PRACTICAL'S

REMOTE SENSING & GPS

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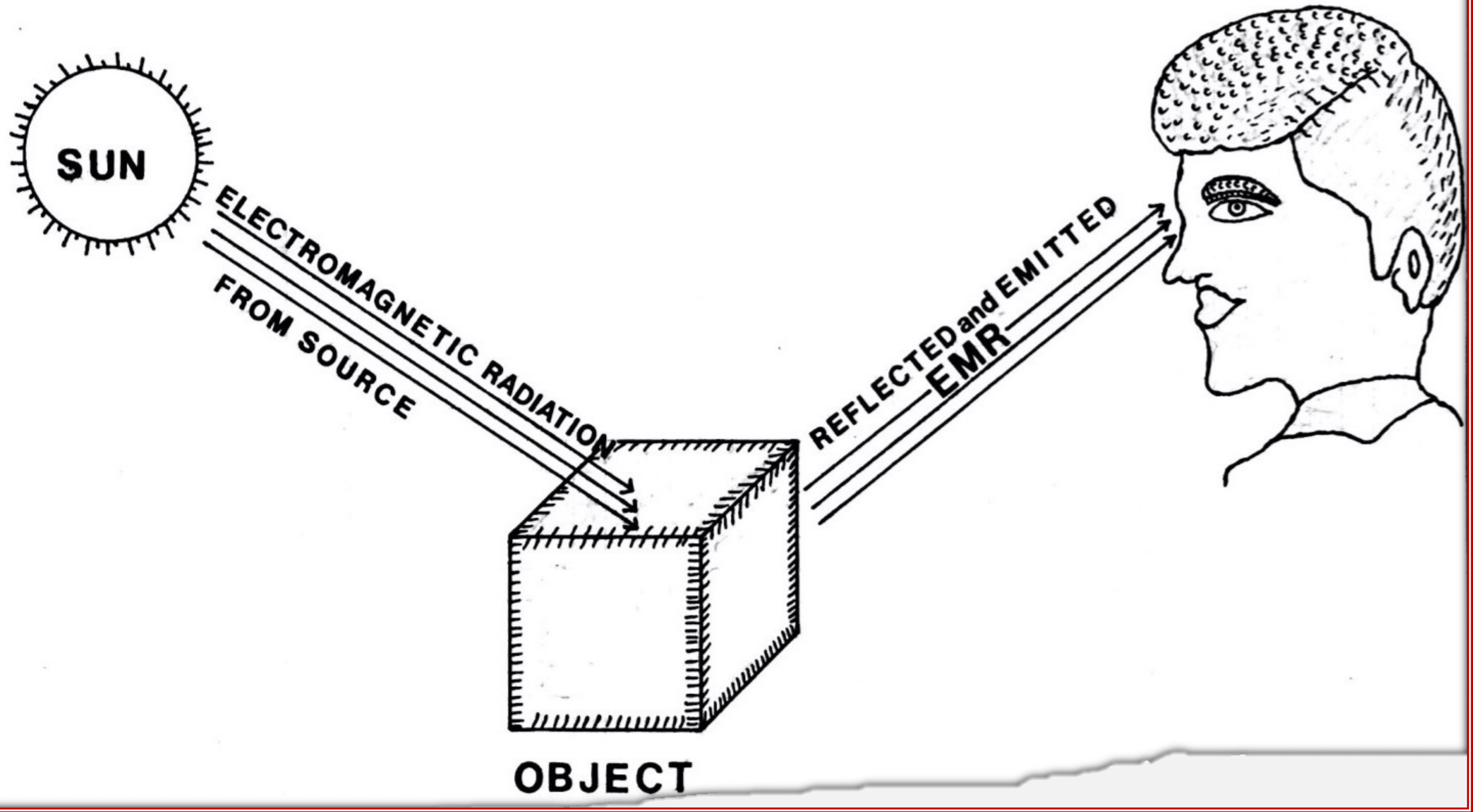
Remote Sensing : Definitions

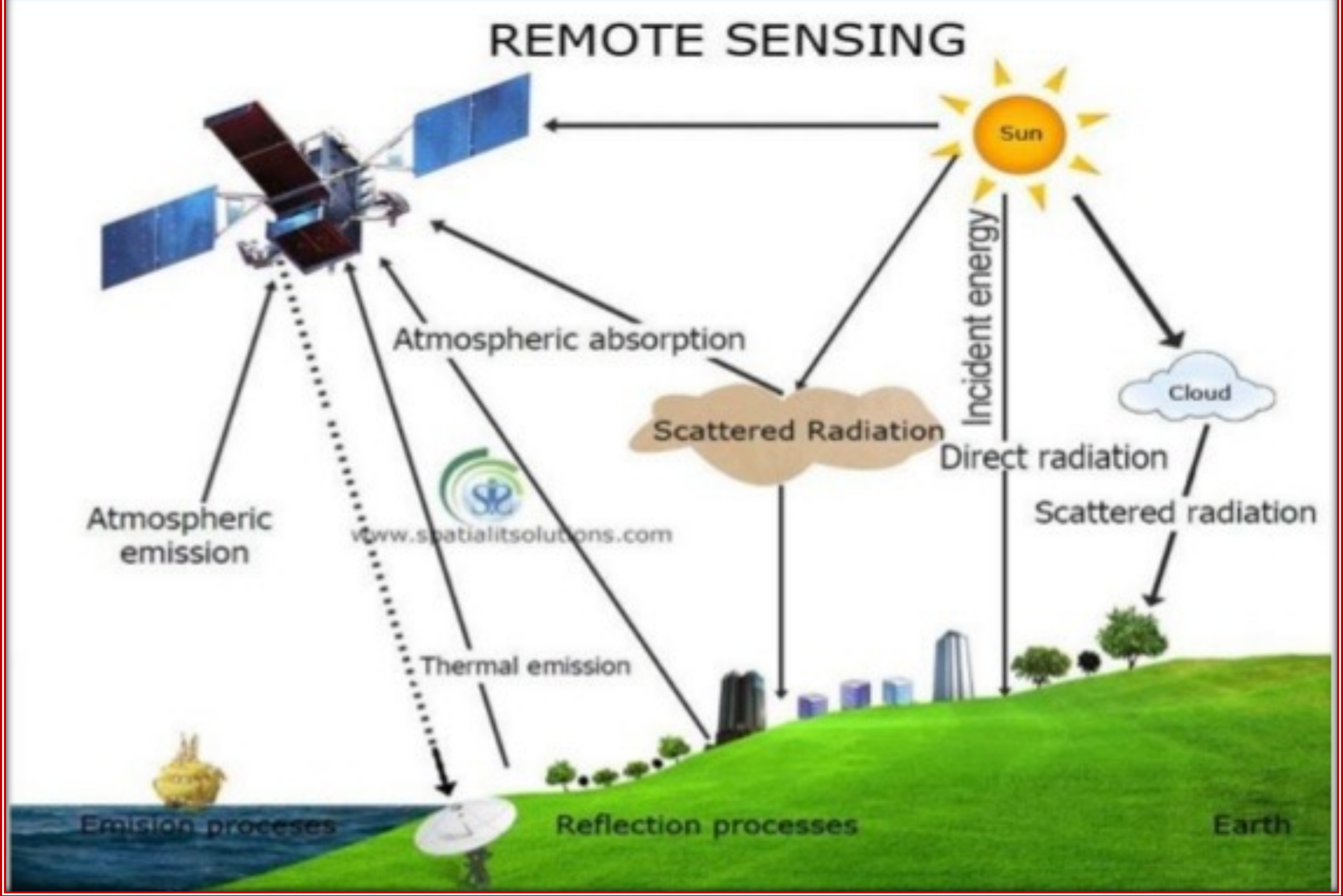
Definitions :

- Remote Sensing has been variously defined but basically it is the art or science of telling something about an object without touching it. - Fischer
- Remote Sensing is the acquisition of physical data of an object without touch or contact. - Lintz & Simonett
- Remote Sensing is the observation of a target by a device separated from it by some distance. - Barrett & Curtis

WORKING OF TYPICAL REMOTE SENSING DEVICE



WHAT IS REMOTE SENSING?



