS

Note : 1988 ISRO Launched IRS-I

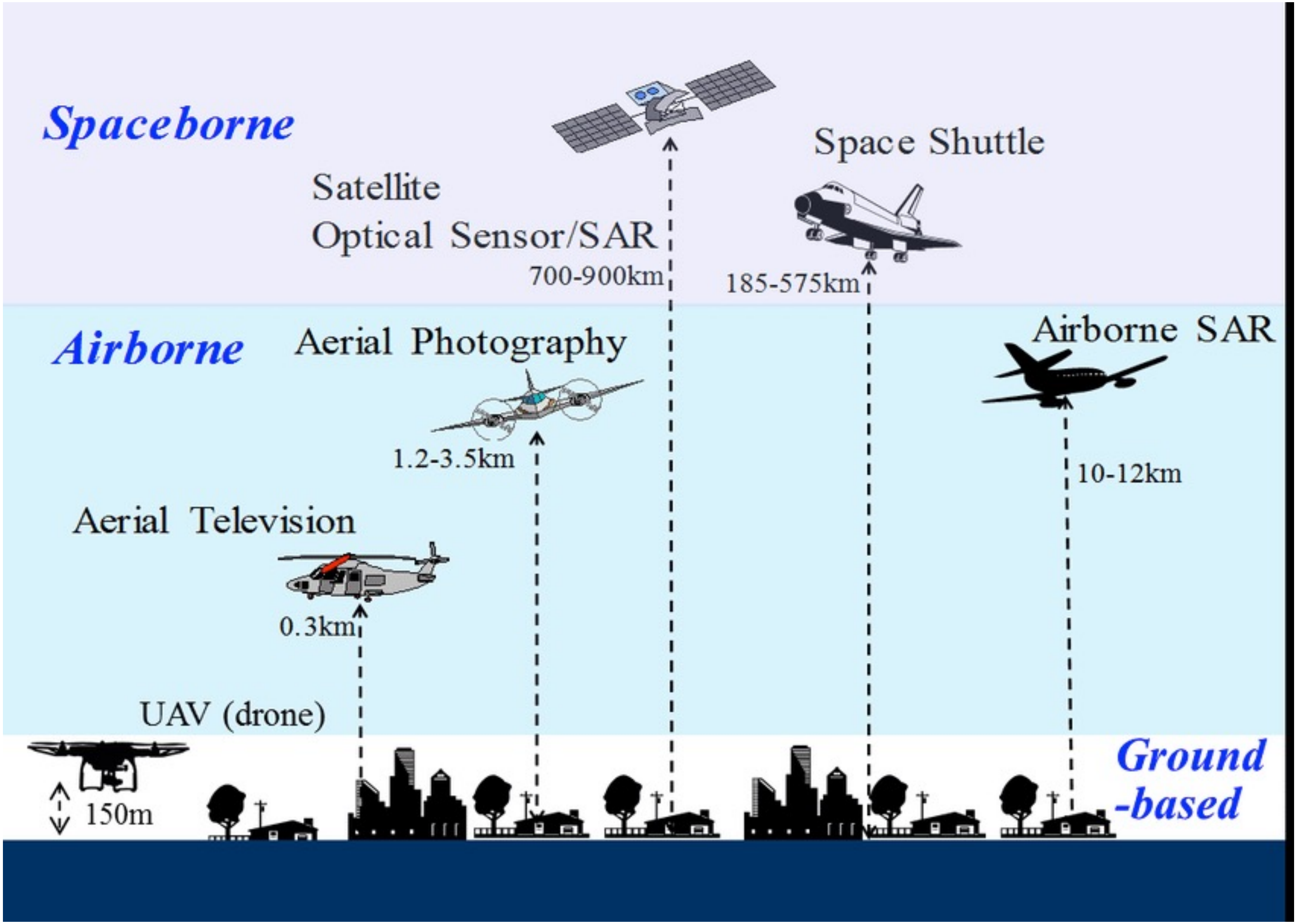
Remote Sensing Platforms

- Ground level remote sensing
  - Very close to the ground (e.g., Hand held camera)
  - Used to develop and calibrate sensors for different features on the Earth's surface
- Aerial remote sensing
  - Low altitude aerial remote sensing
  - High altitude aerial remote sensing
- Space-borne remote sensing
  - Space shuttles
  - Polar orbiting satellites
  - Geo-stationary satellites



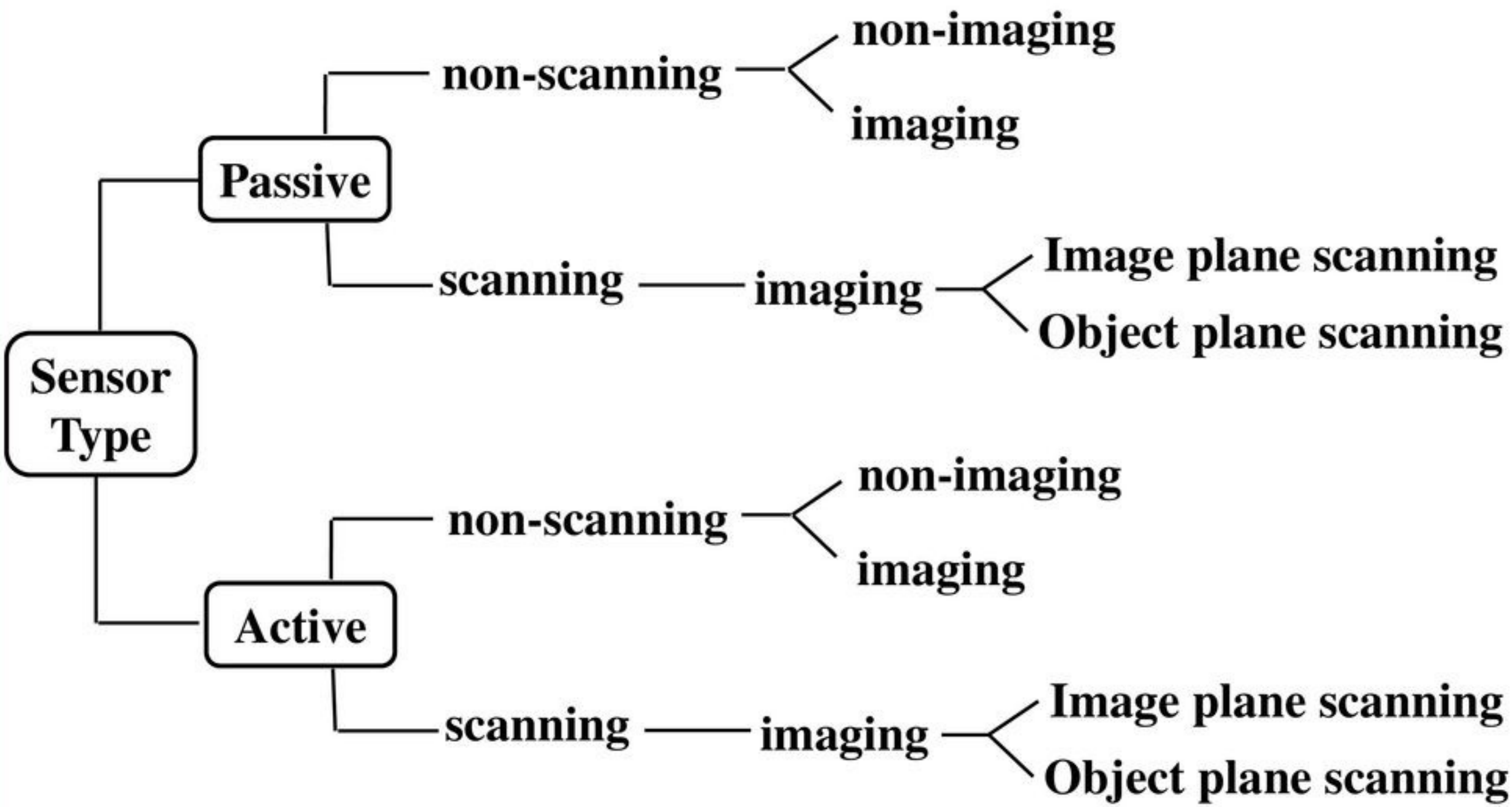
Platforms Used to Acquire Remote Sensing Data

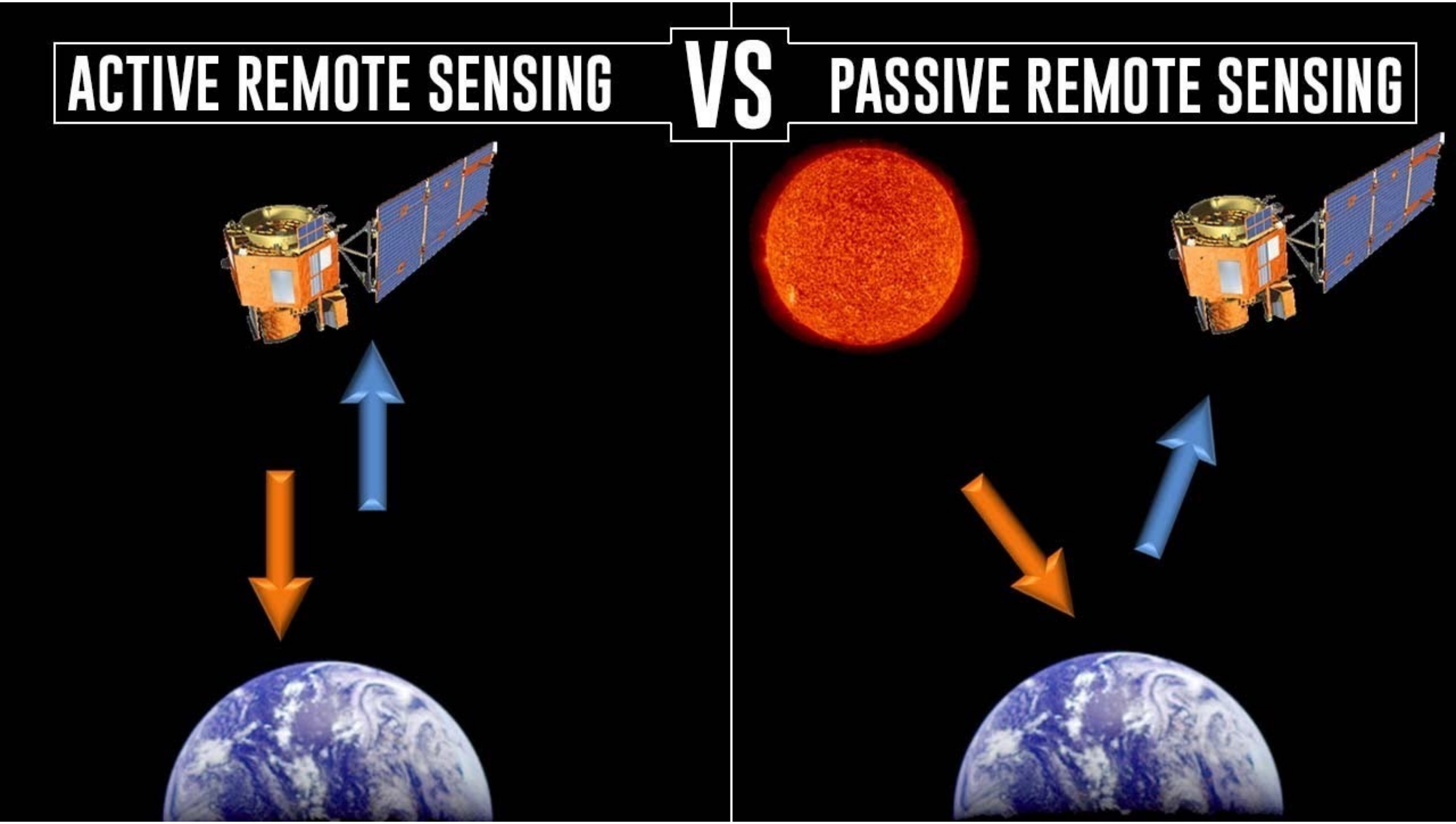
- Aircraft
  - Low, medium & high altitude
  - Higher level of spatial detail
- Satellite
  - Polar-orbiting, sun-synchronous
    - 800-900 km altitude, 90-100 minutes/orbit
  - Geo-synchronous
    - 35,900 km altitude, 24 hrs/orbit
    - stationary relative to Earth



Spaceborne
Satellite
Optical Sensor/SAR
700-900km
Space Shuttle
185-575km
Airborne
Aerial Photography
1.2-3.5km
Airborne SAR
10-12km
Aerial Television
0.3km
UAV (drone)
150m
Ground
-based

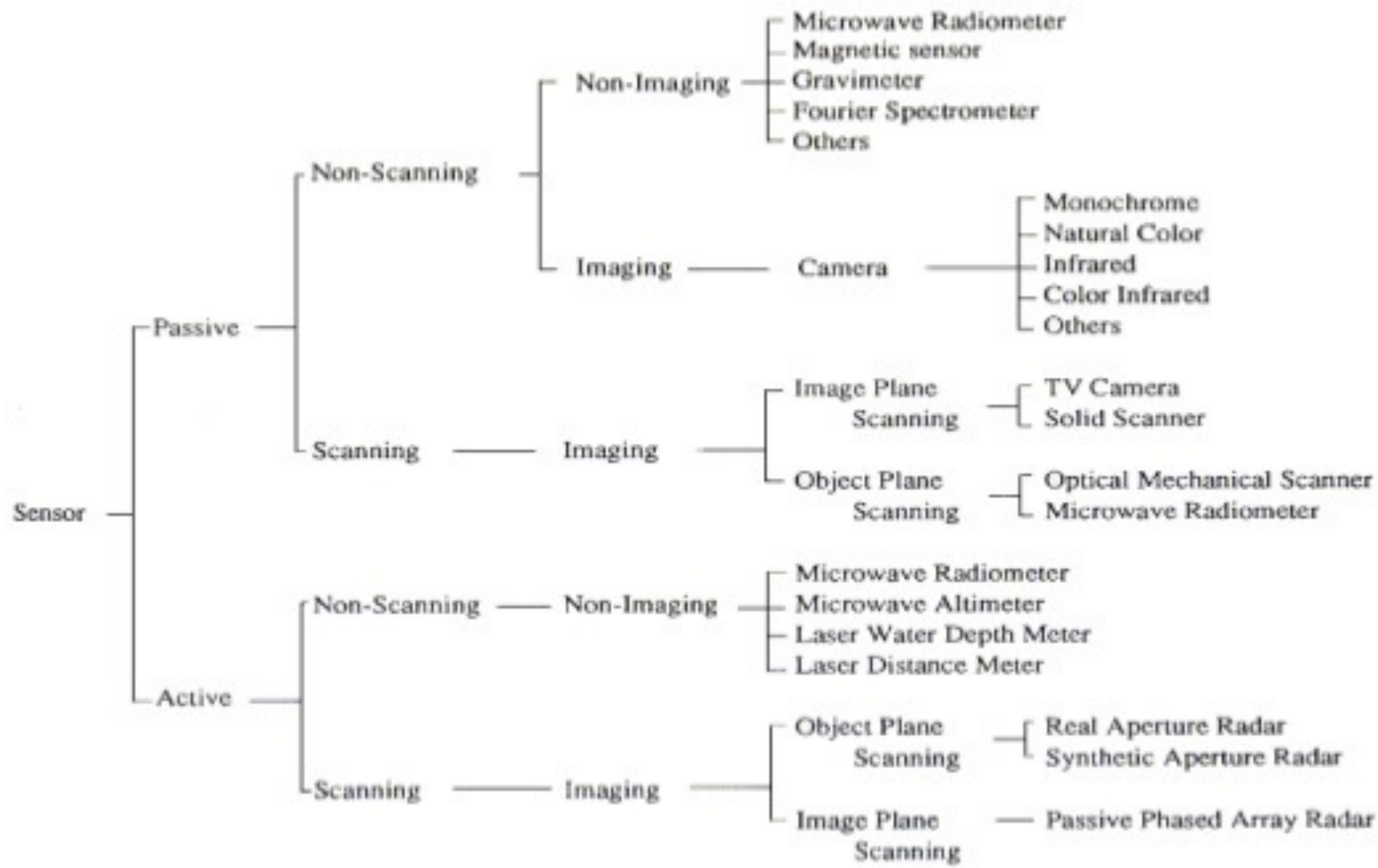
Sensor Types




ACTIVE REMOTE SENSING
VS
PASSIVE REMOTE SENSING

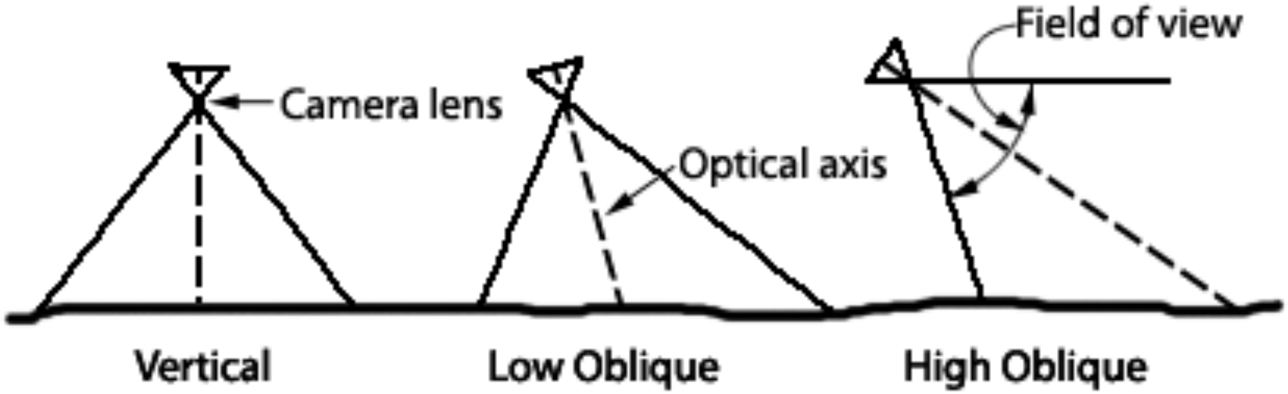
REMOTE SENSING SENSORS

Types of sensors :

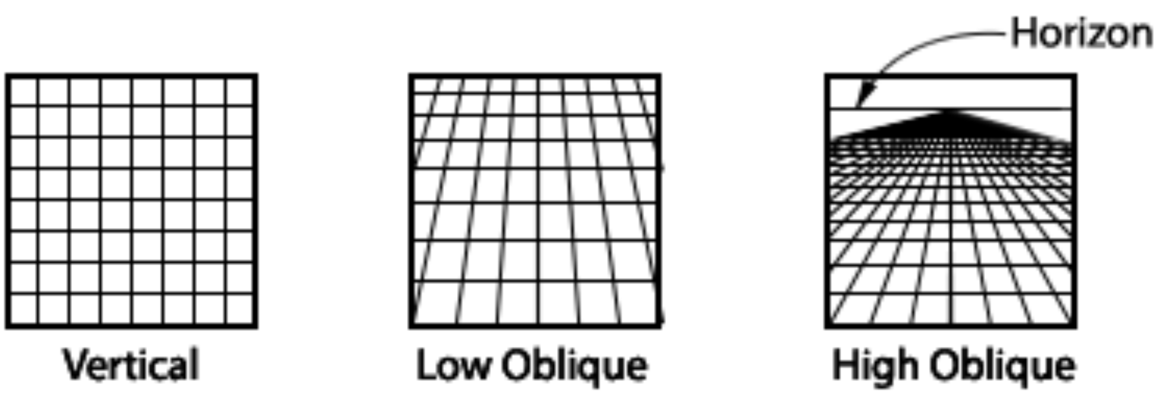


TYPES OF AERIAL CAMERAS

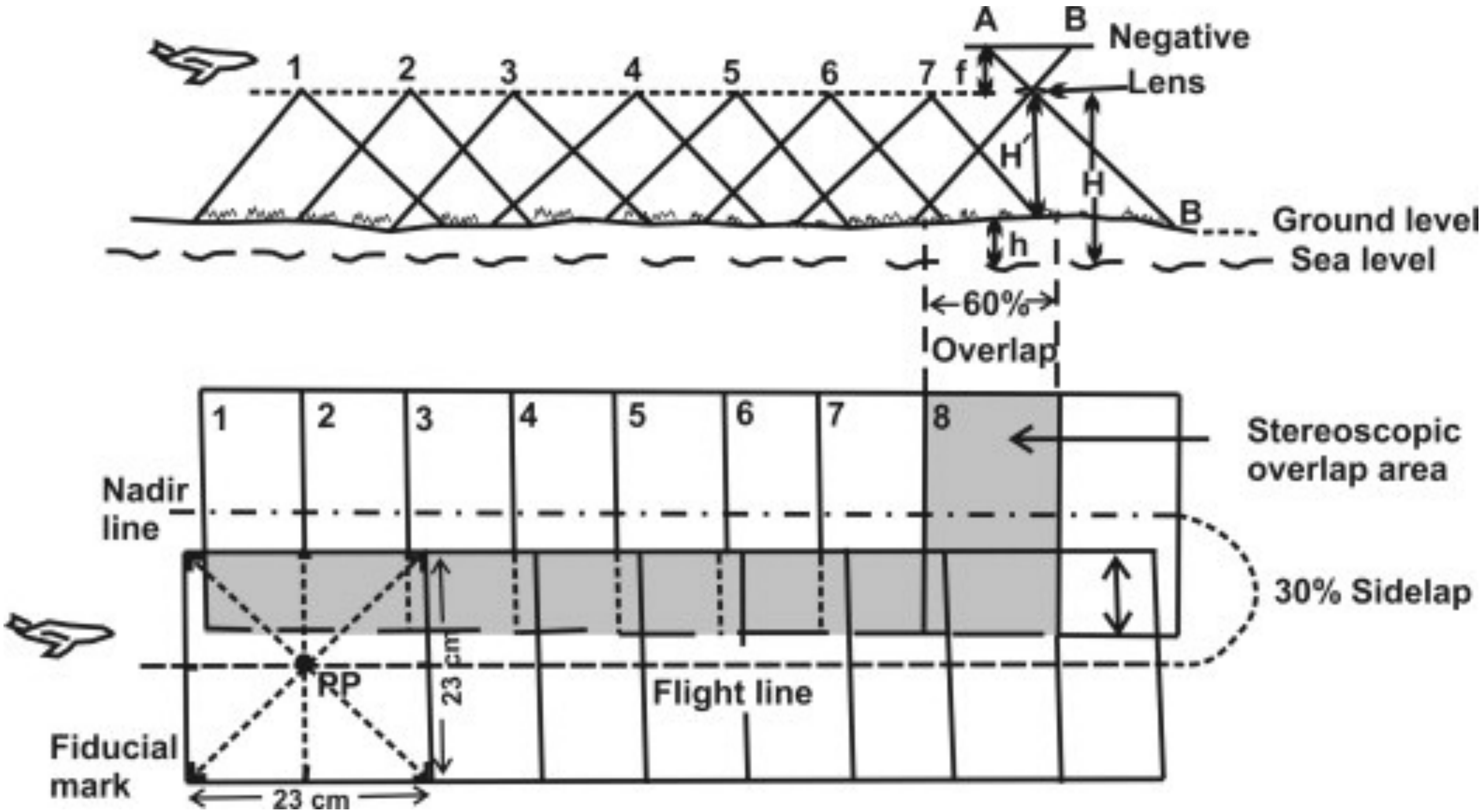
- *There are many types of aerial cameras:*
  - *Aerial mapping camera (single lens),*
  - *Reconnaissance camera,*
- *Strip camera,*
  - *Panoramic camera,*
  - *Multilens camera, the multi camera array (multiband aerial camera)*
  - *Digital camera*



Camera orientation for various types of aerial photographs

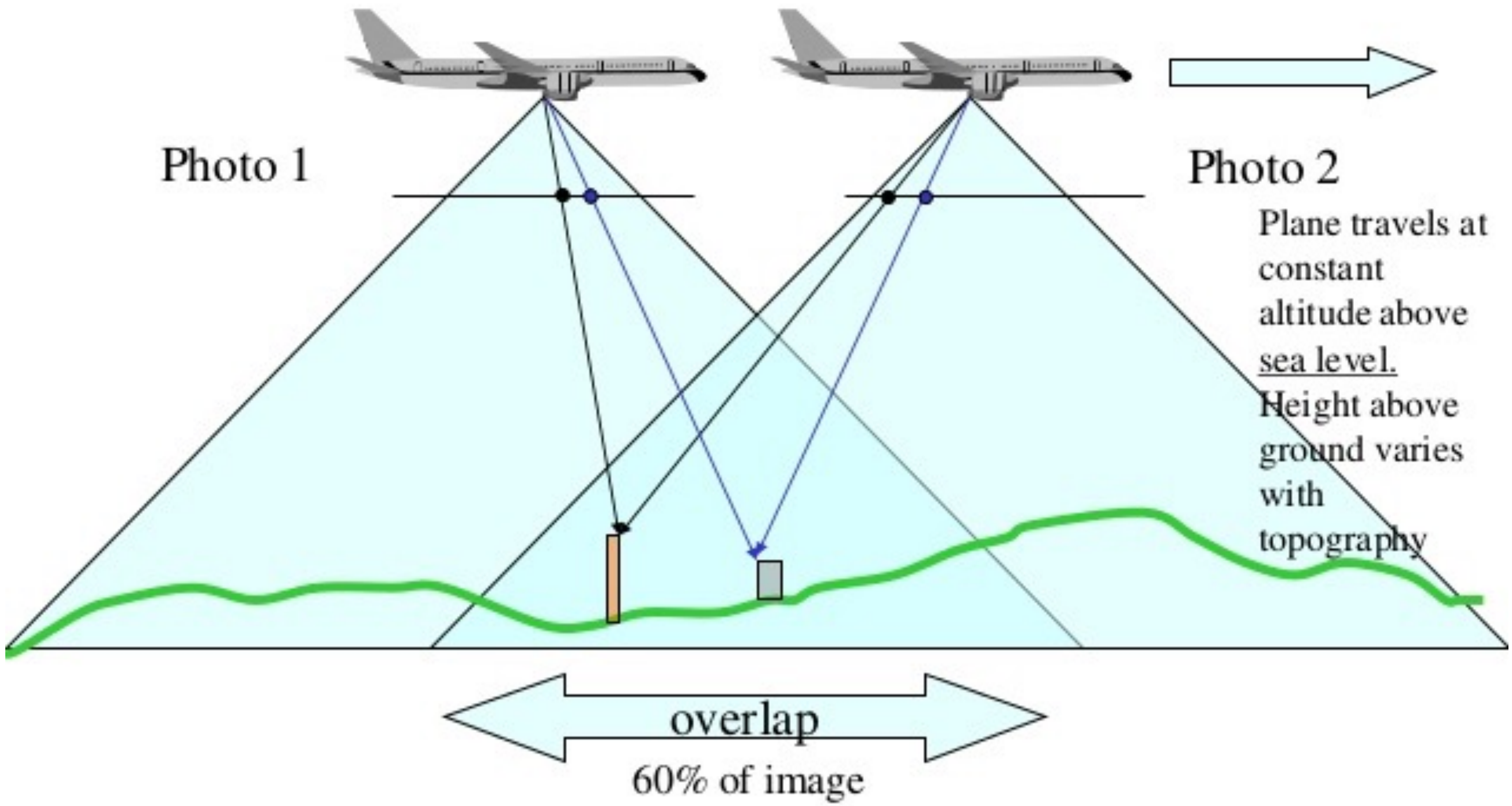


How a grid of section lines appears on various types of photos.