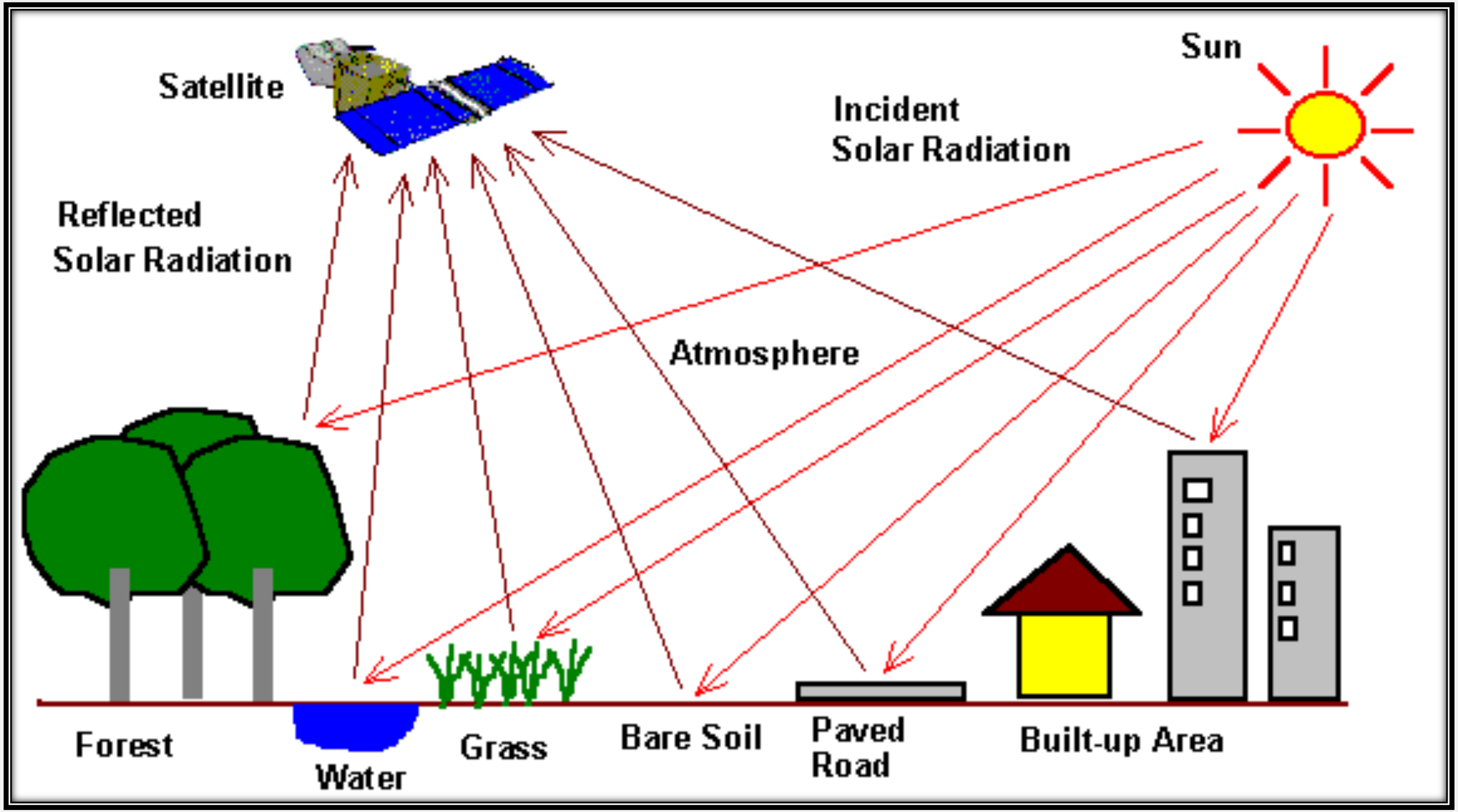
Remote Sensing : Development & History

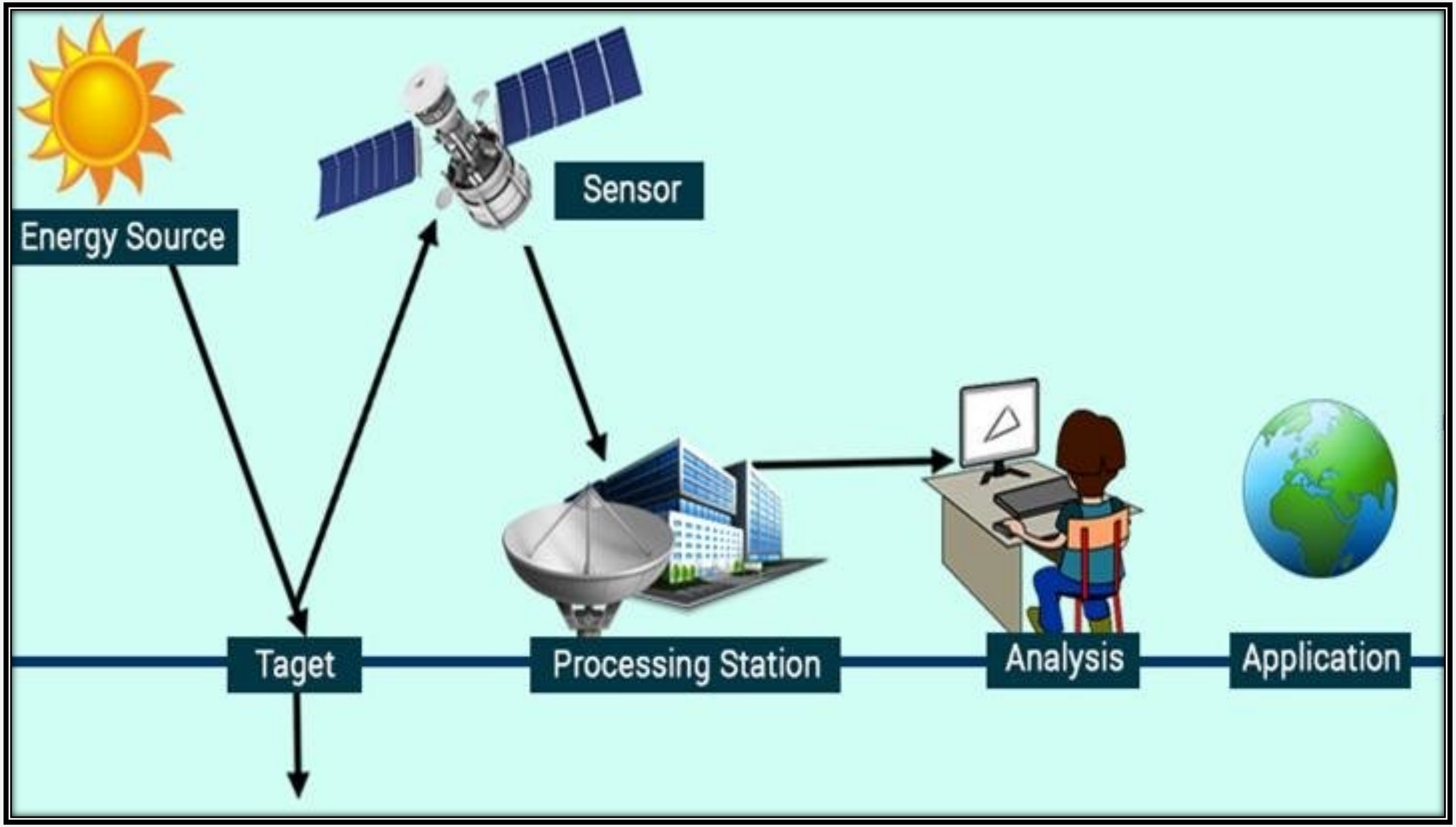
History of Remote Sensing

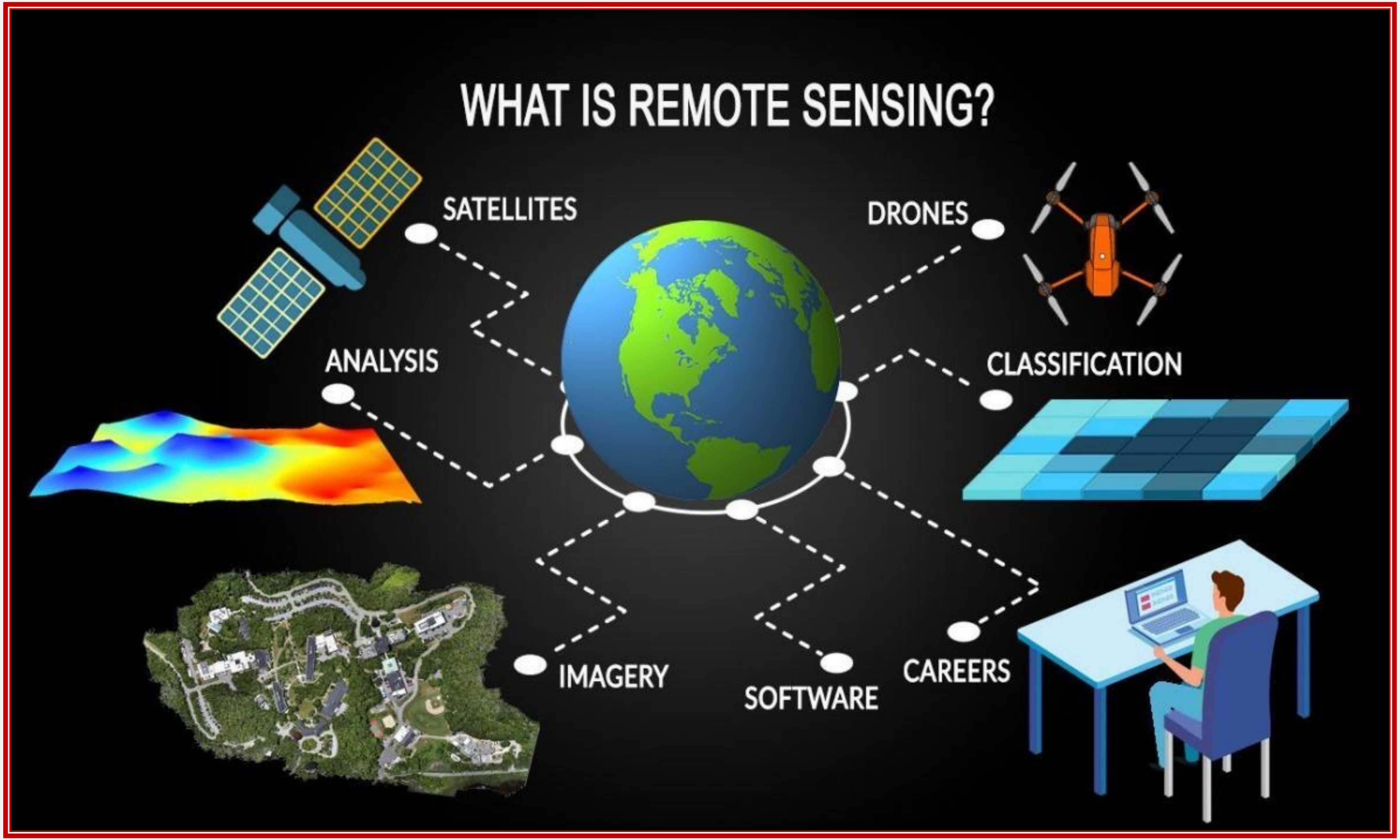
- 1929–1939: Economic depression generates environmental crises that lead to governmental applications of aerial photography
- 1930–1940: Development of radars in Germany, US, and UK
- 1939–1945: World War II: applications of nonvisible portions of electromagnetic spectrum; training of persons in acquisition 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


Satellite
Sun
Incident
Solar Radiation
Reflected
Solar Radiation
Atmosphere
Forest
Water
Grass
Bare Soil
Paved
Road
Built-up Area