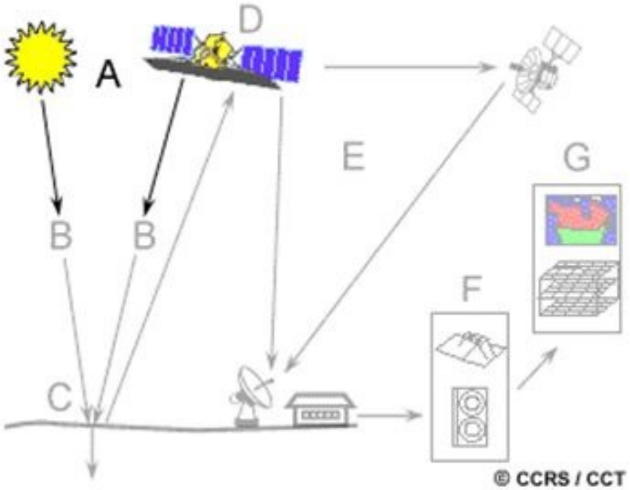


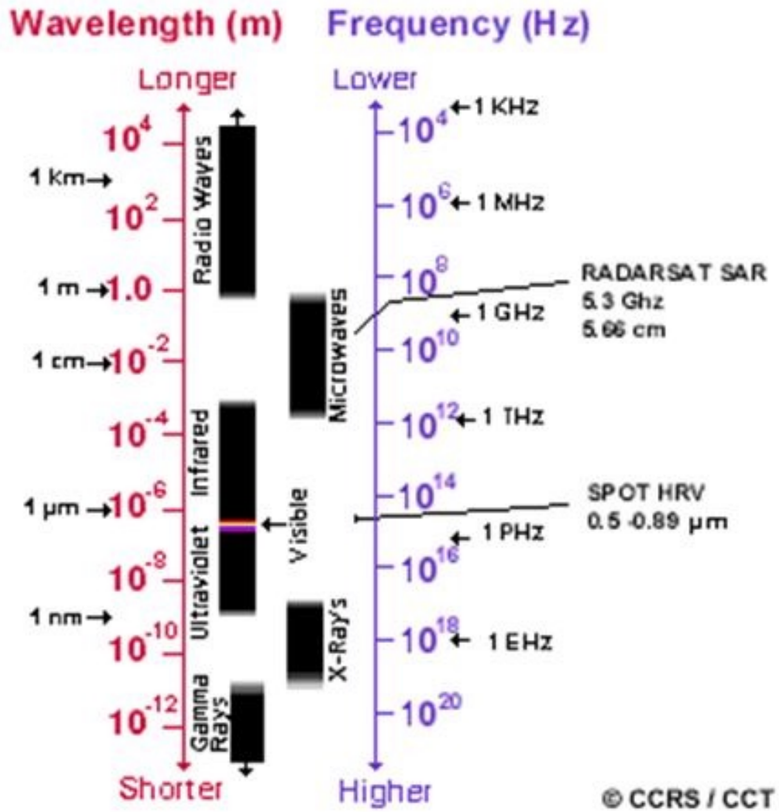
A
B
Negative
1
2
3
4
5
6
7
f
Lens
H′
H
B
Ground level
h
Sea level
60%
Overlap
1
2
3
4
5
6
7
8
Stereoscopic overlap area
Nadir line
30% Sidelap
23 cm
RP
Flight line
Fiducial mark
23 cm

- Overlapping aerial photographs can be used to build 3-d stereoscopic visual models. These can be used to map out contours and heights of features

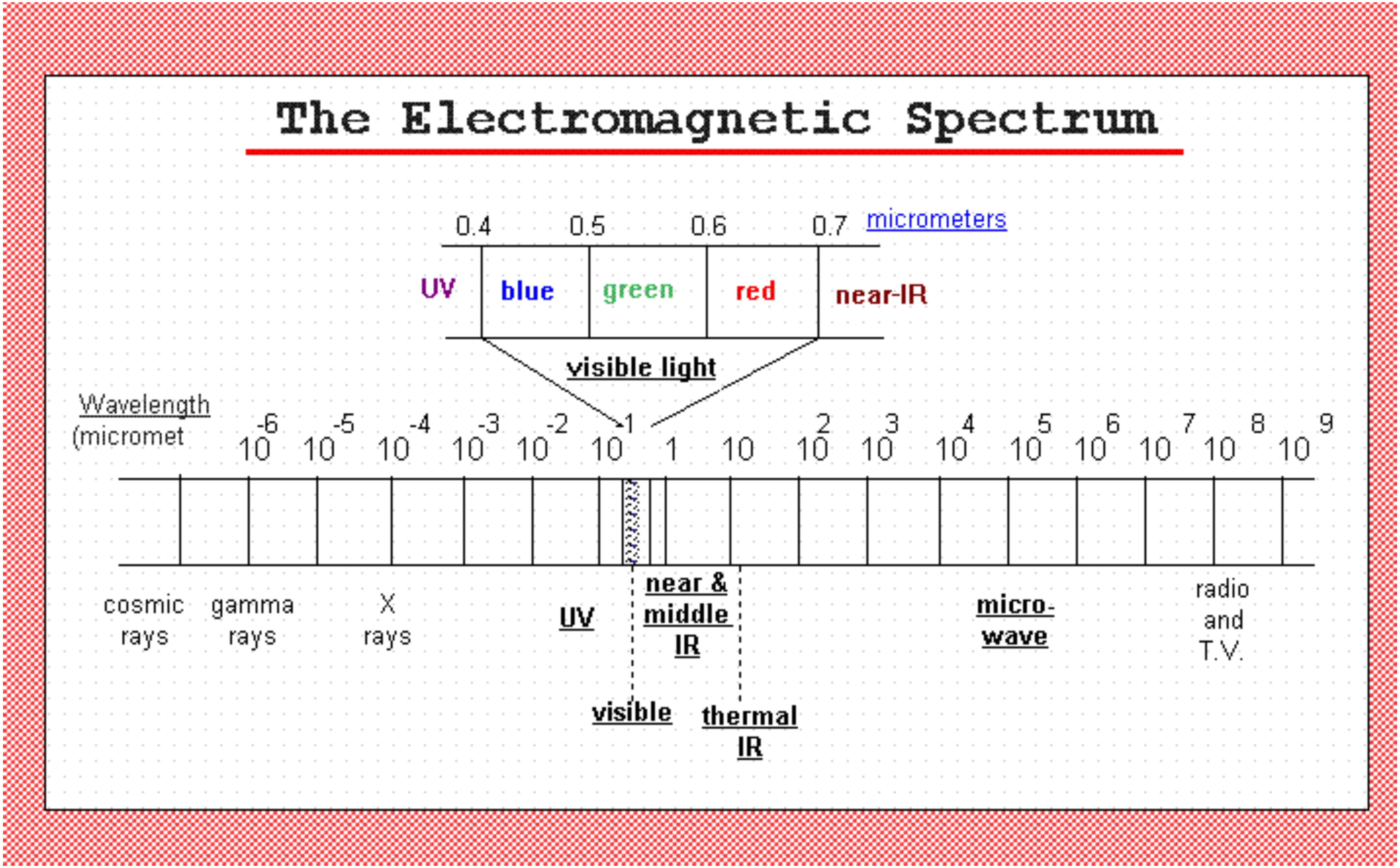


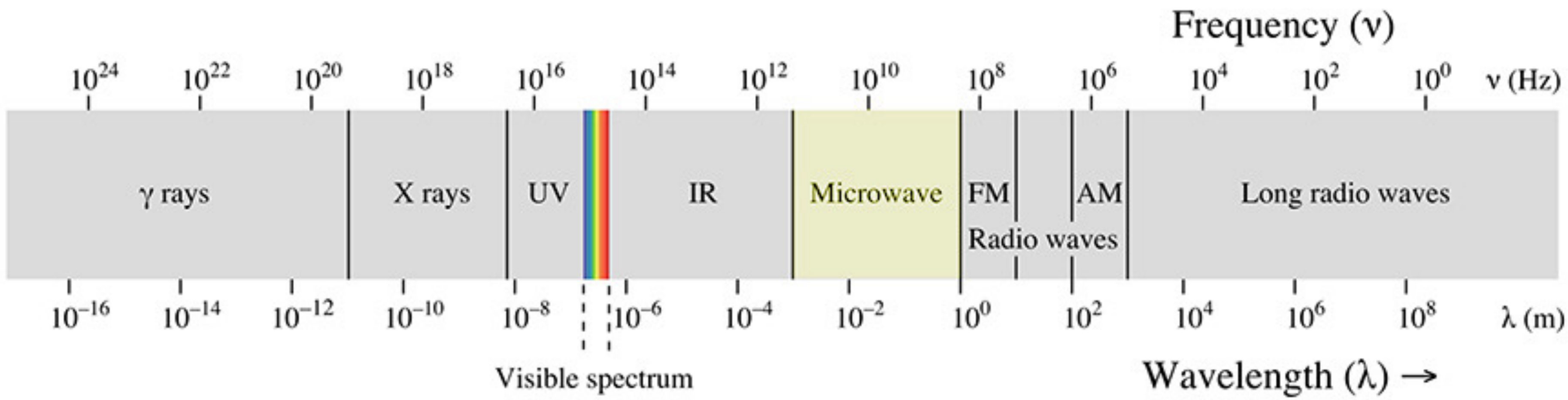
Remote sensing and EMR

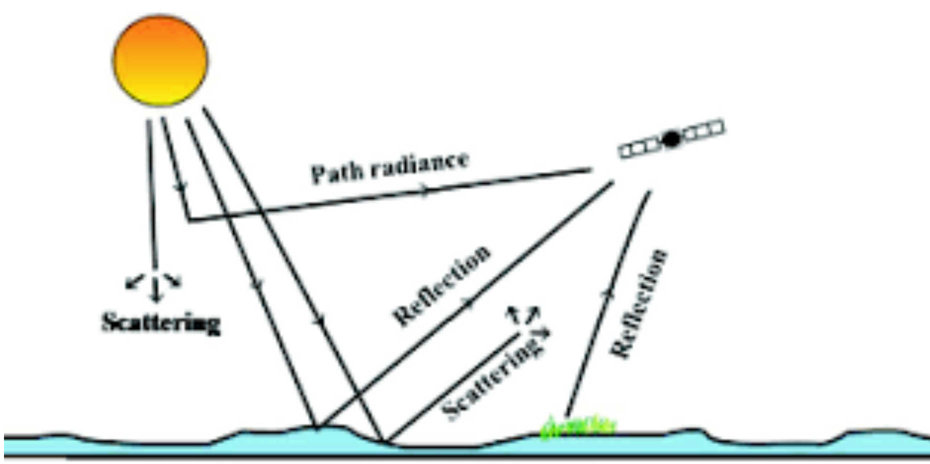


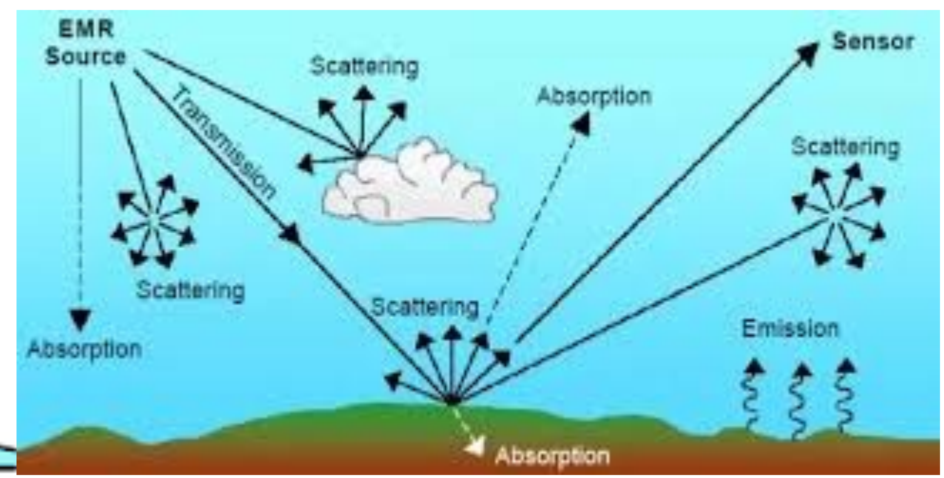


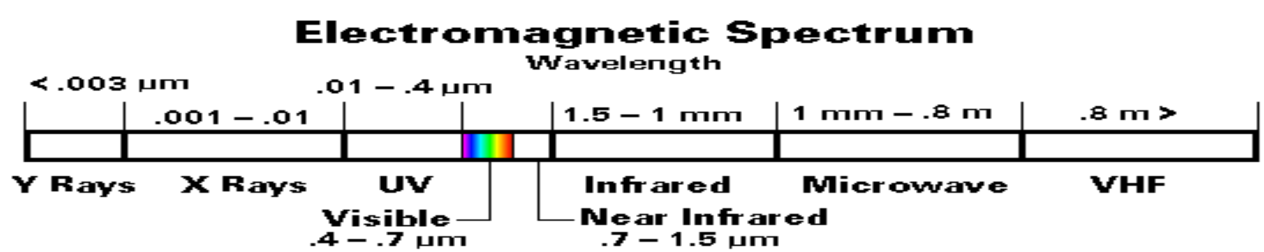
- remote sensing needs an **energy source to illuminate the target** (unless the sensed energy is being emitted by the target). This energy is in the form of **electromagnetic radiation**


The Electromagnetic Spectrum
0.4
0.5
0.6
0.7
micrometers
UV
blue
green
red
near-IR
visible light
Wavelength
(micromet
10^-6
10^-5
10^-4
10^-3
10^-2
10^-1
1
10
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
cosmic rays
gamma rays
X rays
UV
near & middle IR
micro-wave
radio and T.V.
visible
thermal IR

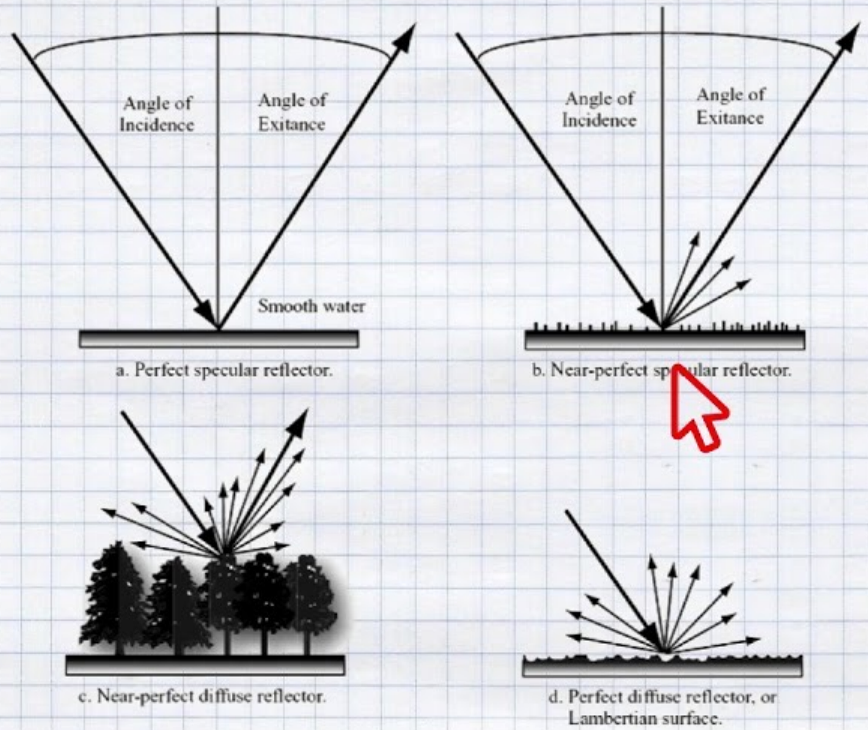

Frequency (ν)
10^24 10^22 10^20 10^18 10^16 10^14 10^12 10^10 10^8 10^6 10^4 10^2 10^0 ν (Hz)
γ rays
X rays
UV
IR
Microwave
FM
AM
Radio waves
Long radio waves
10^−16 10^−14 10^−12 10^−10 10^−8 10^−6 10^−4 10^−2 10^0 10^2 10^4 10^6 10^8 λ (m)
Visible spectrum
Wavelength (λ) →


Path radiance
Scattering
Reflection
Scattering
Reflection


EMR Source
Scattering
Transmission
Absorption
Sensor
Scattering
Scattering
Scattering
Absorption
Emission
Absorption

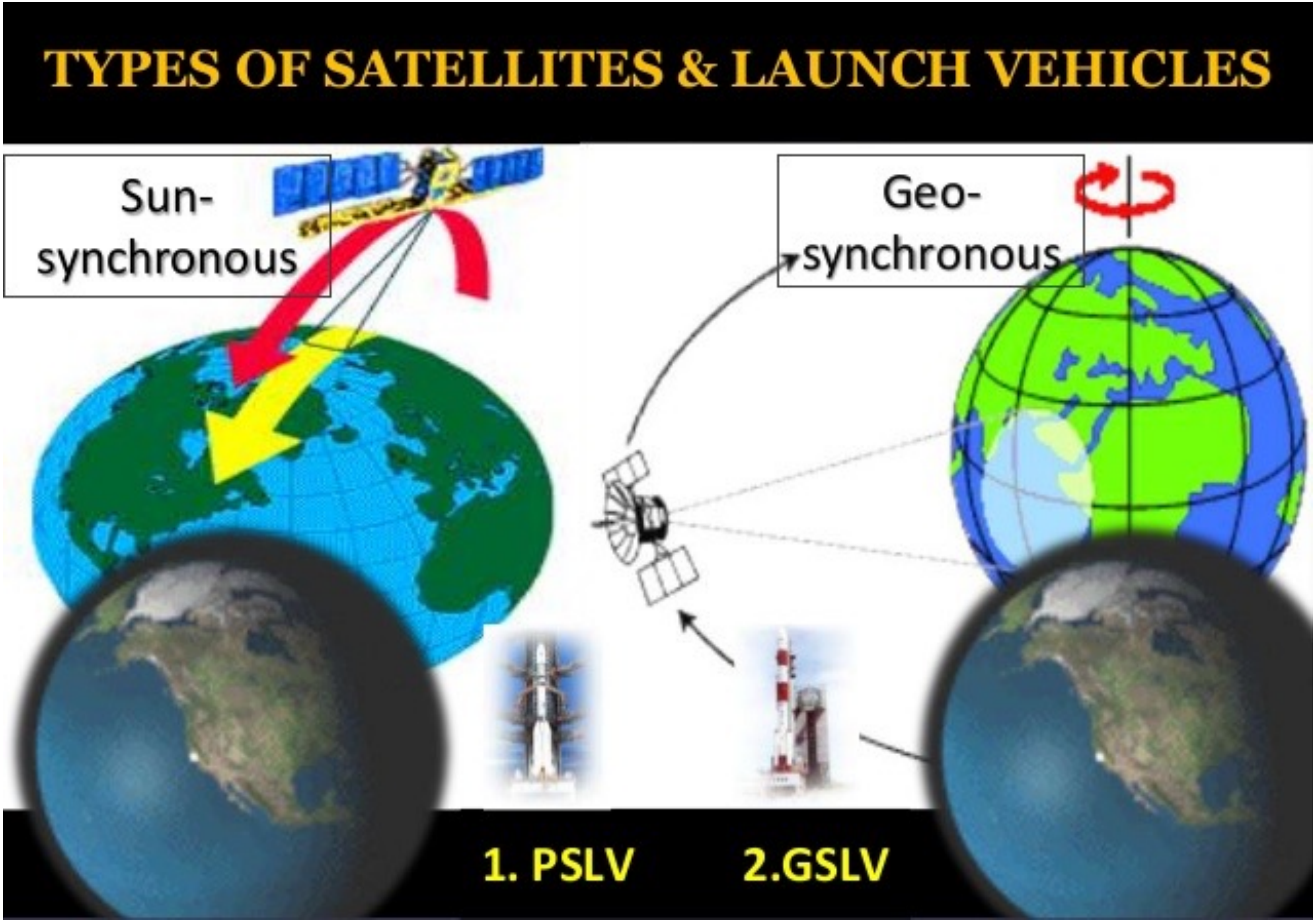

Electromagnetic Spectrum
Wavelength
< .003 µm
.01 – .4 µm
.001 – .01
1.5 – 1 mm
1 mm – .8 m
.8 m >
Y Rays
X Rays
UV
Infrared
Microwave
VHF
Visible
.4 – .7 µm
Near Infrared
.7 – 1.5 µm

EMR Radiation and Its Interactions with Atmosphere



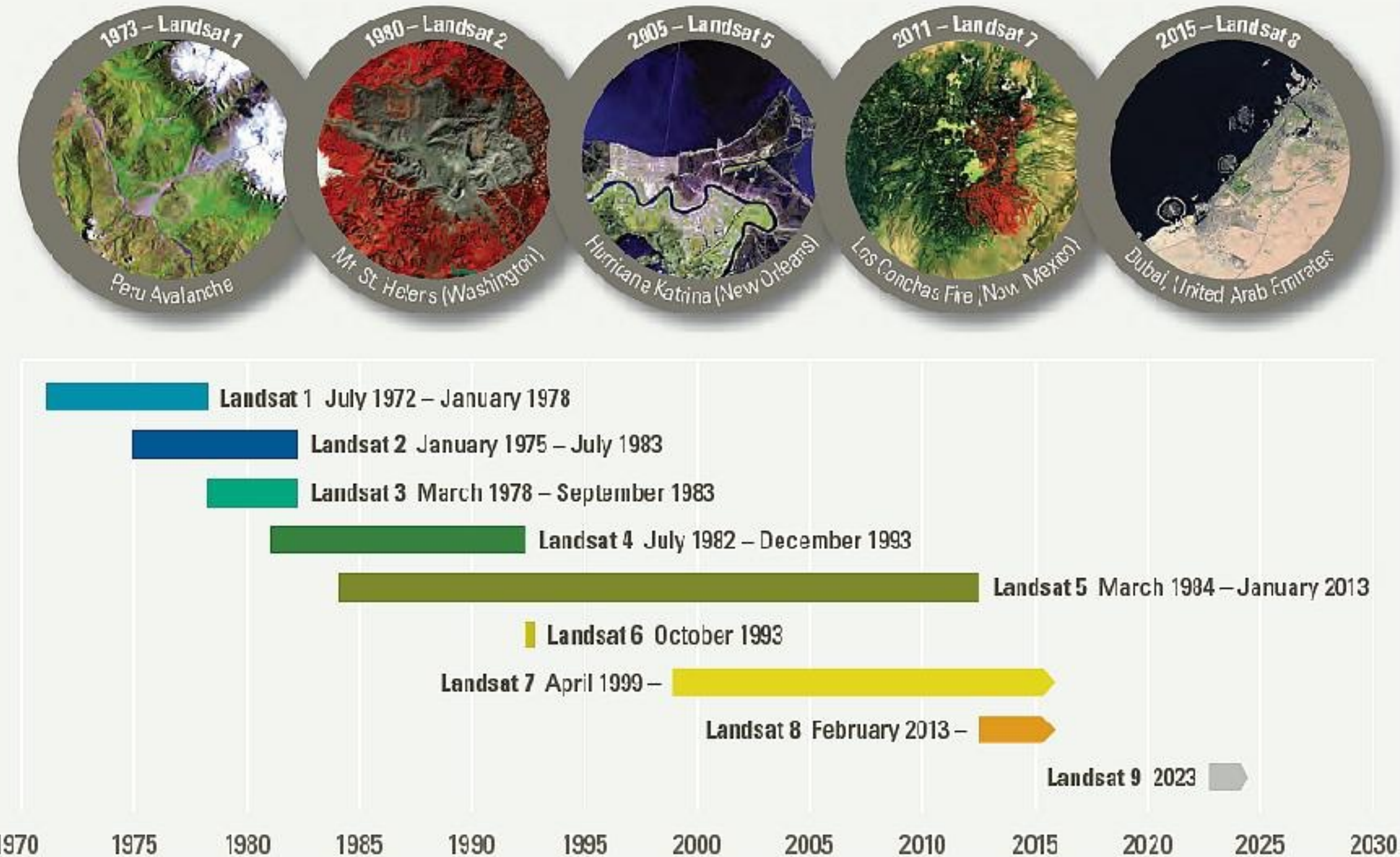
Region	Wavelength	Remarks	Detector device
Gamma ray	<0.03nm	Incoming radiation is completely absorbed by The upper atmosphere and is not available for Remote sensing	Scintillation counters Gamma ray spectrometers
Xray	0.03 – 3.0nm	Completely absorbed by atmosphere. Not employed In remote sensing	
Ultraviolet	0.3 – 0.4 µm	Incoming wavelengths less than 0.3nm are Completely 0.4 µm absorbed by ozone in the Upper atmosphere	Scanners with filtered multipliers and cameras with filtered infrared film
Photographic UV band	0.3 – 0.4 µm	Transmitter through atmosphere. Detectable with Film and photo detectors, but atmosphere scattering Is severe	
Visible	0.4 – 0.7 µm	Imaged with film and photo detectors. Includes Reflected energy peak of earth at 0.5 µm	Film in cameras and scanners with filtered photo multipliers
Infrared	0.7 - 100 µm	Interaction with matter varies with wavelength. Atmospheric transmission on windows are Separated.	
Reflected IR band	0.7 – 3.0 µm	Reflected solar radiation that contains to Information about thermal properties of Materials. The band from 0.7 – 0.9 µm is Detectable with film and is called detectable with Film and is called photo graphics IR band	(7 – 15m) canners with infrared sensitive film and solid-state defectors in scanners and radiometers
Thermal IR band	3 - 5 µm 8 - 14 µm	Principle atmospheric windows in the thermal region Images a these wavelengths are acquired by Opticalmechanical scanners and special video systems But not by film. Microwave 0.1 – 30cm longer Wavelengths can penetrate clouds, fog and rain Images may be acquired in the active or passive Mode.	(1.5 – 14) solid state detectors in scanners and radiometers
Radar	0.1 – 30cm	Active form of microwave remote sensing. Radar Images are acquired at various wavelength bands.	Side looking airborne radars and receivers in scanners and radiometers
Radio	>30cm	longest wavelength portion of electromagnetic Spectrum. Some classified radars with very long Wavelengths operate in this region.	Electromagnetic pulse techniques.