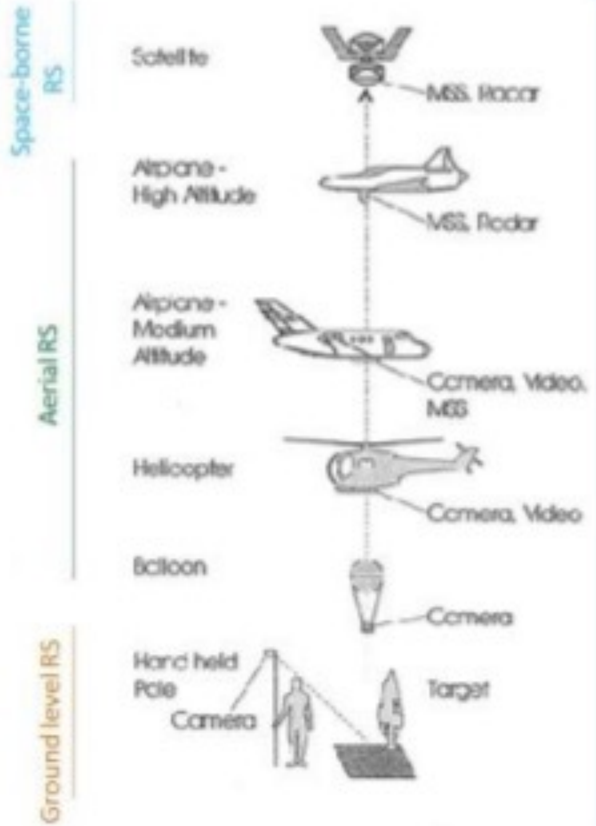

Energy Source
Sensor
Taget
Processing Station
Analysis
Application


WHAT IS REMOTE SENSING?
SATELLITES
DRONES
ANALYSIS
CLASSIFICATION
IMAGERY
SOFTWARE
CAREERS

Remote Sensing : Platforms

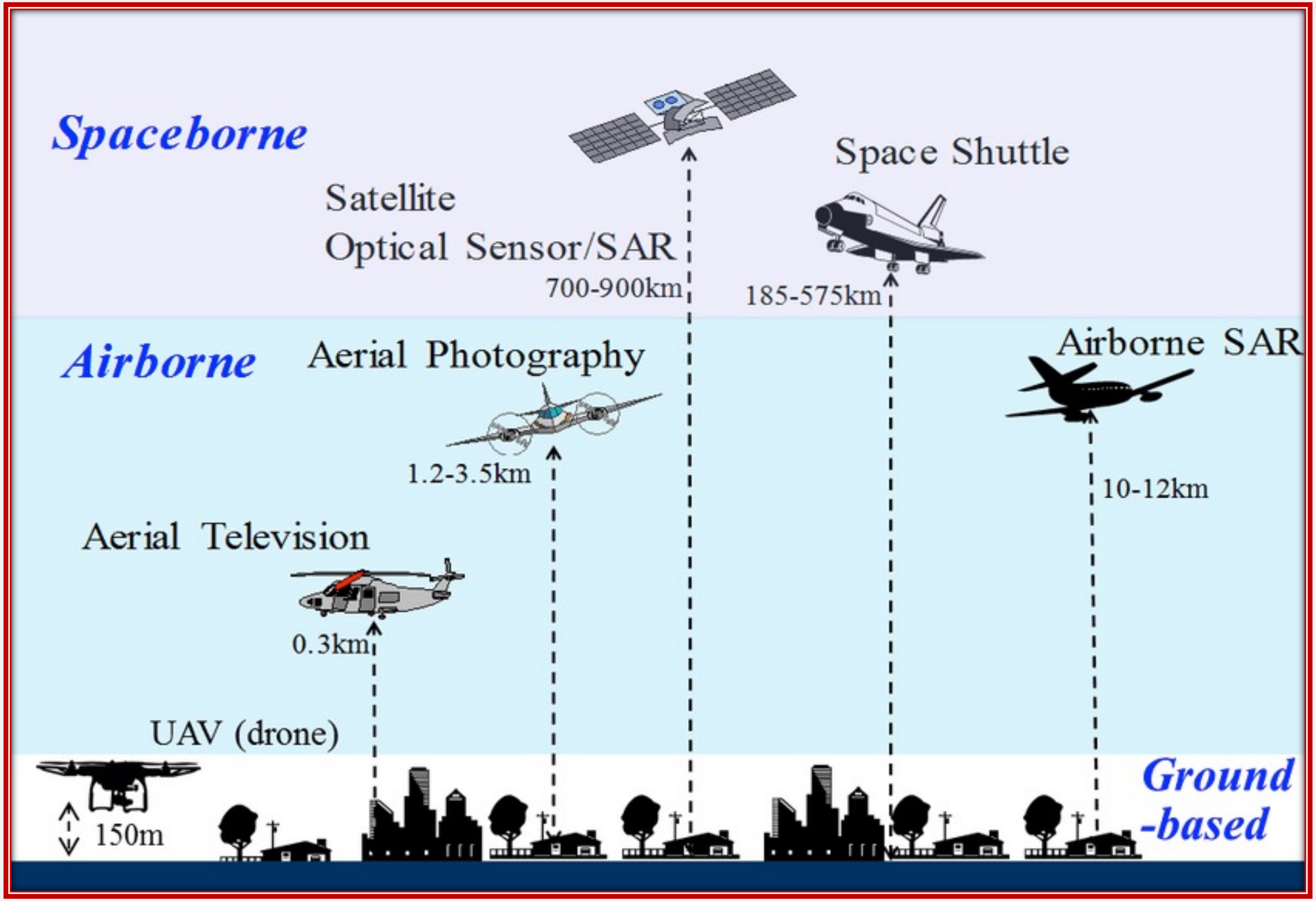
Remote Sensing Platforms

- 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

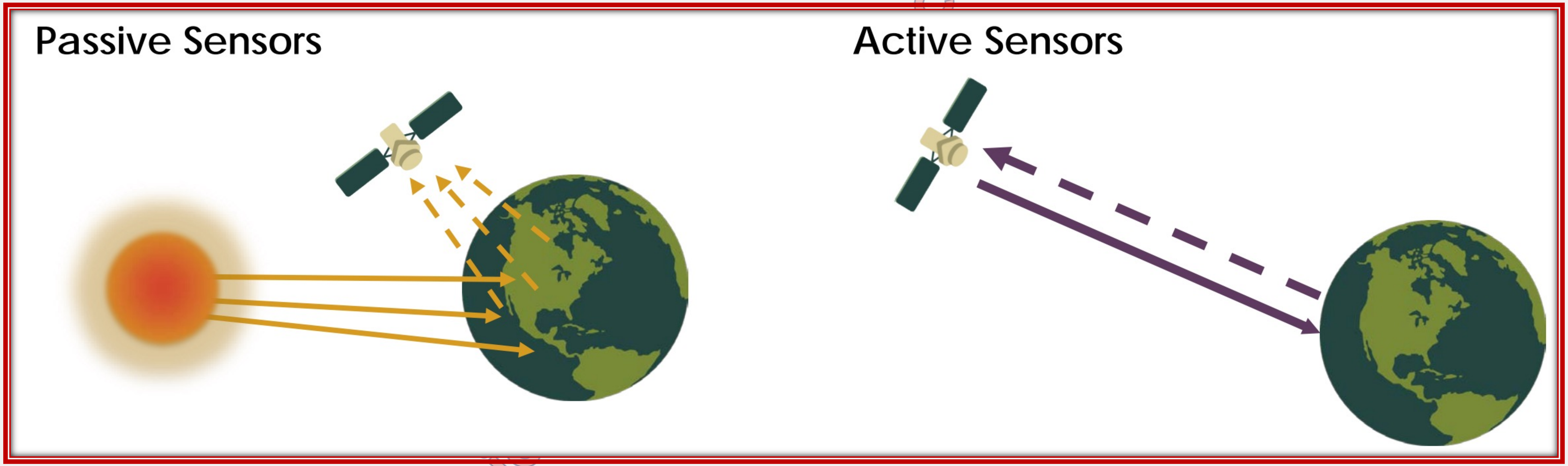


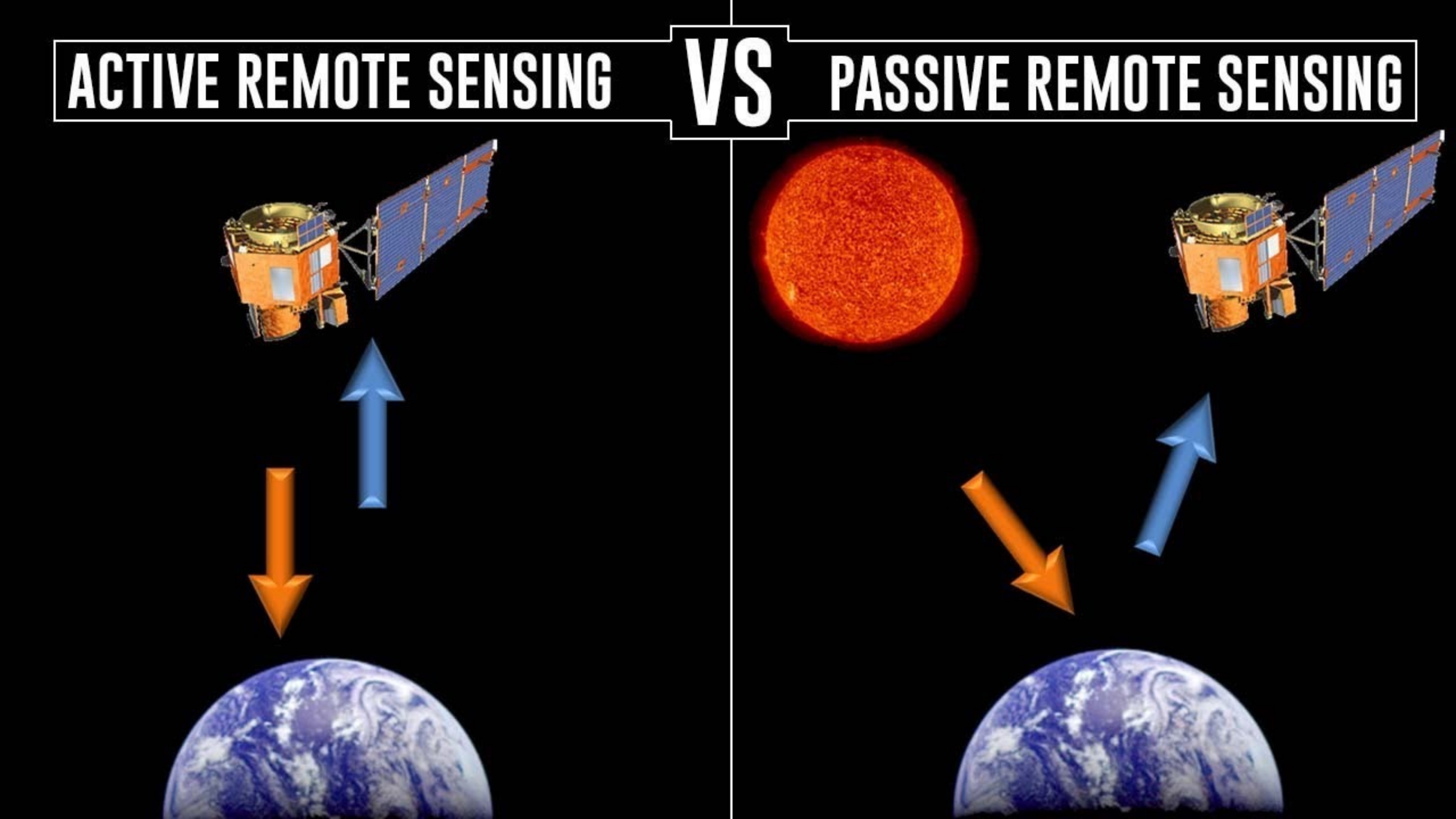
Platforms Used to Acquire Remote Sensing Data