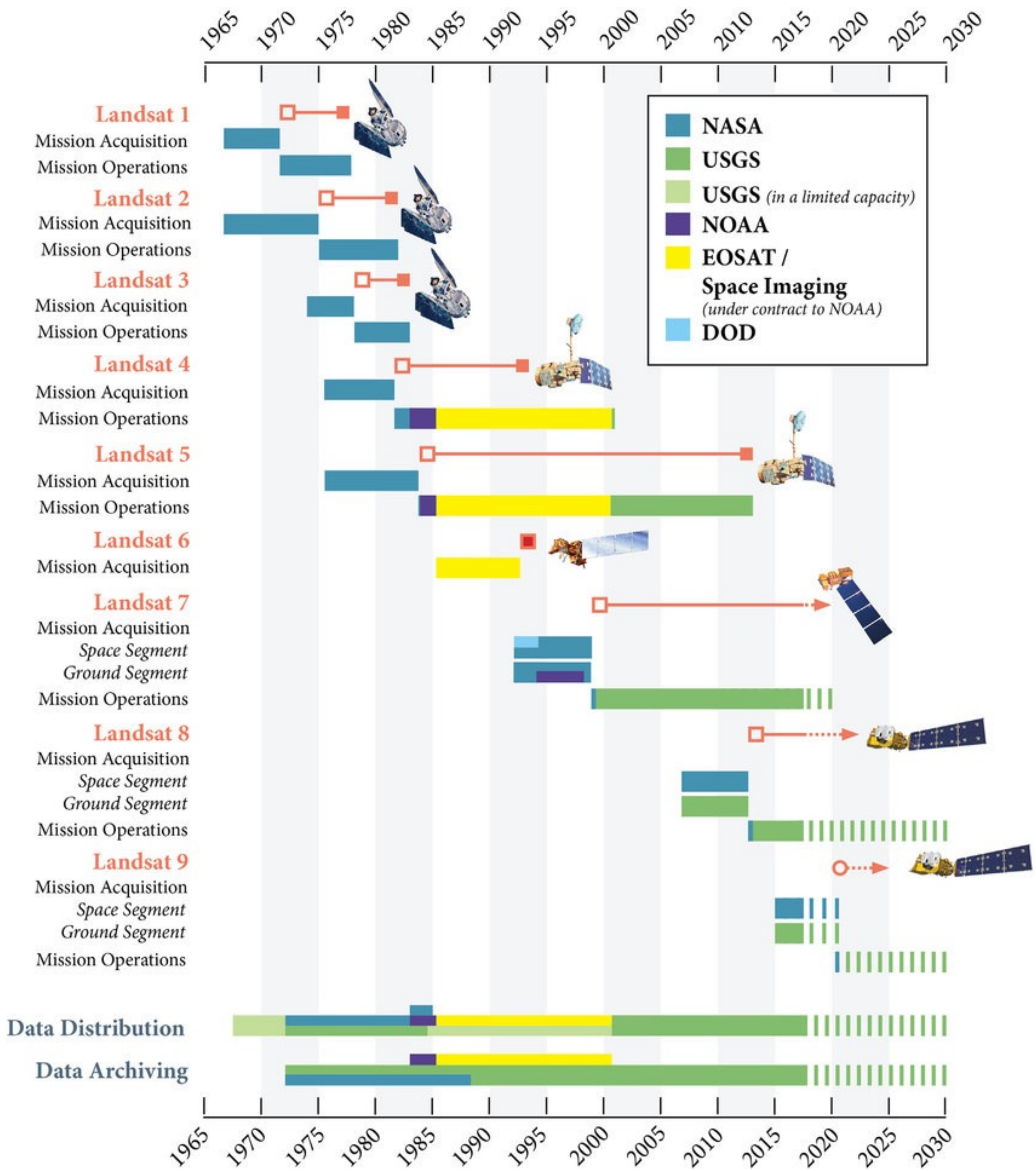
Band	Wavelength	Nominal Spectral Location	Principal Applications
1	0.45-0.52	Blue	Useful for coastal water mapping as it is designed for water body penetration. Also useful for forest type mapping, soil/ vegetation discrimination, and cultural feature identification.
2	0.52-0.60	Green	Useful for vegetation discrimination and vigor assessment as designed to measure green reflectance peak of vegetation. Also useful for identification of cultural feature.
3	0.63-0.69	Red	Aiding in plant species differentiation, as it is designed to sense in a chlorophyll absorption region. Also useful for identification of cultural feature.
4	0.76-0.90	Near infrared	Useful for determination of vegetation types, vigor, and biomass content, for soil moisture discrimination and for delineating water bodies.
5	15.5-1.75	Mid-infrared	Useful for determination of vegetation moisture content, soil moisture discriminations, and thermal mapping applications.
6	10.4-12.5	Thermal infrared	Useful in vegetation stress analysis, soil moisture discrimination, and thermal mapping applications.
7	2.08-2.35	Mid-infrared	Useful for discrimination of types of mineral and rock and determination of vegetation moisture content.

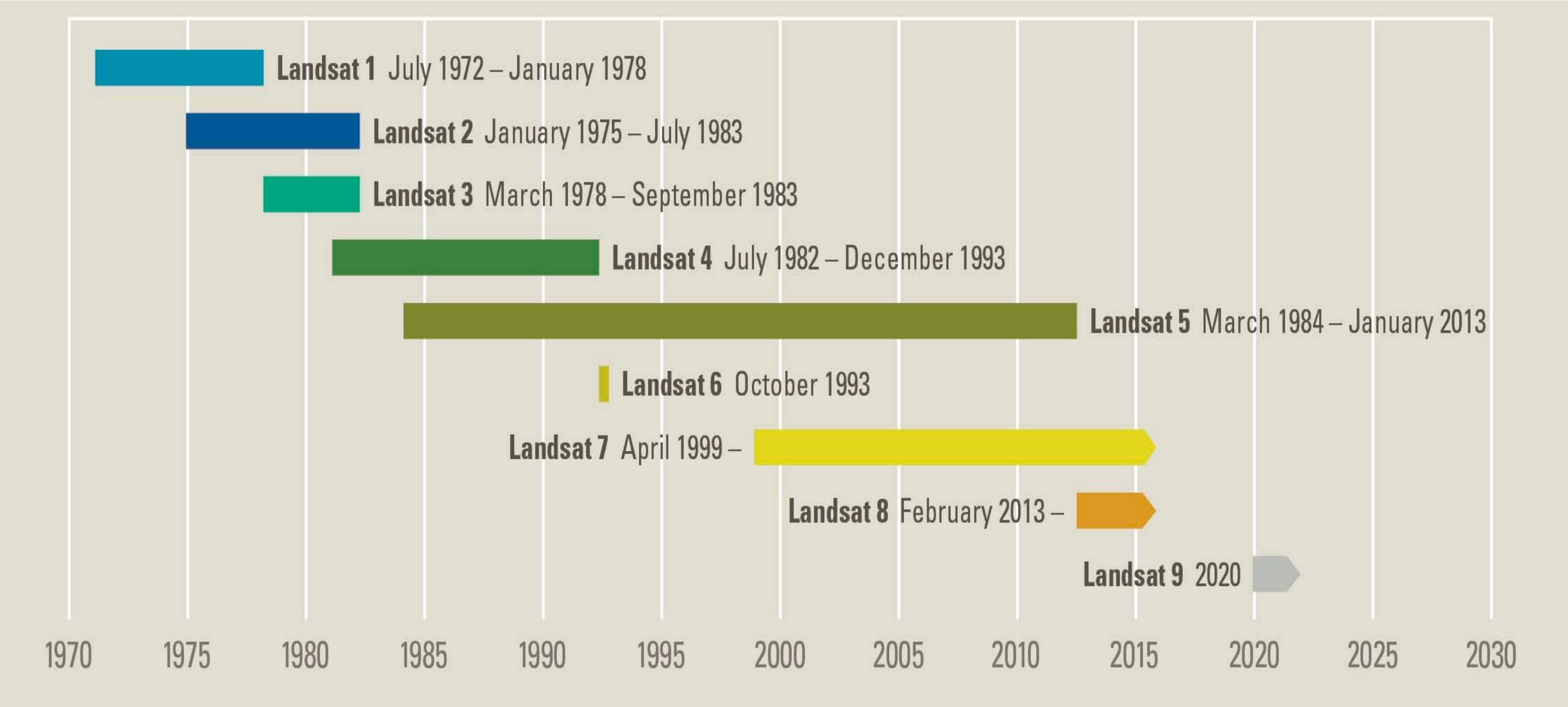


TYPES OF SATELLITES & LAUNCH VEHICLES
Sun-synchronous
Geo-synchronous
1. PSLV
2.GSLV

Landsat Missions: Imaging the Earth Since 1972

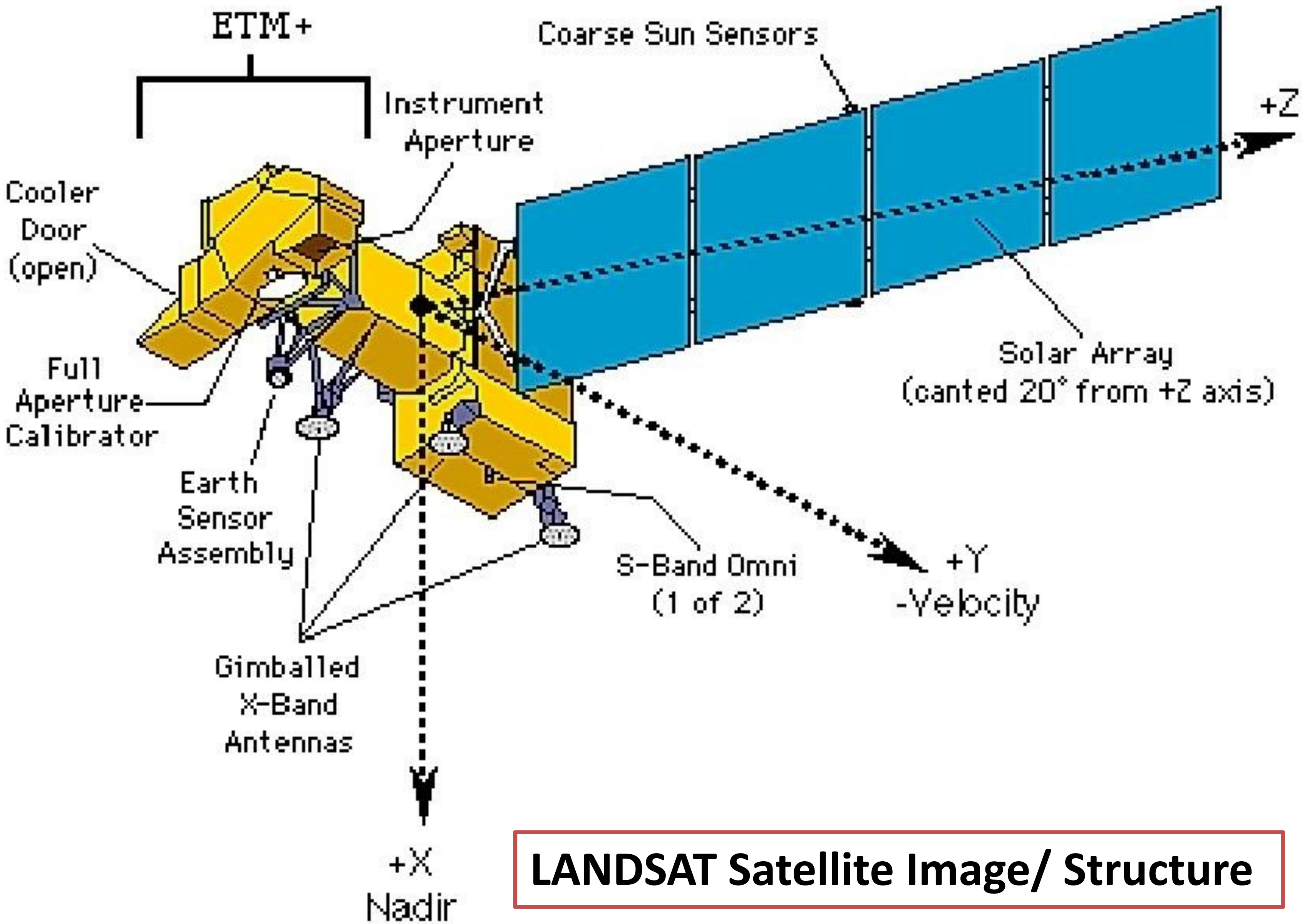



1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
Landsat 1
Mission Acquisition
Mission Operations
Landsat 2
Mission Acquisition
Mission Operations
Landsat 3
Mission Acquisition
Mission Operations
Landsat 4
Mission Acquisition
Mission Operations
Landsat 5
Mission Acquisition
Mission Operations
Landsat 6
Mission Acquisition
Landsat 7
Mission Acquisition
Space Segment
Ground Segment
Mission Operations
Landsat 8
Mission Acquisition
Space Segment
Ground Segment
Mission Operations
Landsat 9
Mission Acquisition
Space Segment
Ground Segment
Mission Operations
Data Distribution
Data Archiving
NASA
USGS
USGS (in a limited capacity)
NOAA
EOSAT / Space Imaging (under contract to NOAA)
DOD