- 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

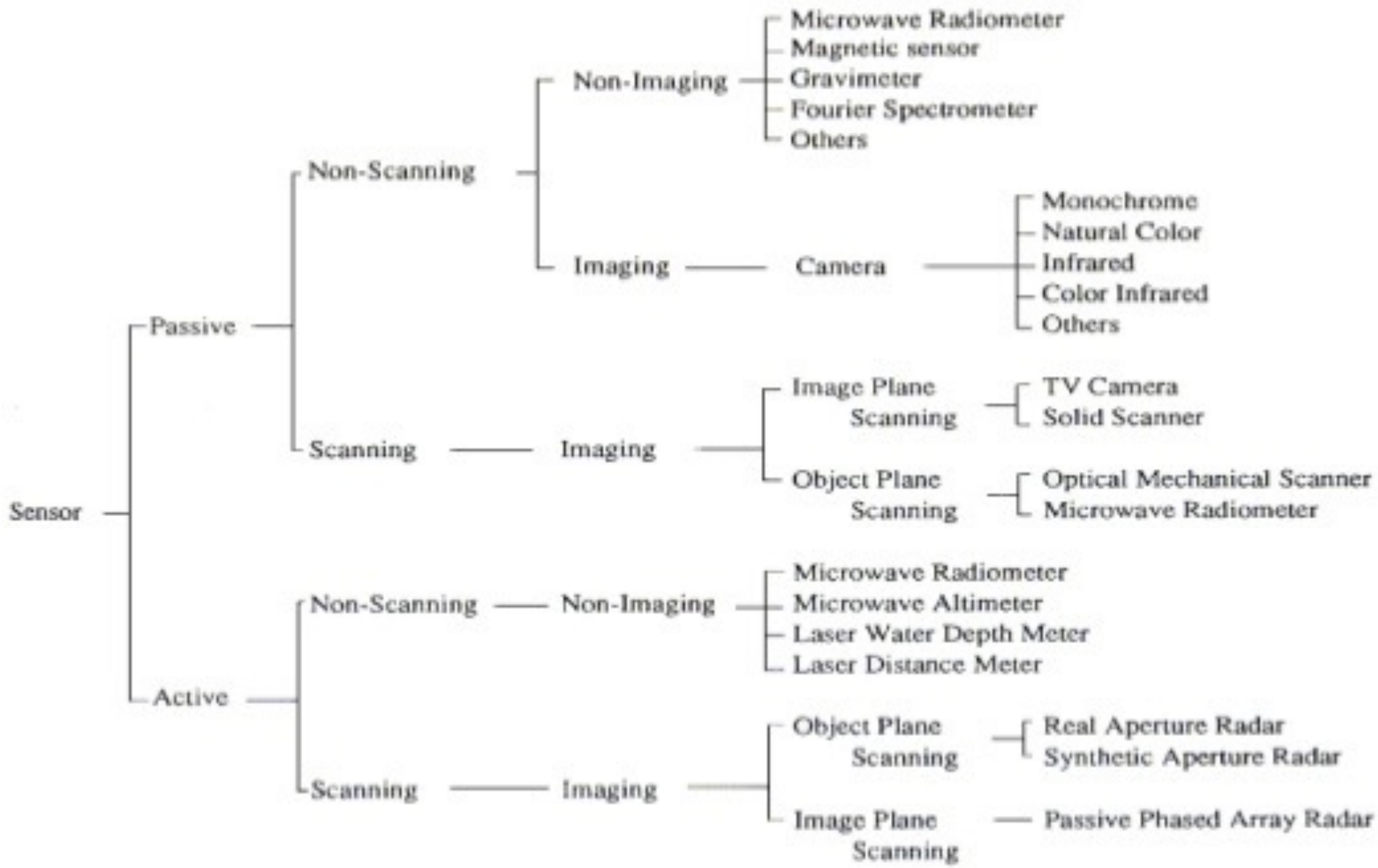
Remote Sensing : Types

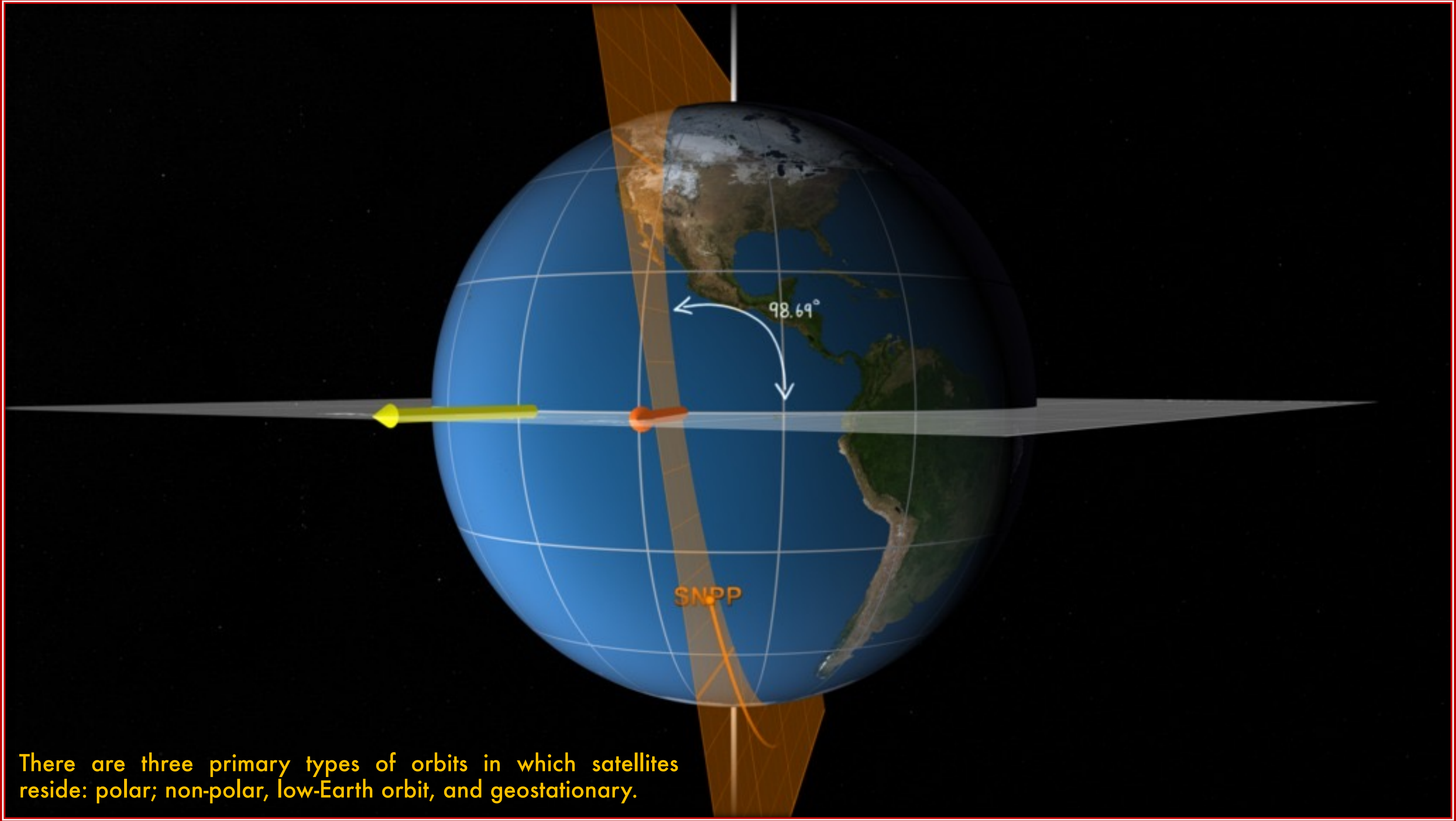

Passive Sensors
Active Sensors


ACTIVE REMOTE SENSING
VS
PASSIVE REMOTE SENSING

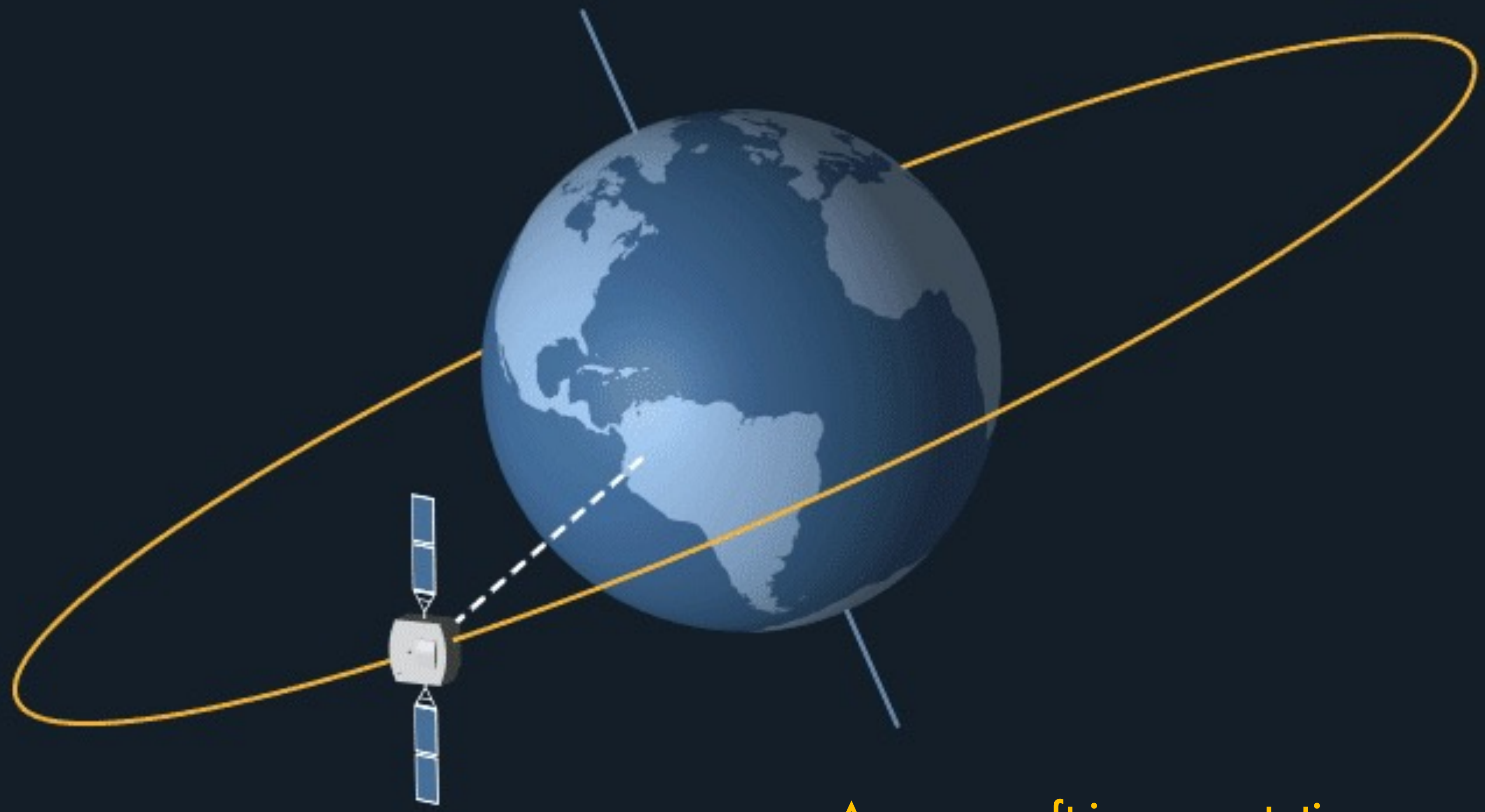
REMOTE SENSING SENSORS

Types of sensors :



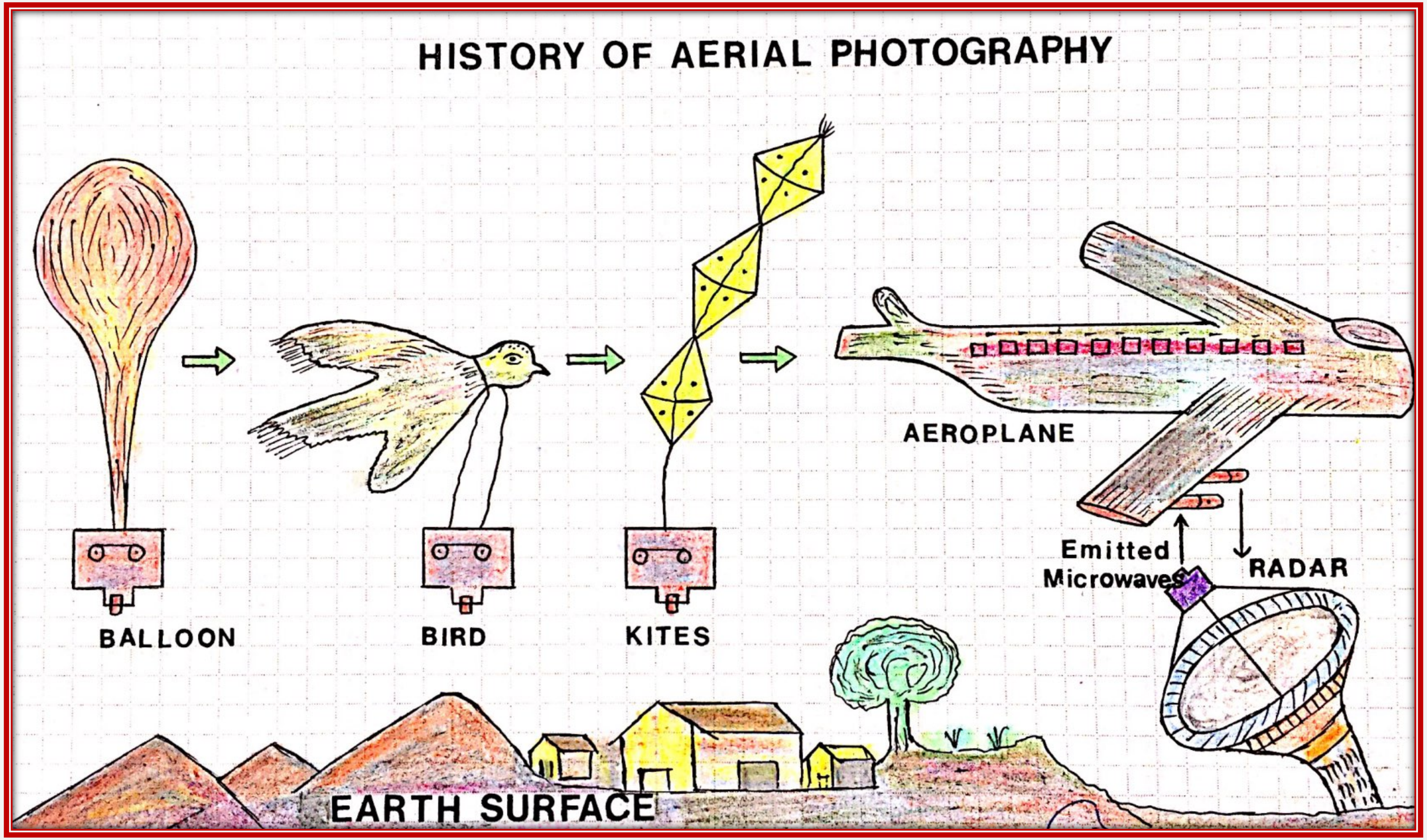


There are three primary types of orbits in which satellites reside: polar; non-polar, low-Earth orbit, and geostationary.

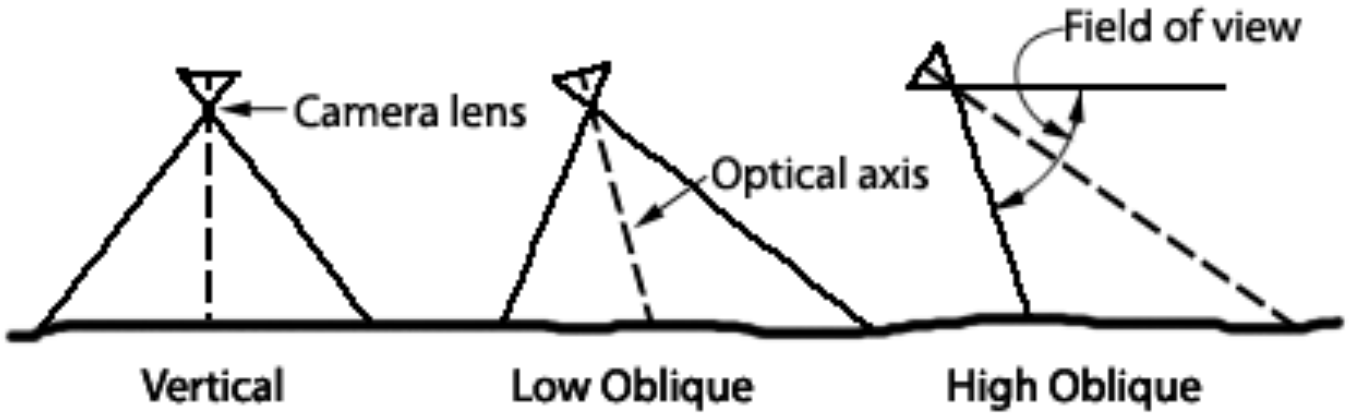


A spacecraft in a geostationary orbit.

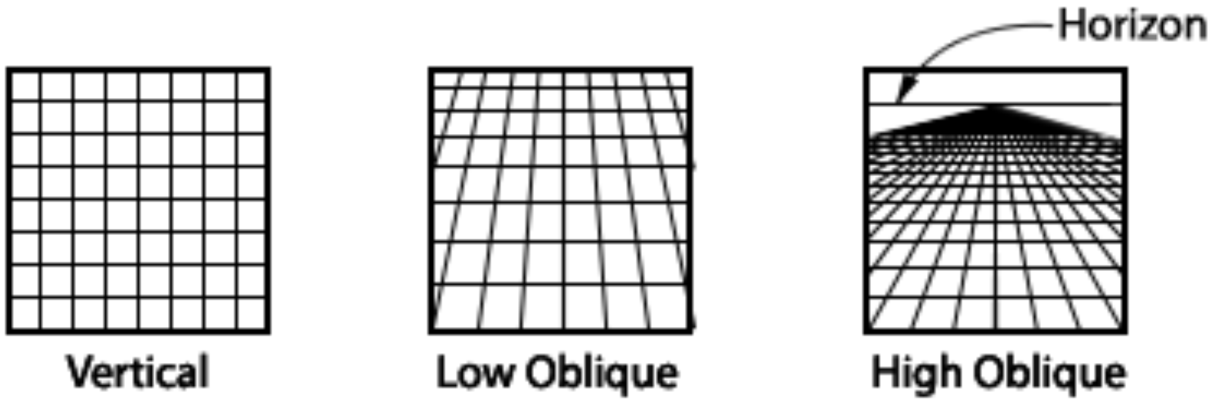
Aerial Photography: Principles & Geometry



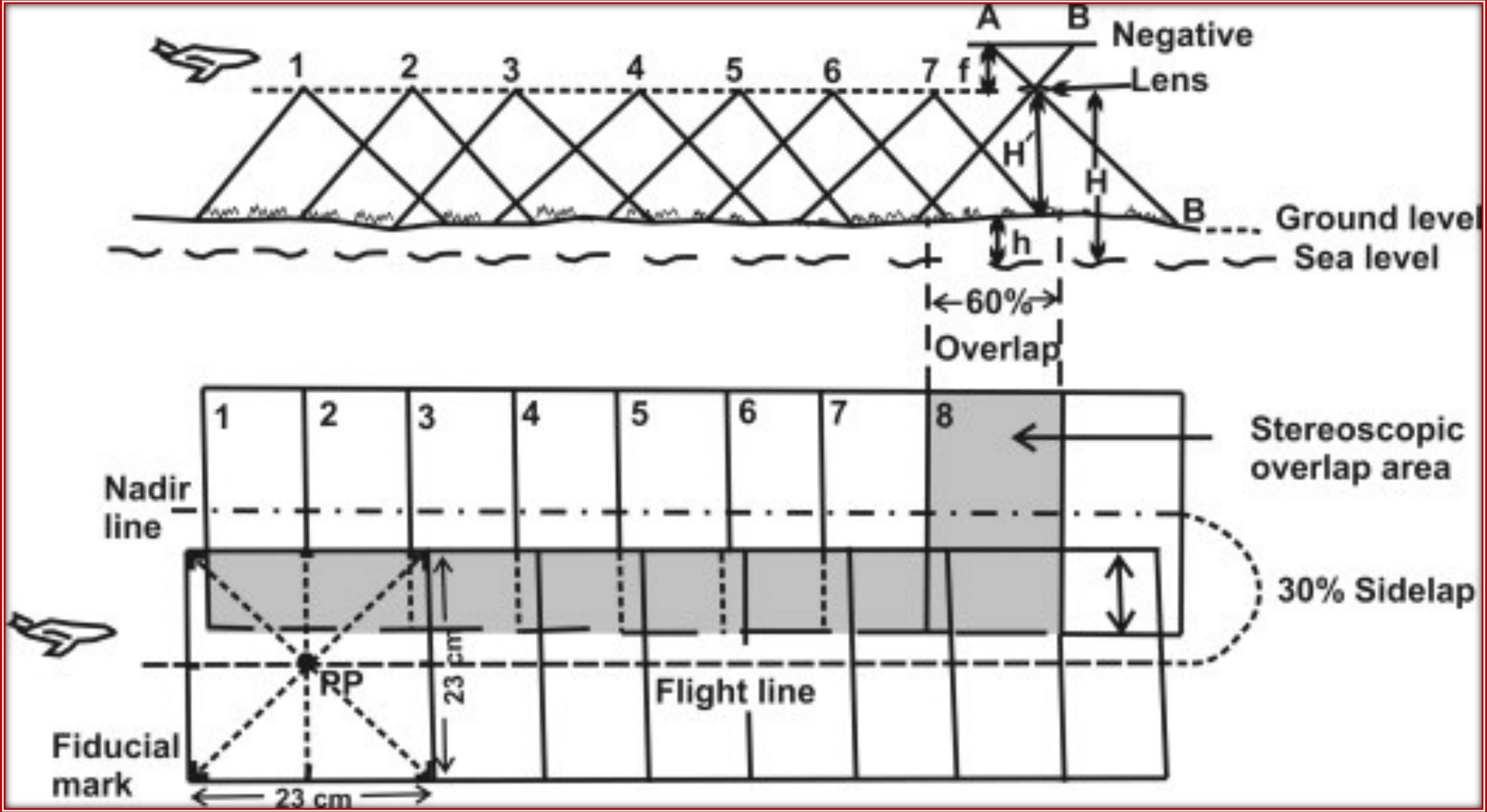
HISTORY OF AERIAL PHOTOGRAPHY
BALLOON
BIRD
KITES
AEROPLANE
Emitted Microwaves
RADAR
EARTH SURFACE



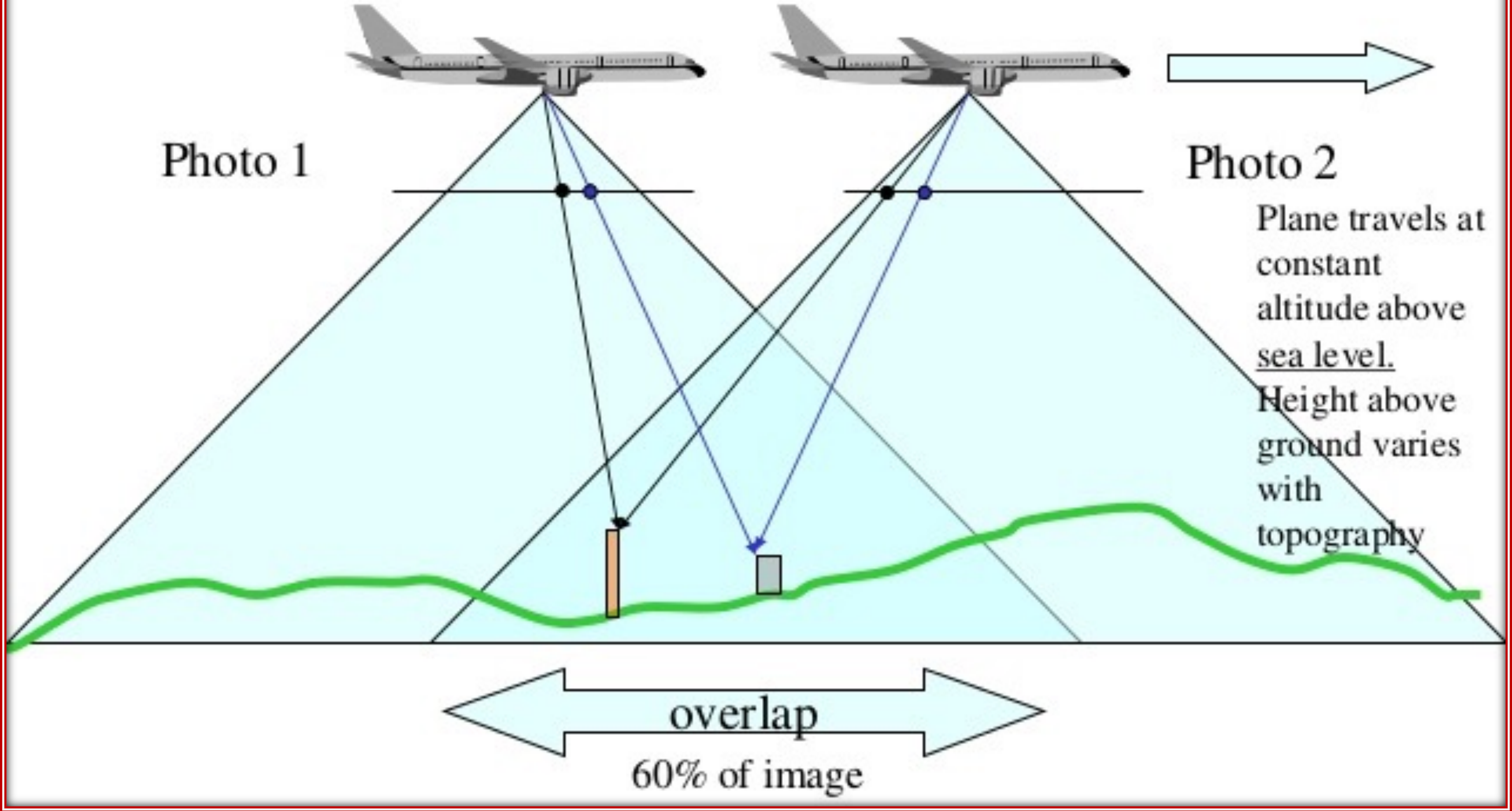
Camera orientation for various types of aerial photographs



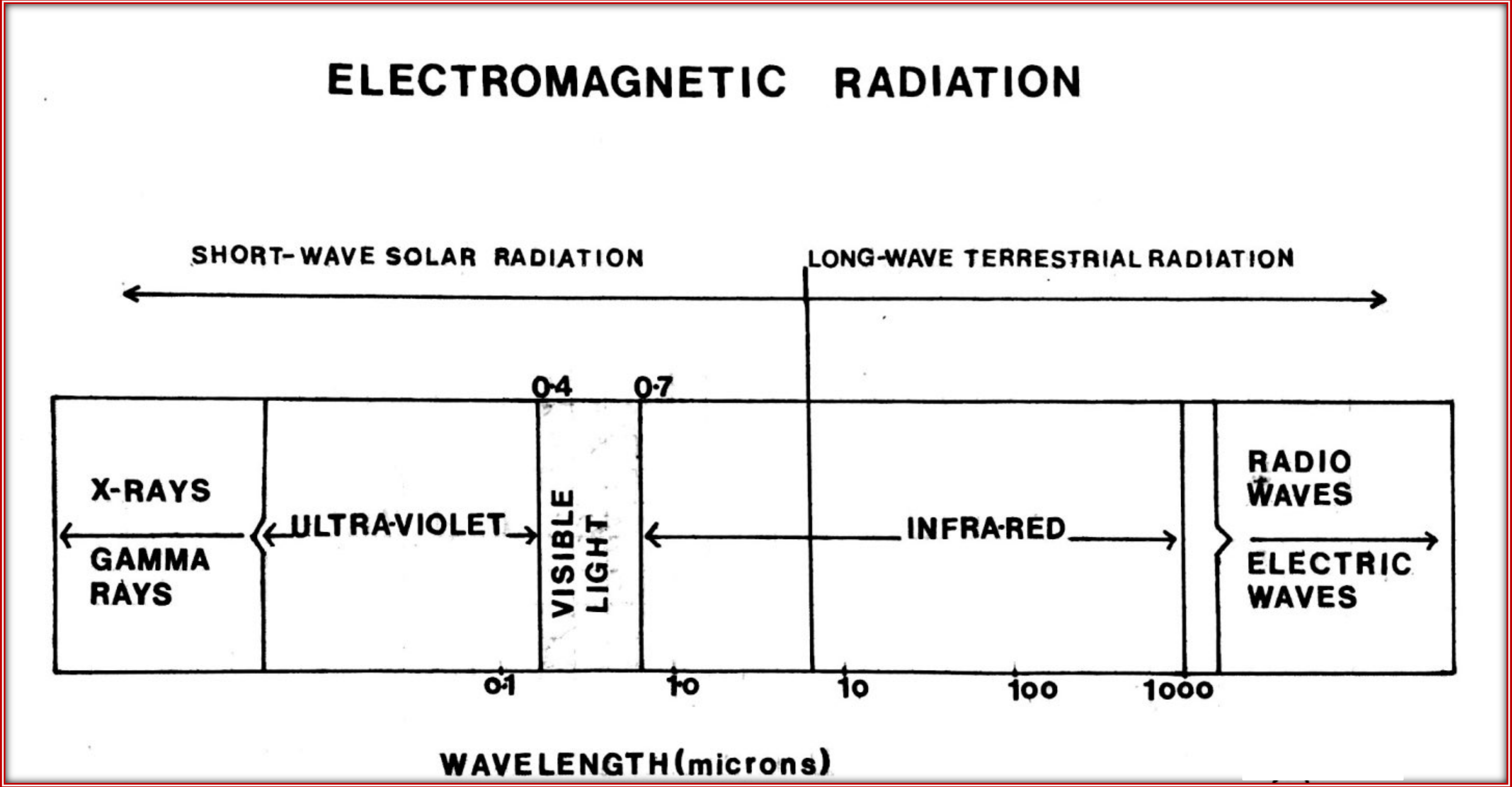
How a grid of section lines appears on various types of photos.