Landsat 1 July 1972 – January 1978
Landsat 2 January 1975 – July 1983
Landsat 3 March 1978 – September 1983
Landsat 4 July 1982 – December 1993
Landsat 5 March 1984 – January 2013
Landsat 6 October 1993
Landsat 7 April 1999 –
Landsat 8 February 2013 –
Landsat 9 2020
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030

Satellite	Sensor	Launch Year	No. of MS bands [nominal resolution]	Panchromatic resolution (nominal) (m)	Thermal bands [resolution]	Altitude (km)
Landsat 1	MSS/RBV	1972	4 [80 m]	-	-	920
Landsat 2	MSS/RBV	1975	4 [80 m]	-	-	920
Landsat 3	MSS/RBV	1978	4 [80 m]	-	-	920
Landsat 4	MSS/TM	1982	6 [30 m]	-	1 [120 m]	705
Landsat 5	MSS/TM	1984	6 [30 m]	-	1 [120 m]	705
Landsat 6*	ETM+	1993	-	-	-	-
Landsat 7	ETM+	1999	6 [30 m]	1 [15 m]	1 [60 m]	705
Landsat 8	OLI/TIRS	2013	8^{β} [30 m]	1 [15 m]	2 [100 m]	705



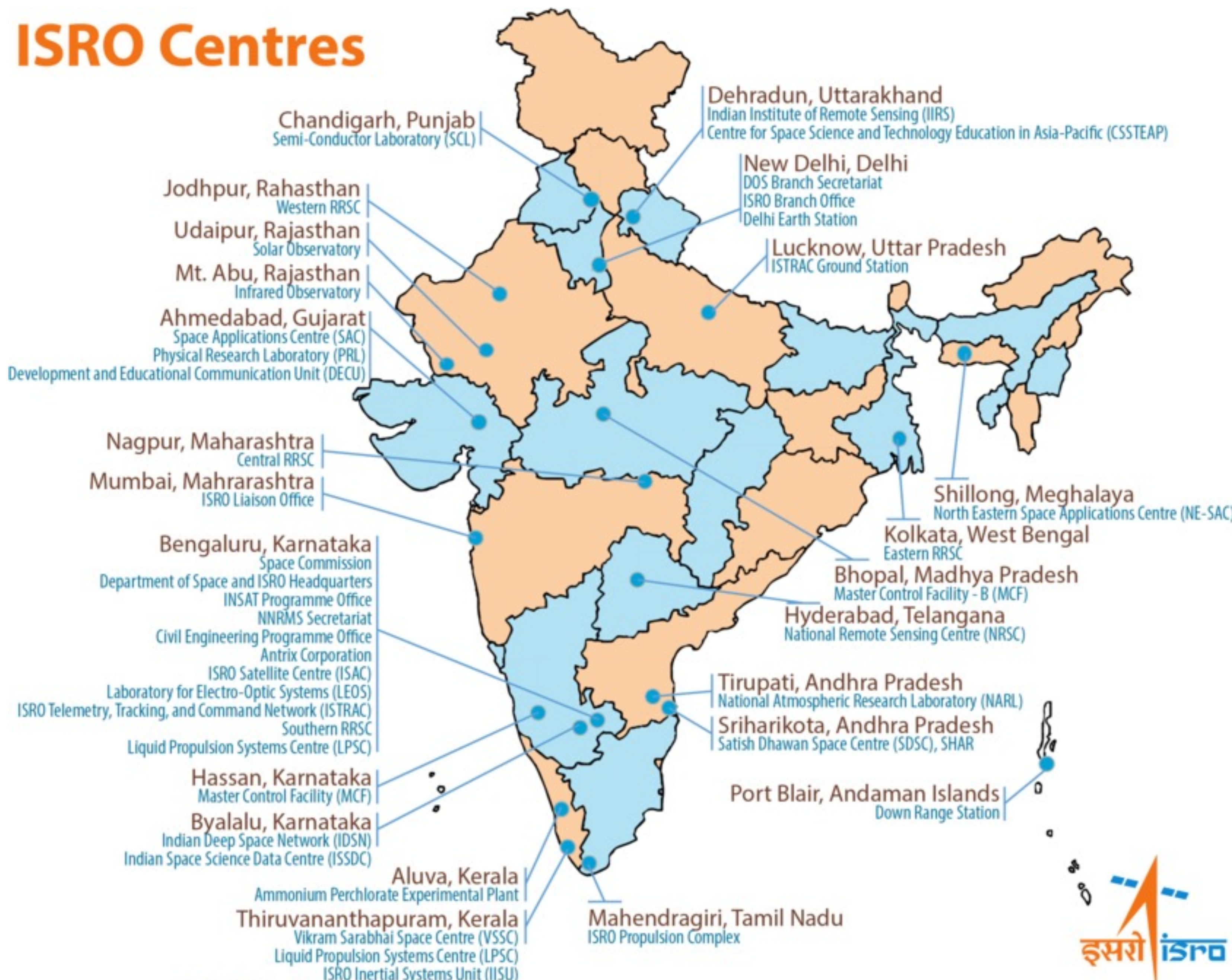
LANDSAT Satellite Image/ Structure

Indian Remote Sensing Satellite Series

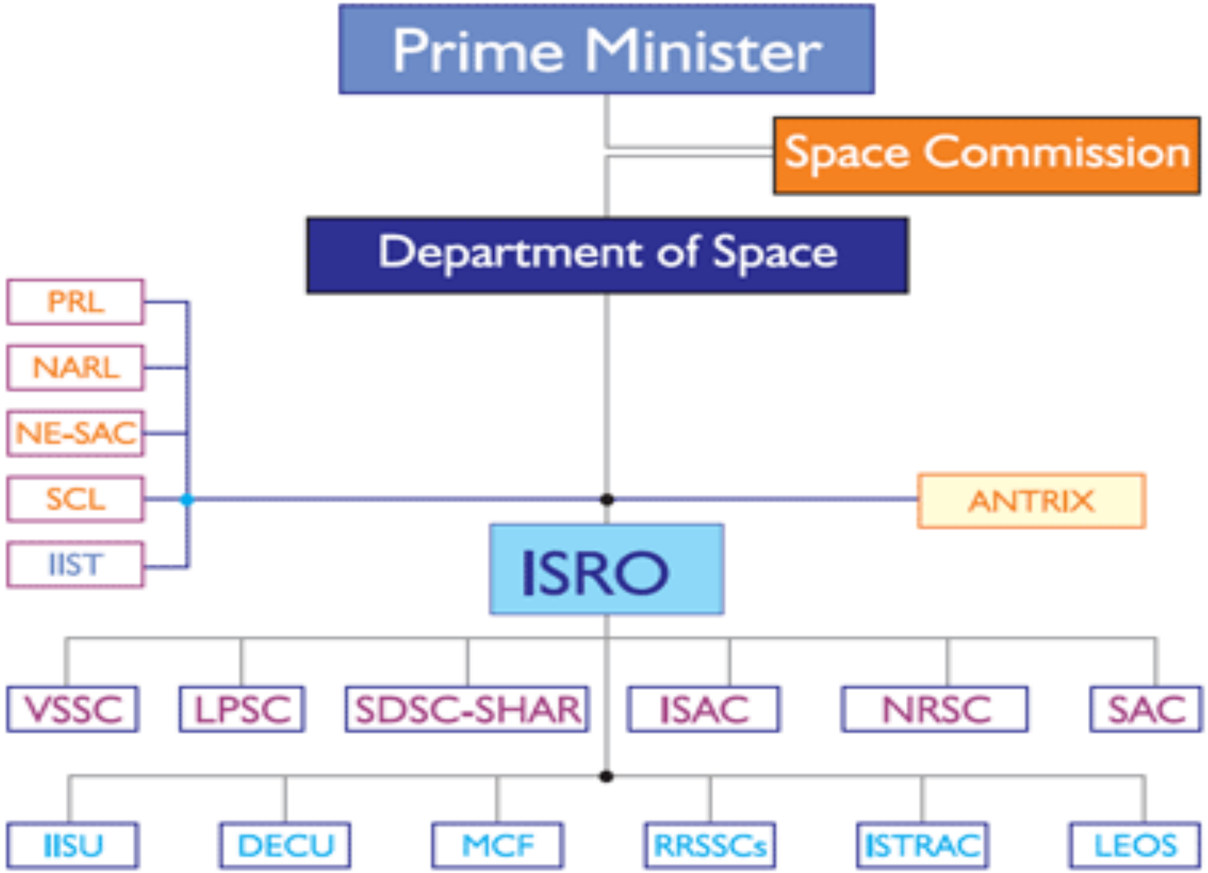
By

Indian Space Research Organization (ISRO)

ISRO Centres



Map by Emily Lakdawalla for The Planetary Society based on isro.gov.in/about-isro/isro-centres. 10 May 2018



NRSC: National Remote Sensing Centre, **PRL:** Physical Research Laboratory, **NARL:** National Atmospheric Research Laboratory, **NE-SAC:** North Eastern Space Applications Centre, **SCL:** Semi-Conductor Laboratory, **ISRO:** Indian Space Research Organisation, **Antrix:** Antrix Corporation Limited, **VSSC:** Vikram Sarabhai Space Centre, **LPSC:** Liquid Propulsion Systems Centre, **SDSC:** Satish Dhawan Space Centre, **ISAC:** ISRO Satellite Centre, **SAC:** Space Applications Centre, **IISU:** ISRO Inertial Systems Unit, **DECU:** Development and Educational Communication Unit, **MCF:** Master Control Facility, **RRSSCs:** Regional Remote Sensing Service Centres, **ISTRAC:** ISRO Telemetry, Tracking and Command Network, **LEOS:** Laboratory for Electro-optic Systems, **IIST:** Indian Institute of Space Science and Technology

History of Indian Remote Sensing Satellites

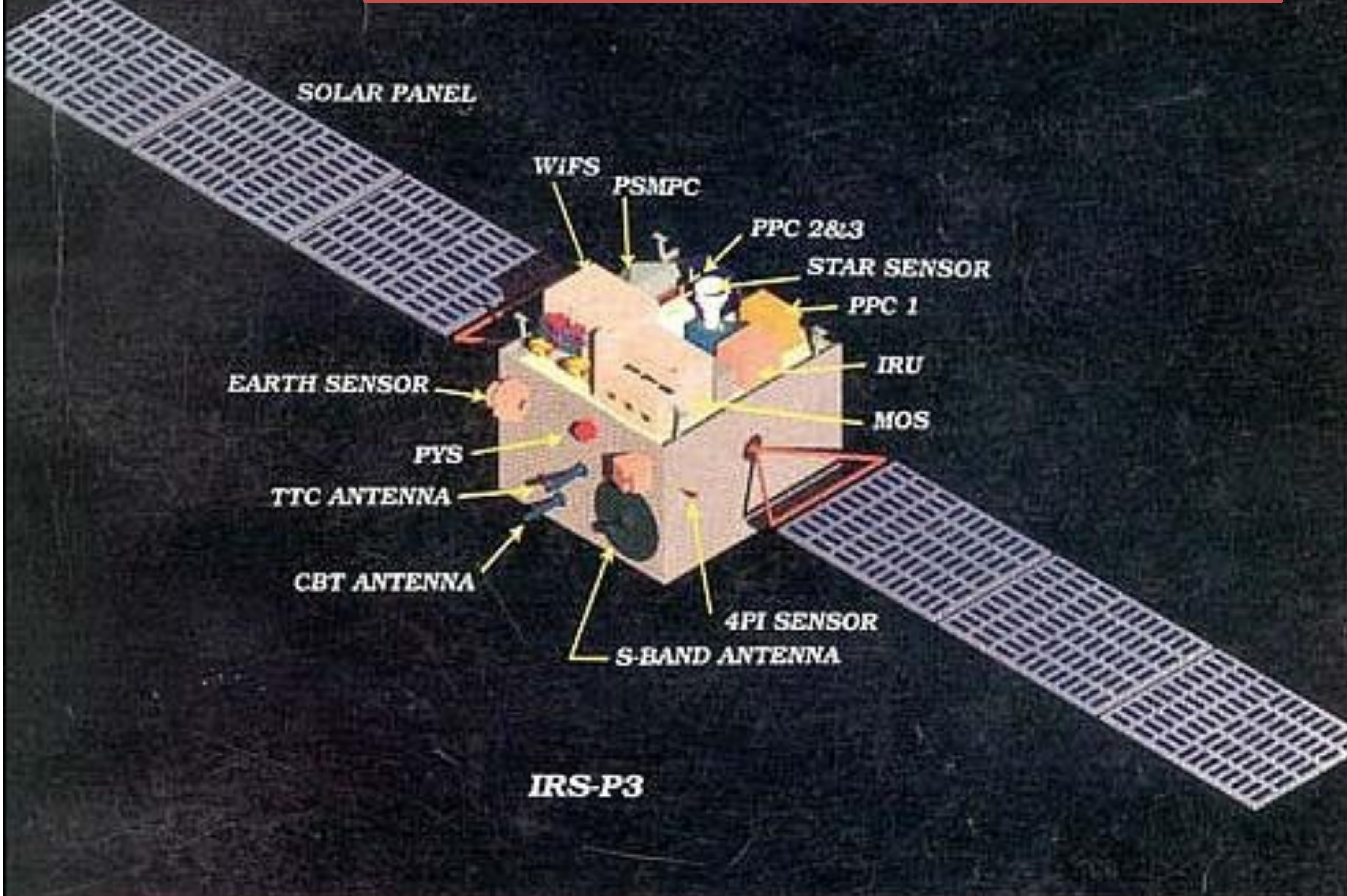
Mission	Year of Launch	Sensors	Sensor Specifications
Bhaskara-I/II	1979/1981	Microwave Radiometer (SAMIR)	19/22/31 GHz
INSAT-1 series	1982-1990	VHRR	VIS : 2.75 km Resolution NIR : 11 km Resolution.
INSAT-2A, 2B	1992, 1995	VHRR	VIS : 2 km Resolution. TIR, WV : 8 km Resolution.
INSAT-2E	1999	VHRR	VIS : 2 km Resolution. TIR, WV : 8 km Resolution.
		CCD	VIS, NIR, SWIR : 1 km Resolution
IRS-1A, 1B	1988, 1991	LISS-I Multispectral	Resolution : 72.5 m, Swath : 148 km
		LISS-II Multispectral	Resolution : 36.25 m, Swath : 142 km
IRS-P2	1994	LISS-II Multispectral	Resolution 36 m, Swath 148 km
IRS*-1C, 1D	1995, 1997	Panchromatic	Resolution : 5.8 m, Swath : 70 km
		LISS-III Multispectral	Resolution : 23.5 m, 70.5 m Swath : 141 km, 148 km
		WiFS	Resolution : 188.3 m, Swath : 774 km
IRS*-P3	1996	WiFS	Resolution : 188.3 m, Swath : 774 km
		MOS-A,B,COpto-electronic	Resolution : 0.5- 1.5 km, Swath : 248 km
IRS*-P4	1999	OCM Ocean monitor	Resolution : 360 m, 20 nm Spectral Swath: 1420 km
		MSMR Microwave Radiometer	6.6, 10.75, 18, 21 GHz channels Resolution: 40-120 km, 1^{o}K Accuracy Swath : 1360 km
IRS*-P6(Resourcesat)		2003	LISS IV Multispectral Resolution : 5.8 m, Swath : 70 km
		LISS-III Multispectral	Resolution : 23.5m, 70.5 m Swath : 141 km, 148 km
		AWiFS	Resolution : 70 m, Swath : 774 km