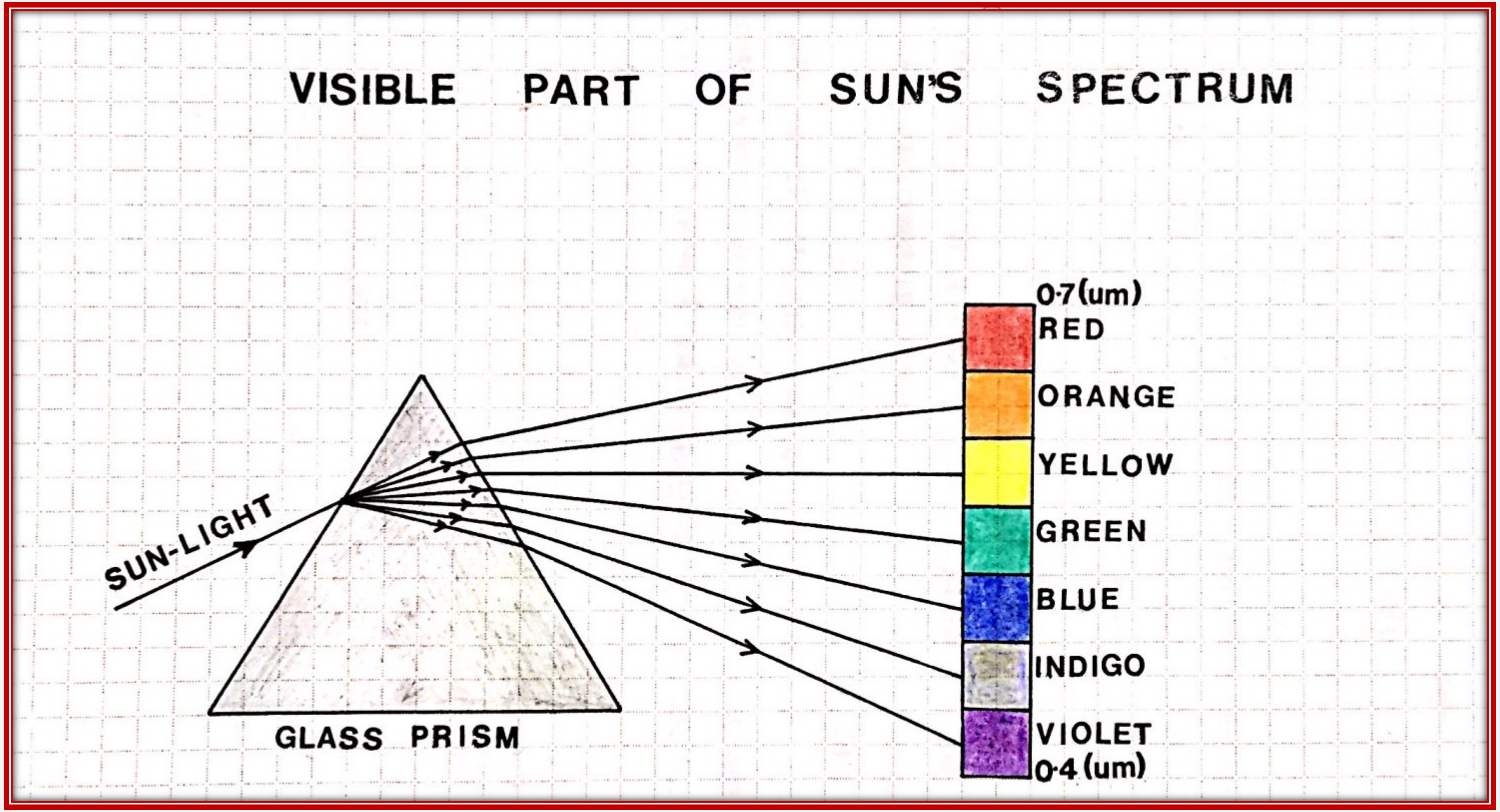

A
B
Negative
1
2
3
4
5
6
7
f
Lens
H'
H
B
Ground level
h
Sea level
60%
Overlap
1
2
3
4
5
6
7
8
Stereoscopic
overlap area
Nadir
line
30% Sidelap
RP
23 cm
Flight line
Fiducial
mark
23 cm

- 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

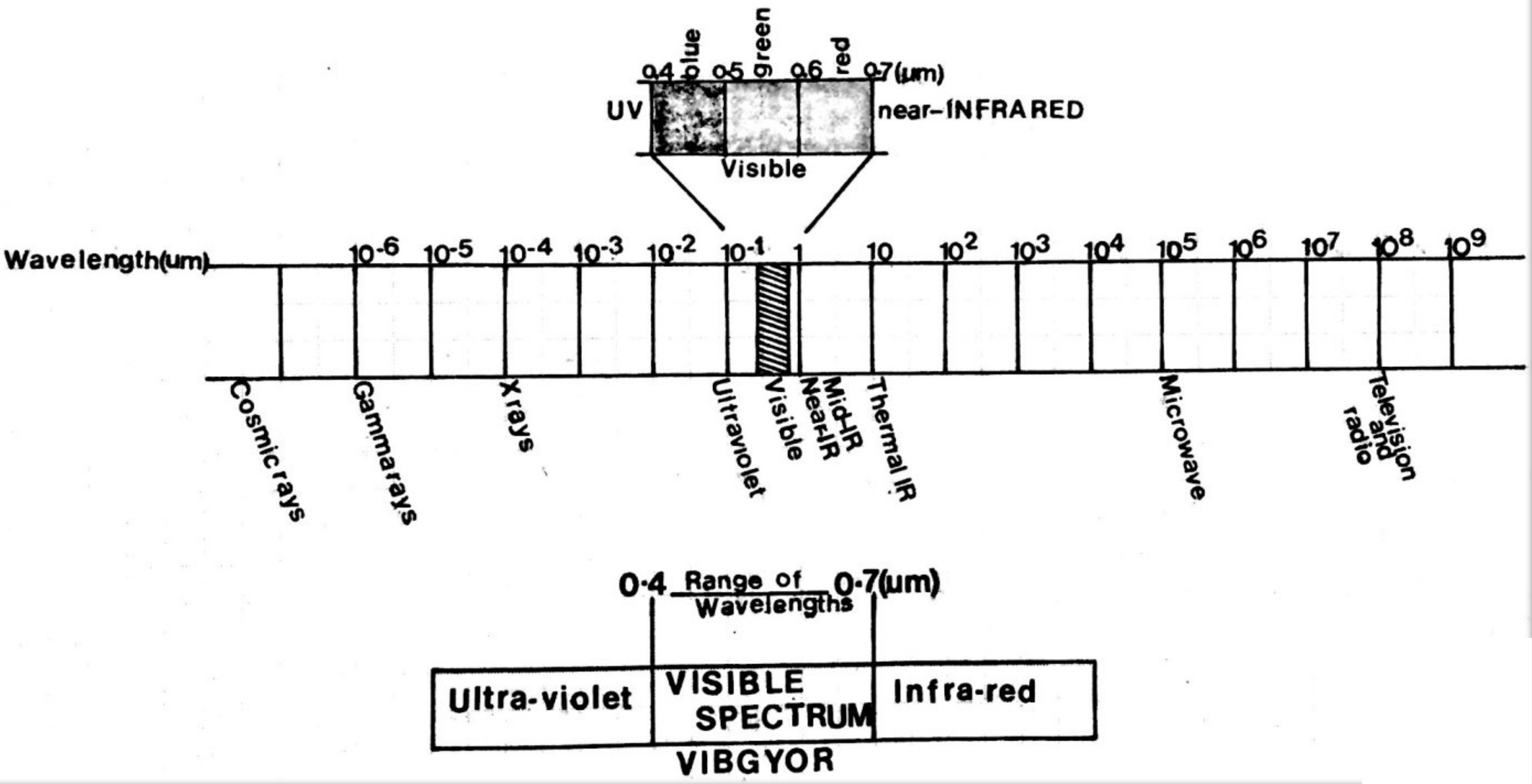


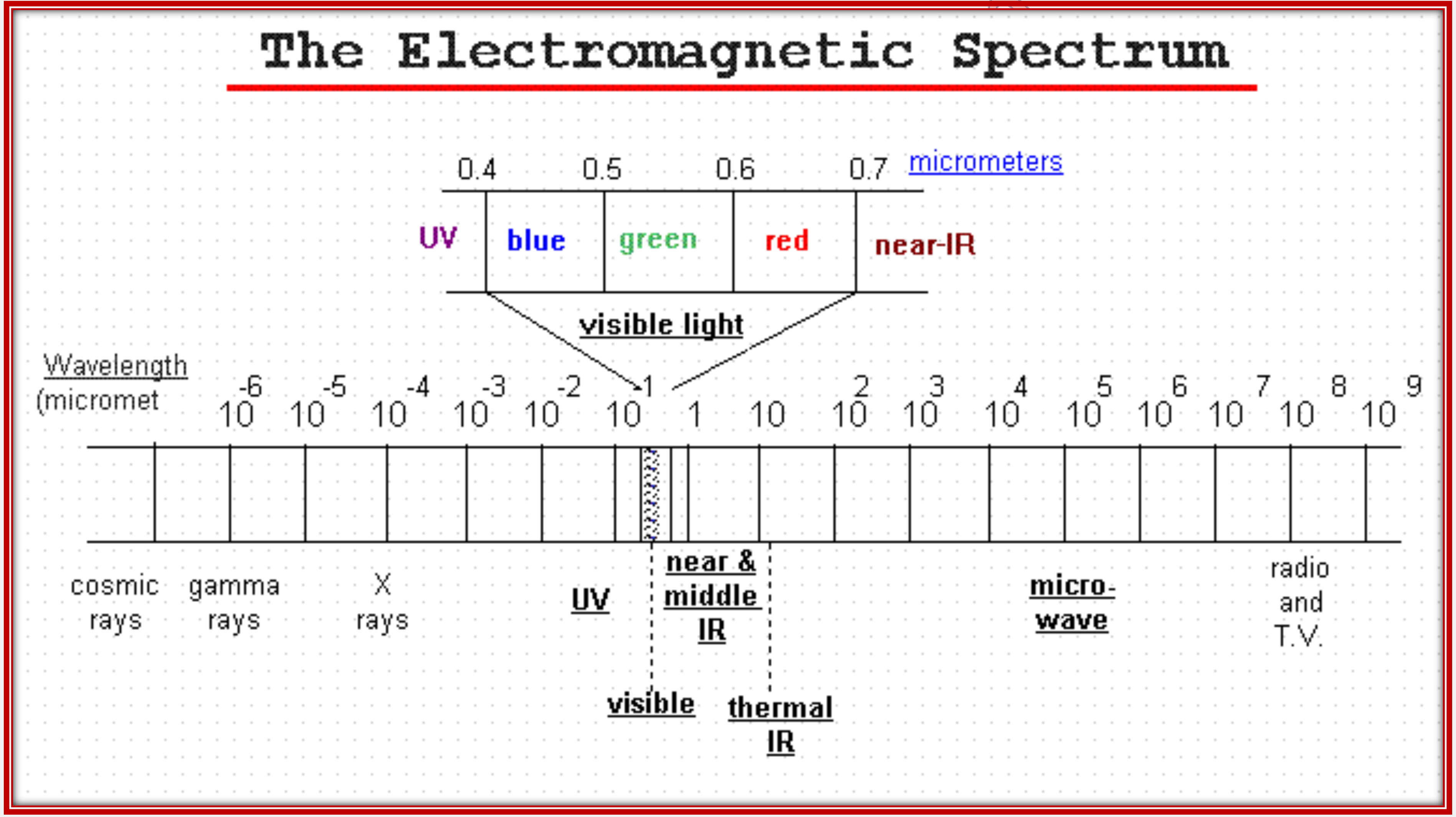
Electromagnetic Spectrum


ELECTROMAGNETIC RADIATION
SHORT-WAVE SOLAR RADIATION
LONG-WAVE TERRESTRIAL RADIATION
0·4
0·7
X-RAYS
GAMMA RAYS
ULTRA-VIOLET
VISIBLE LIGHT
INFRA-RED
RADIO WAVES
ELECTRIC WAVES
0·1
1·0
10
100
1000
WAVELENGTH (microns)


VISIBLE PART OF SUN'S SPECTRUM
SUN-LIGHT
GLASS PRISM
0·7 (um)
RED
ORANGE
YELLOW
GREEN
BLUE
INDIGO
VIOLET
0·4 (um)

ELECTROMAGNETIC SPECTRUM




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

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.

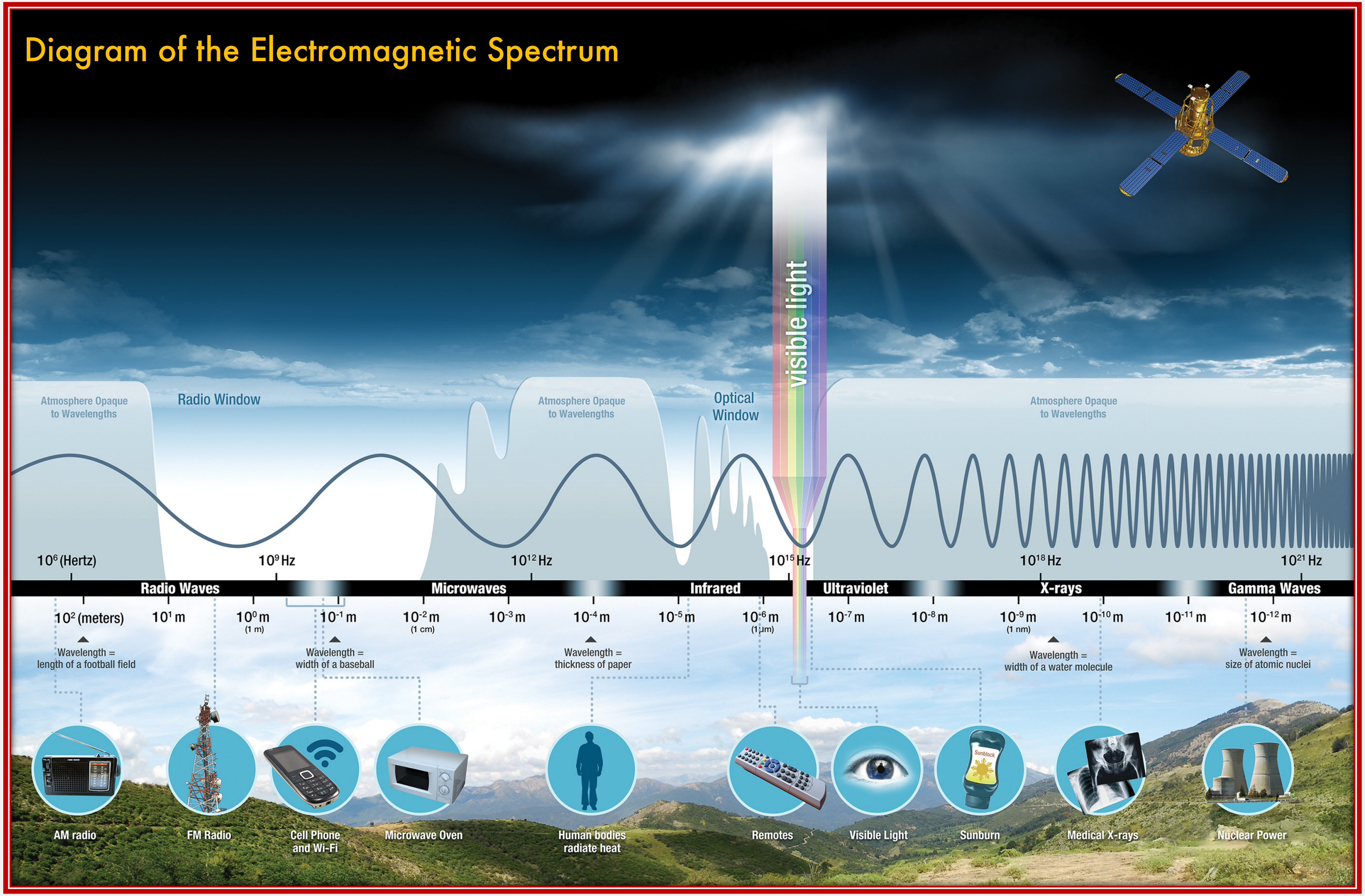
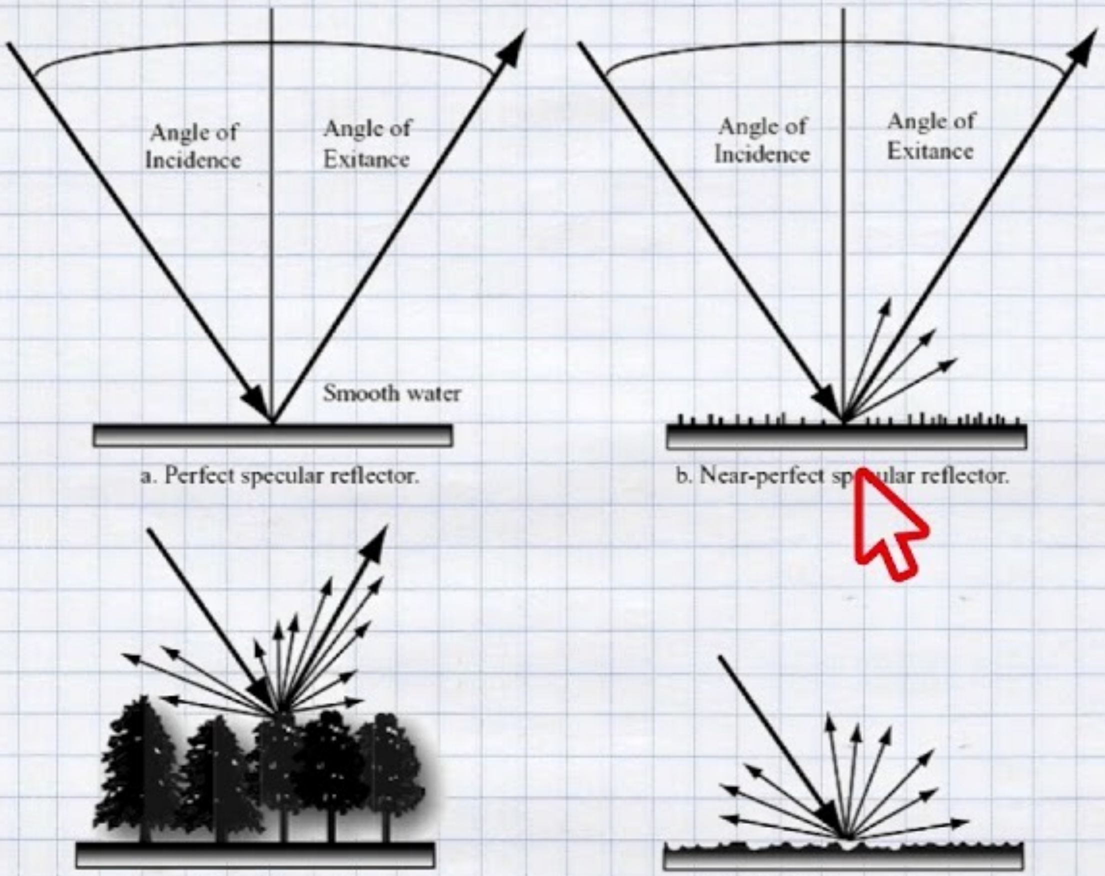


Diagram of the Electromagnetic Spectrum
visible light
Atmosphere Opaque to Wavelengths
Radio Window
Atmosphere Opaque to Wavelengths
Optical Window
Atmosphere Opaque to Wavelengths
10^6 (Hertz)
10^9 Hz
10^{12} Hz
10^{15} Hz
10^{18} Hz
10^{21} Hz
Radio Waves
Microwaves
Infrared
Ultraviolet
X-rays
Gamma Waves
10^2 (meters)
10^1 m
10^0 m (1 m)
10^{-1} m
10^{-2} m (1 cm)
10^{-3} m
10^{-4} m
10^{-5} m
10^{-6} m (1 µm)
10^{-7} m
10^{-8} m
10^{-9} m (1 nm)
10^{-10} m
10^{-11} m
10^{-12} m
Wavelength = length of a football field
Wavelength = width of a baseball
Wavelength = thickness of paper
Wavelength = width of a water molecule
Wavelength = size of atomic nuclei
AM radio
FM Radio
Cell Phone and Wi-Fi
Microwave Oven
Human bodies radiate heat
Remotes
Visible Light
Sunburn
Medical X-rays
Nuclear Power

EMR Interaction : Atmosphere & Earth Surface

EMR Radiation and Its Interactions with Atmosphere



a. Perfect specular reflector.

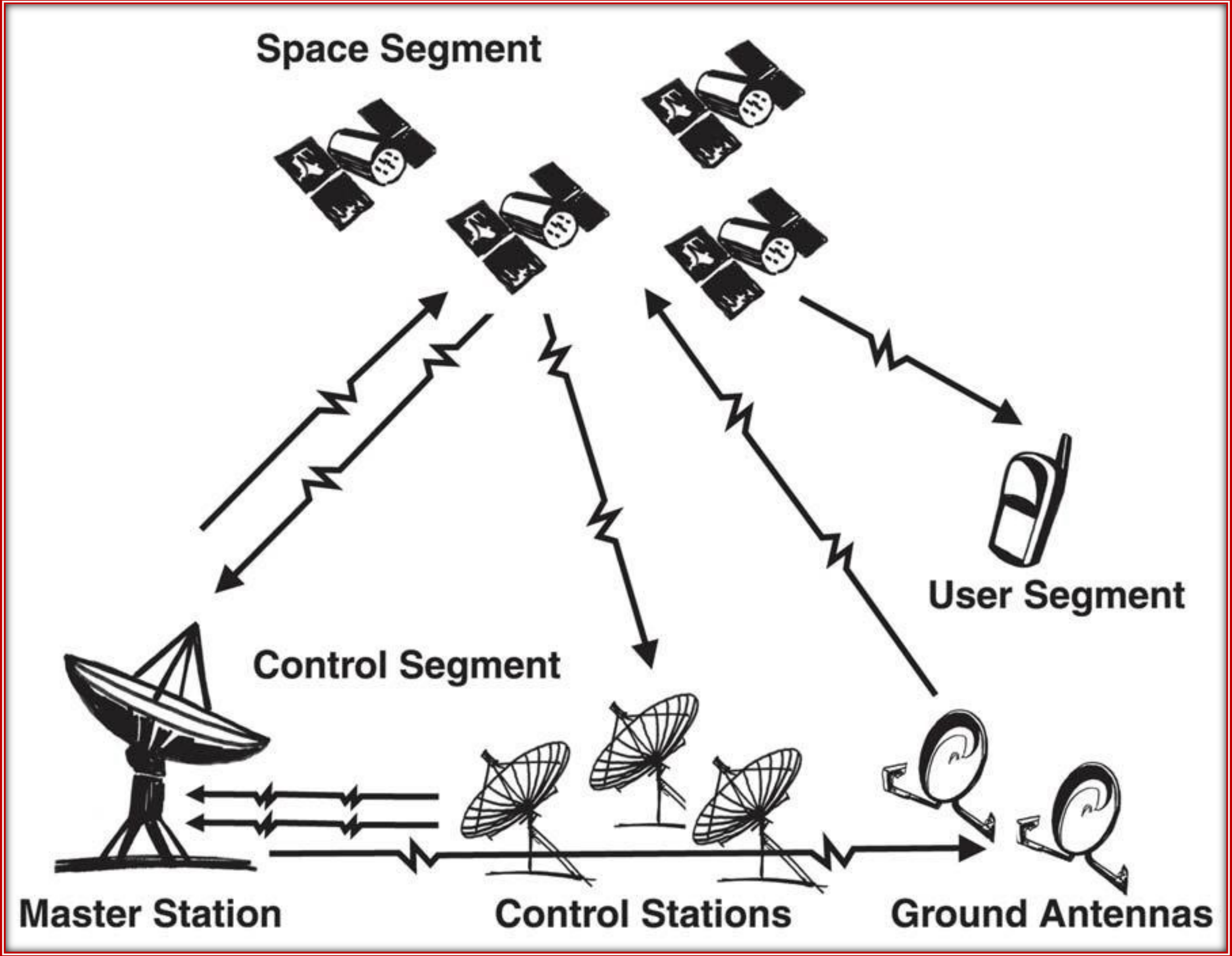
b. Near-perfect specular reflector.

c. Near-perfect diffuse reflector.

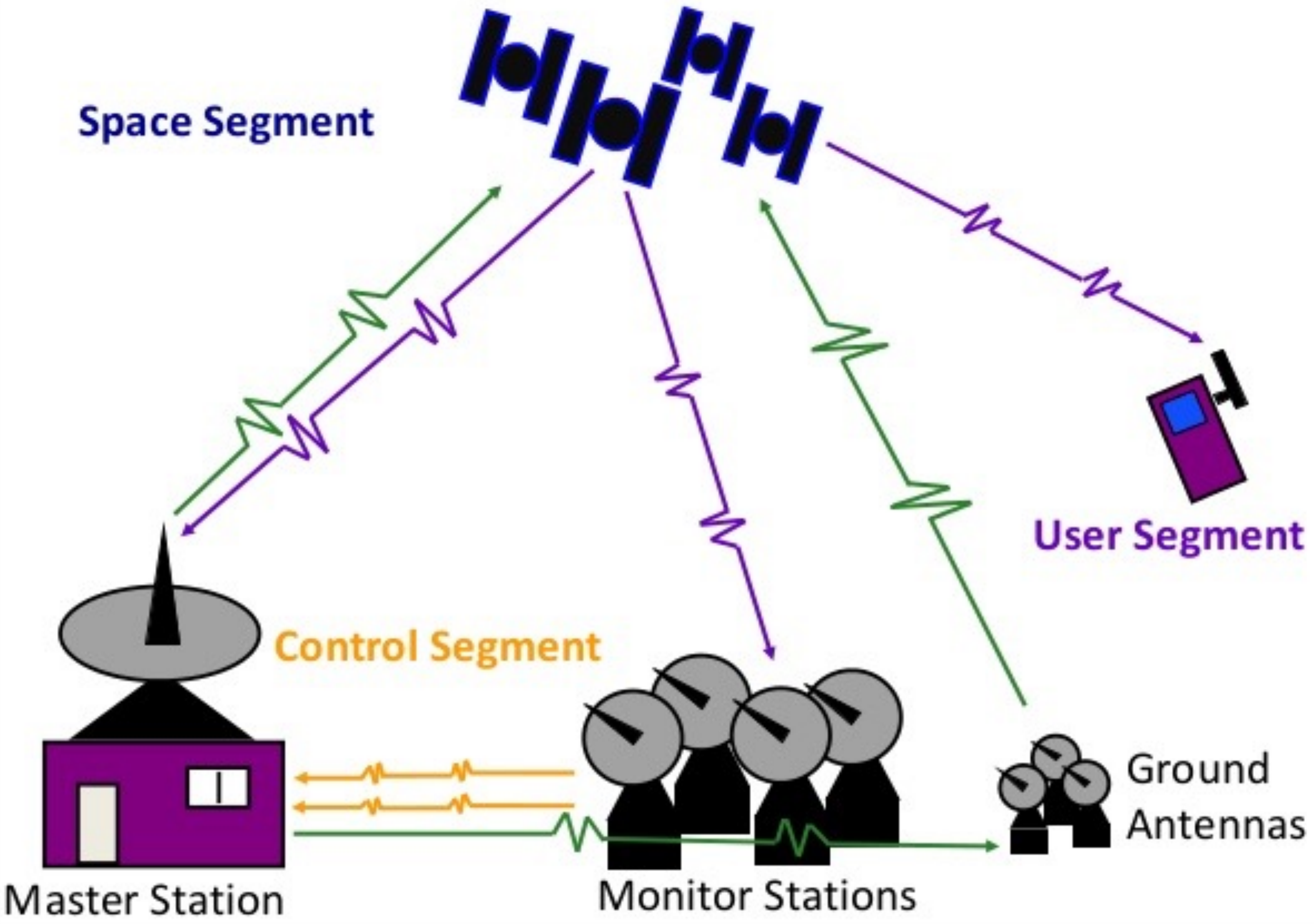
d. Perfect diffuse reflector, or Lambertian surface.