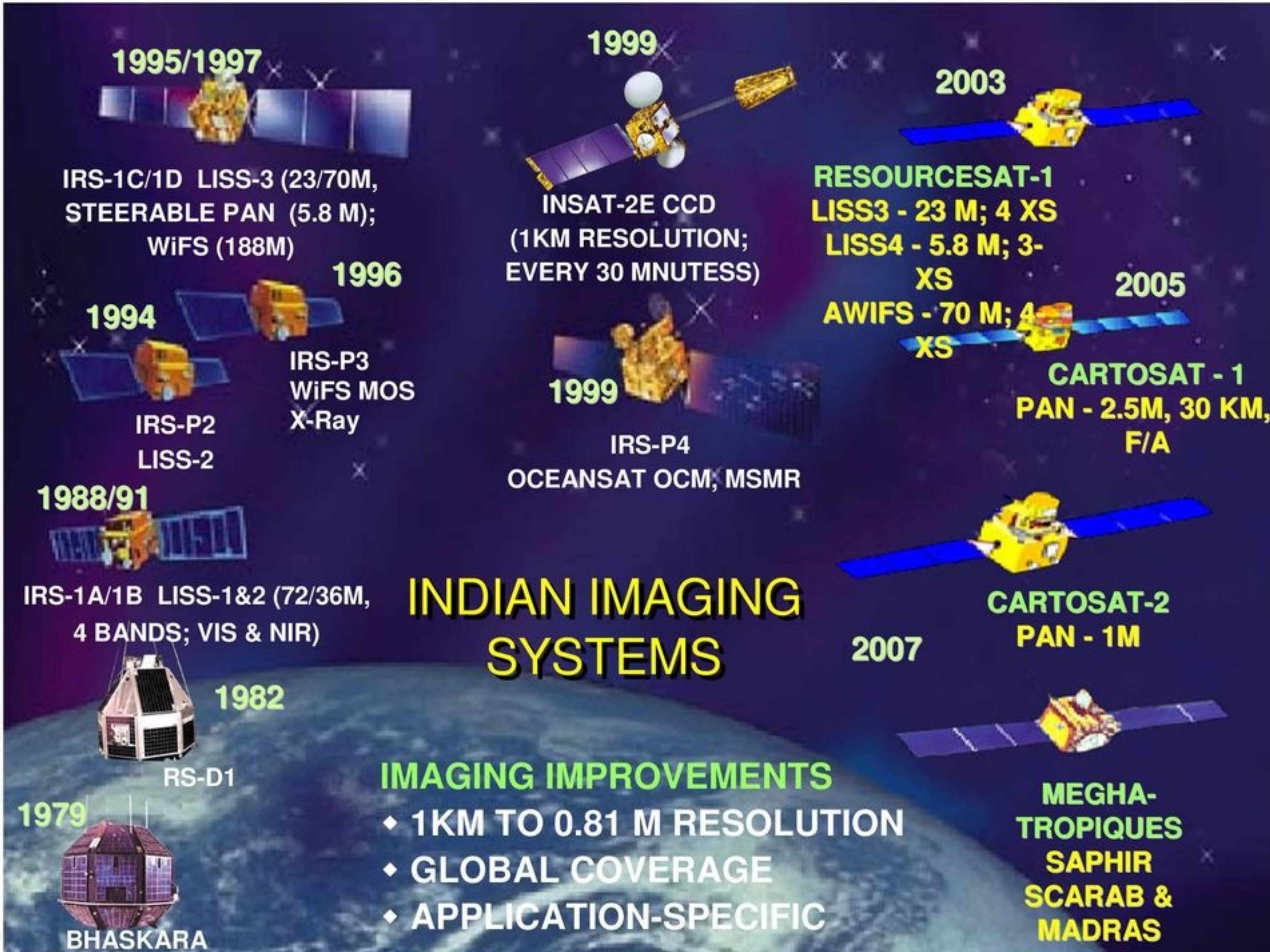
* Currently available satellites.

History of Indian Remote Sensing Satellites

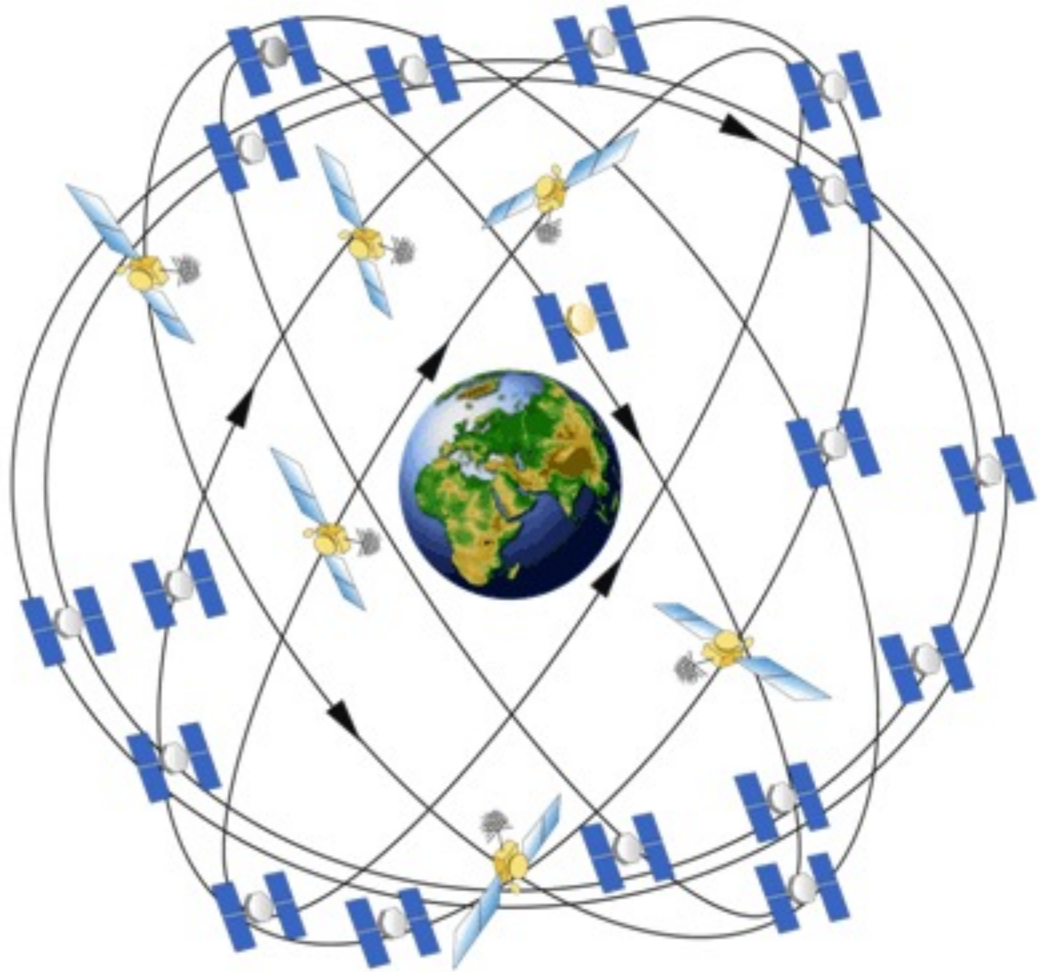
Sr. No.	Satellite	Date of Launch	Launch Vehicle	Status
1	IRS 1A	17 March 1988	Vostok, USSR	Mission Completed
2	IRS 1B	29 August 1991	Vostok, USSR	Mission Completed
3	IRS P1 (also IE)	20 September 1993	PSLV-D1	Crashed, due to launch failure of PSLV
4	IRS P2	15 October 1994	PSLV-D2	Mission Completed
5	IRS 1C	28 December 1995	Molniya, Russia	Mission Completed
6	IRS P3	21 March 1996	PSLV-D3	Mission Completed
7	IRS 1D	29 September 1997	PSLV-C1	Mission Completed
8	IRS P4 (Oceansat-1)	27 May 1999	PSLV-C2	Mission Completed
9	Technology Experiment Satellite (TES)	22 October 2001	PSLV-C3	In Service
10	IRS P6 (Resourcesat-1)	17 October 2003	PSLV-C5	In Service
11	IRS P5 (Cartosat 1)	5 May 2005	PSLV-C6	In Service
12	Cartosat 2 (IRS P7)	10 January 2007	PSLV-C7	In Service
13	Cartosat 2A (IRS P?)	28 April 2008	PSLV-C9	In Service
14	IMS 1 (IRS P?)	28 April 2008	PSLV-C9	In Service
15	Oceansat-2	23 September 2009	PSLV-C14	In Service
16	Cartosat-2B	12 July 2010	PSLV-C15	In Service
17	Resourcesat-2	20 April 2011	PSLV-C16	In Service

IRS Satellite Image/ Structure

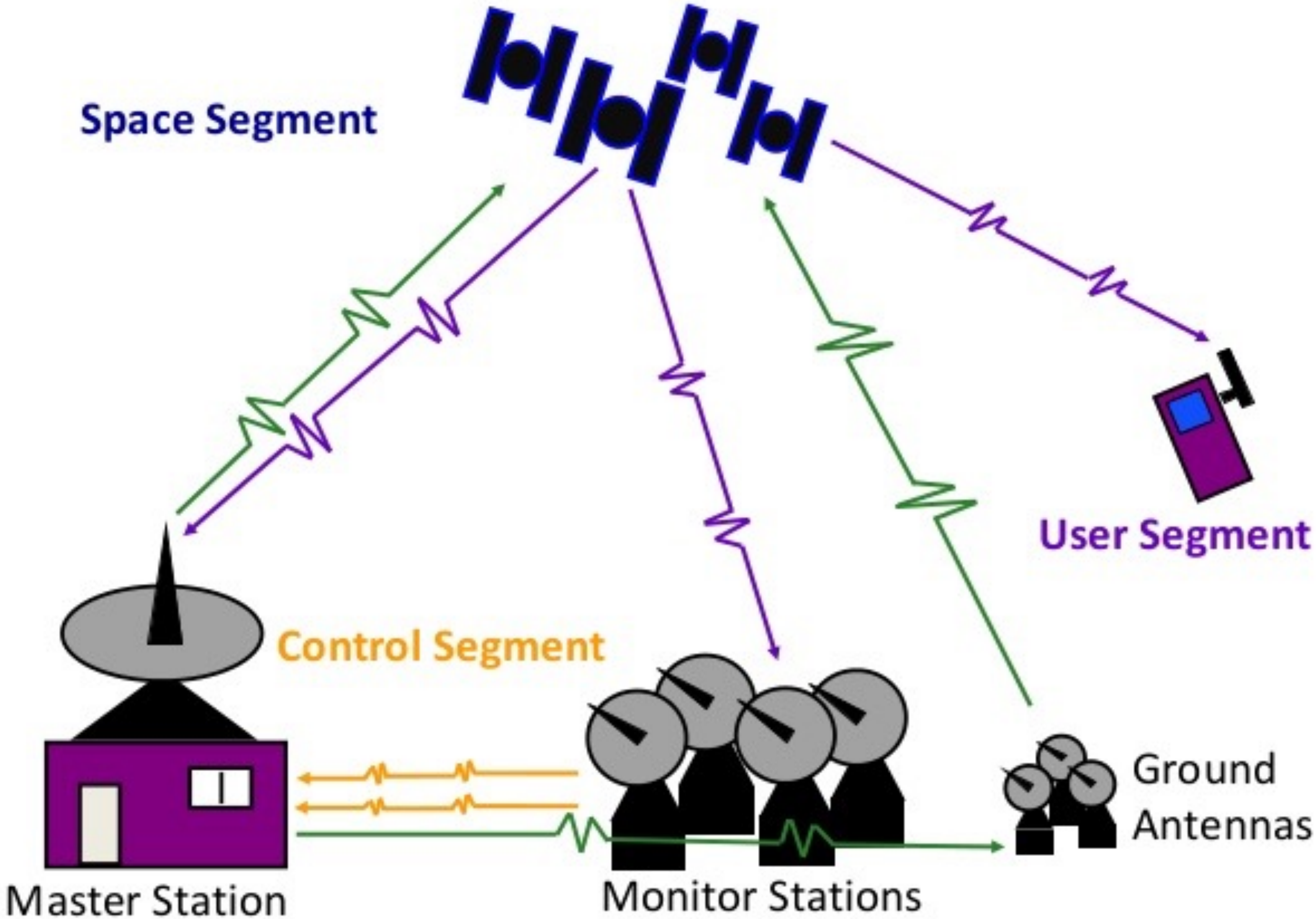


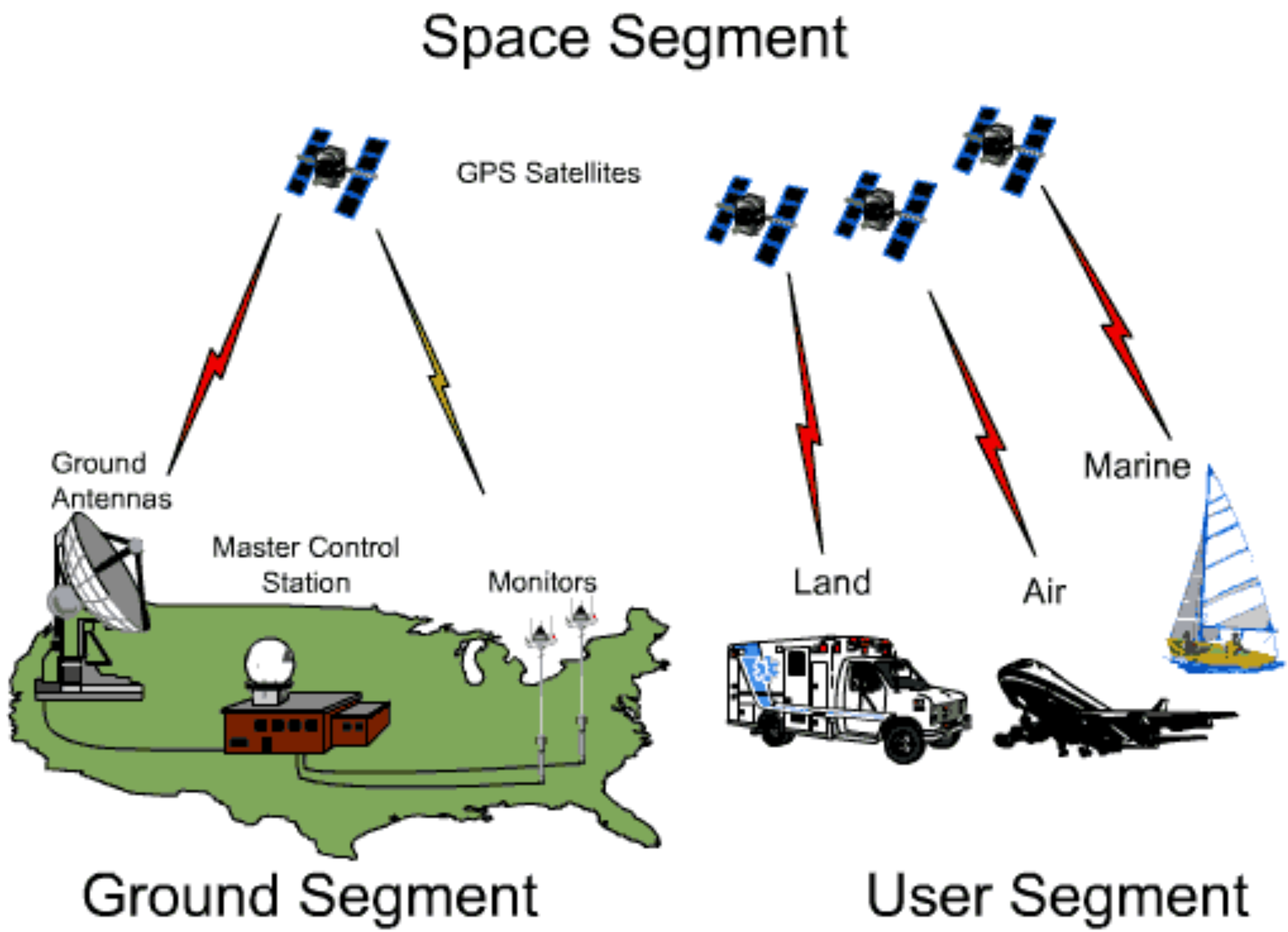

1995/1997
IRS-1C/1D LISS-3 (23/70M,
STEERABLE PAN (5.8 M);
WiFS (188M)
1999
INSAT-2E CCD
(1KM RESOLUTION;
EVERY 30 MNUTESS)
2003
RESOURCESAT-1
LISS3 - 23 M; 4 XS
LISS4 - 5.8 M; 3-XS
AWIFS - 70 M; 4 XS
1996
IRS-P3
WiFS MOS
X-Ray
1994
IRS-P2
LISS-2
1999
IRS-P4
OCEANSAT OCM, MSMR
2005
CARTOSAT - 1
PAN - 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

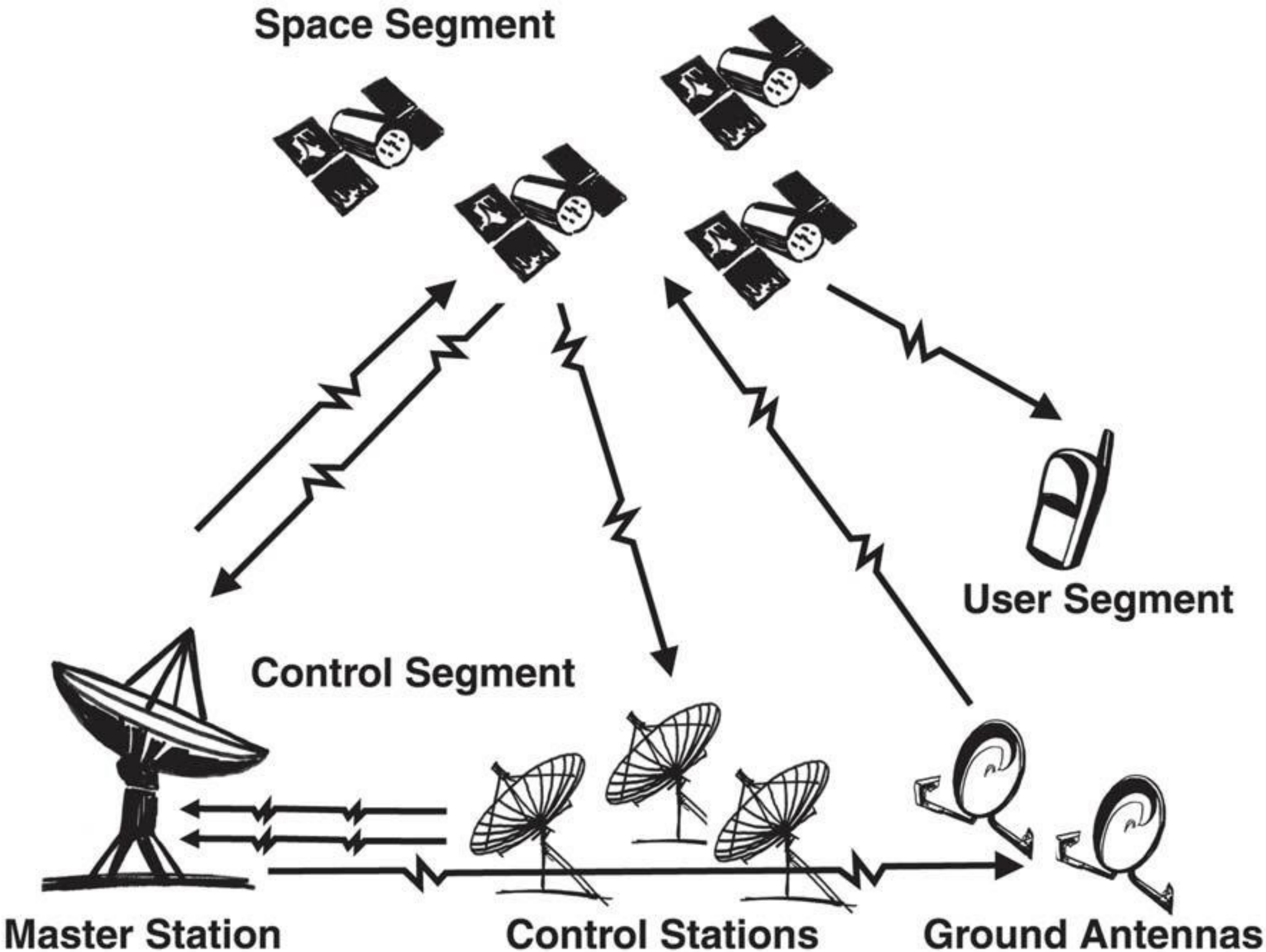
Global Positioning System (GPS)

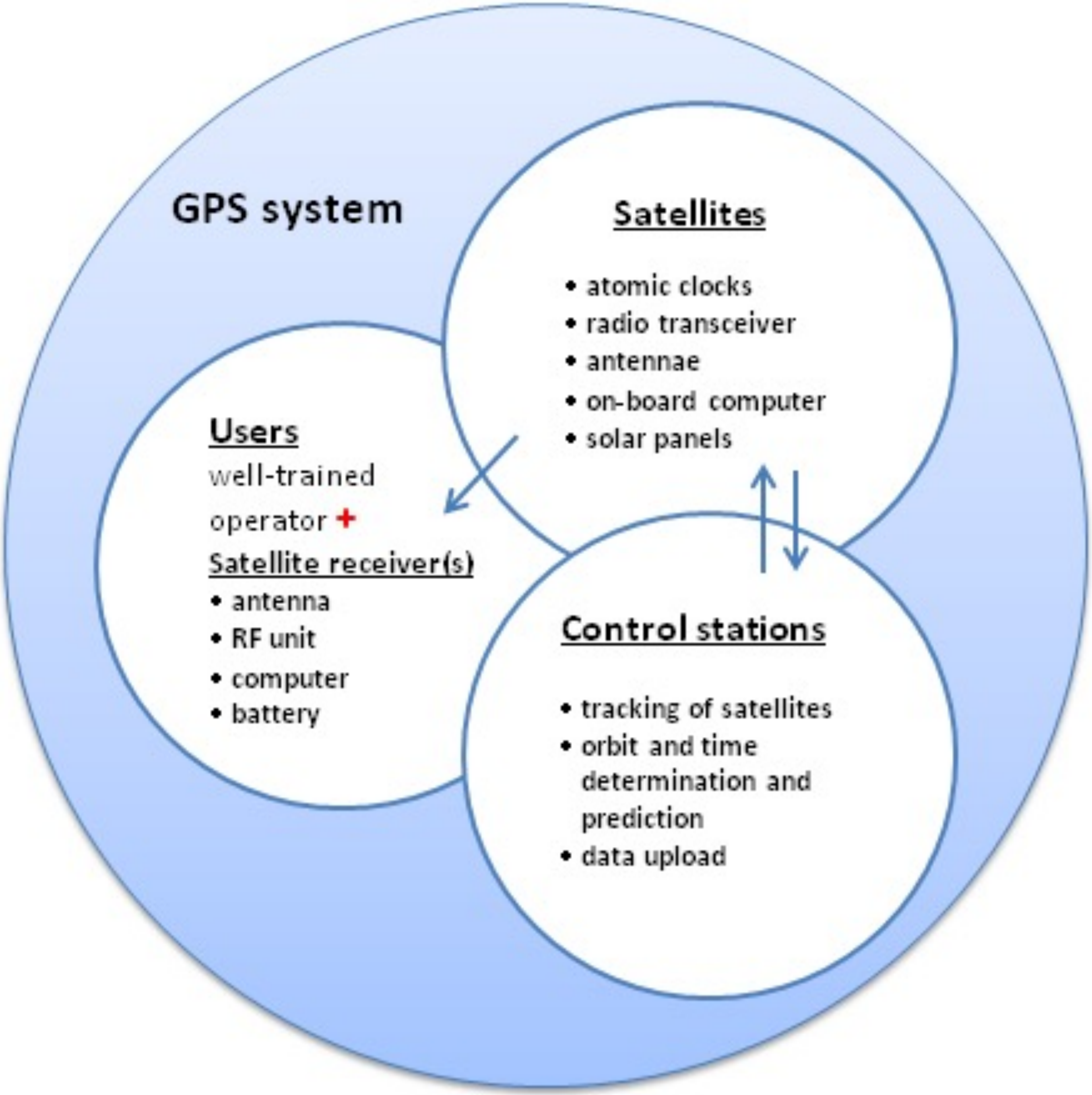


Three Segments of the GPS




Space Segment
GPS Satellites
Ground
Antennas
Master Control
Station
Monitors
Land
Air
Marine
Ground Segment
User Segment


Space Segment
User Segment
Control Segment
Master Station
Control Stations
Ground Antennas


GPS system
Satellites
• atomic clocks
• radio transceiver
• antennae
• on-board computer
• solar panels
Users
well-trained
operator +
Satellite receiver(s)
• antenna
• RF unit
• computer
• battery
Control stations
• tracking of satellites
• orbit and time determination and prediction
• data upload