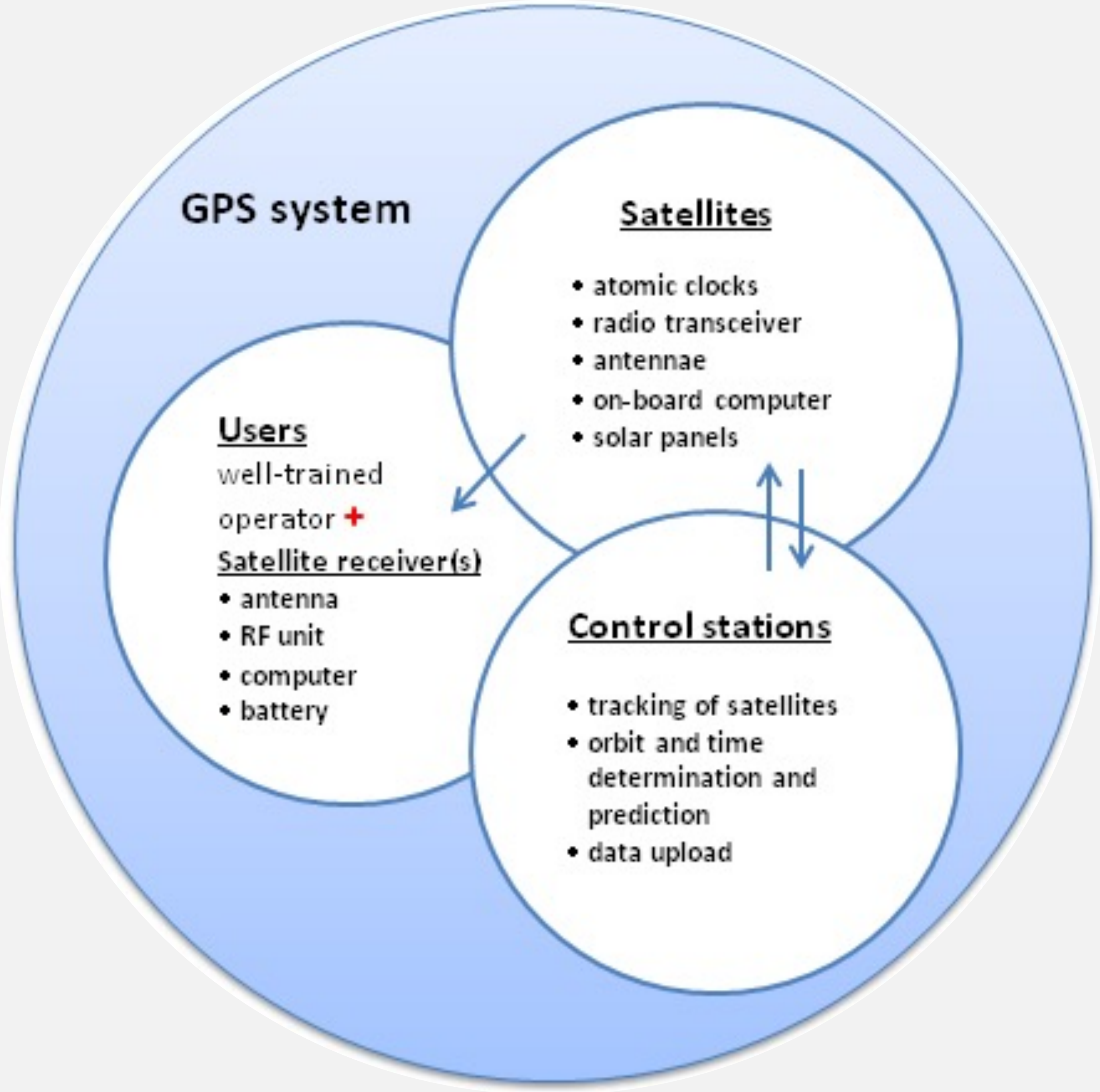
Fundamentals :

Global Positioning System (GPS)


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

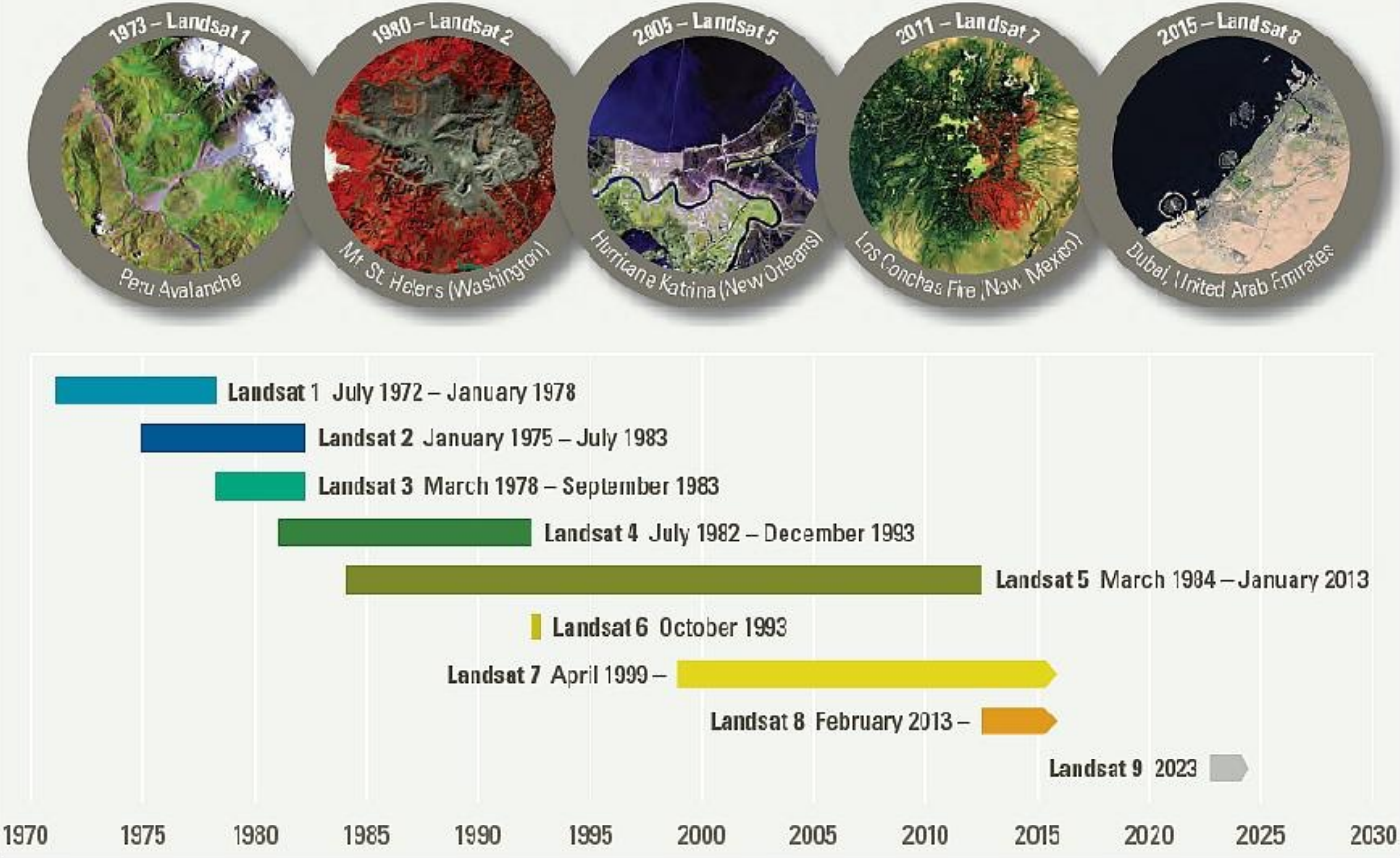
Three Segments of the GPS

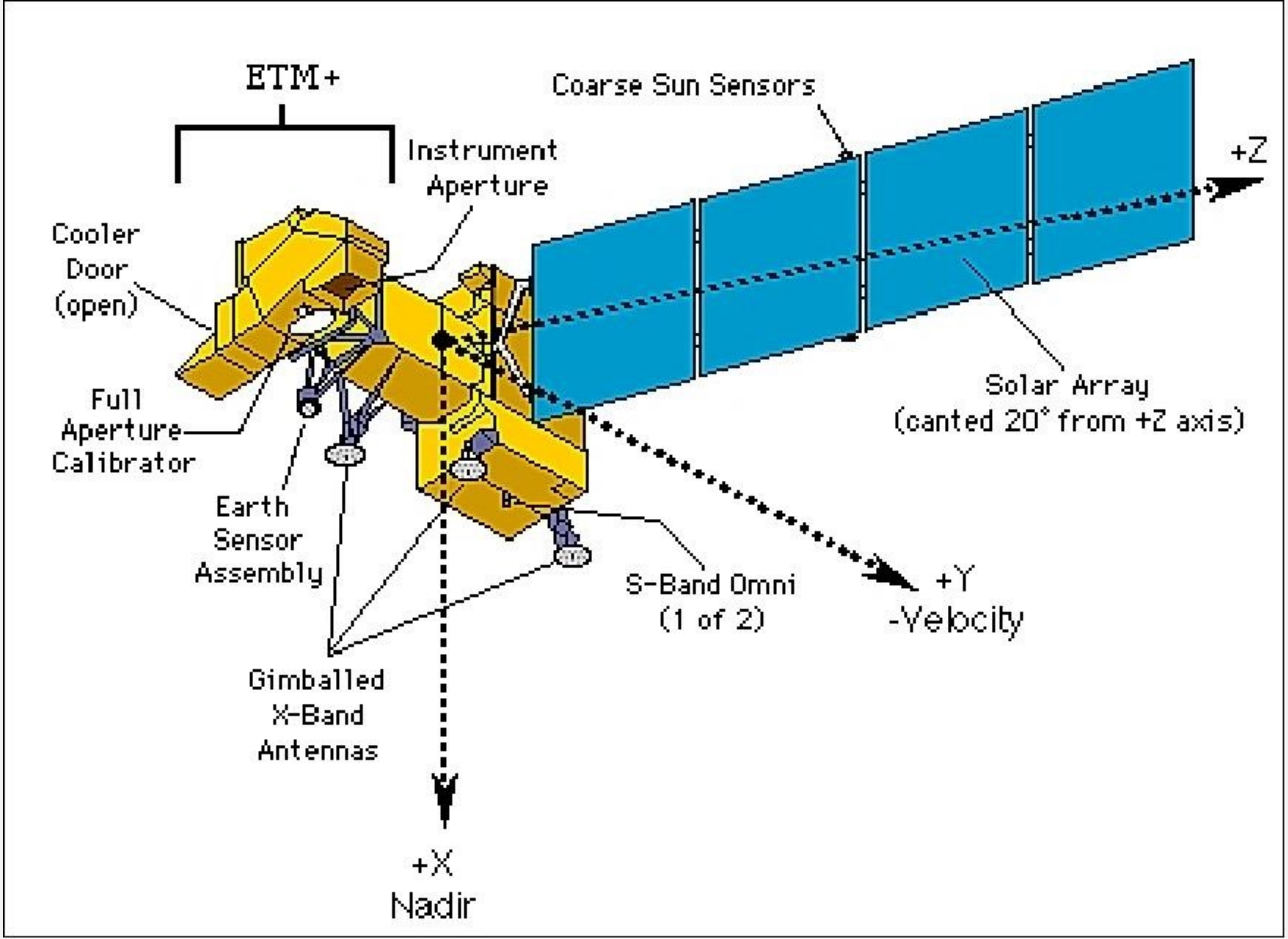


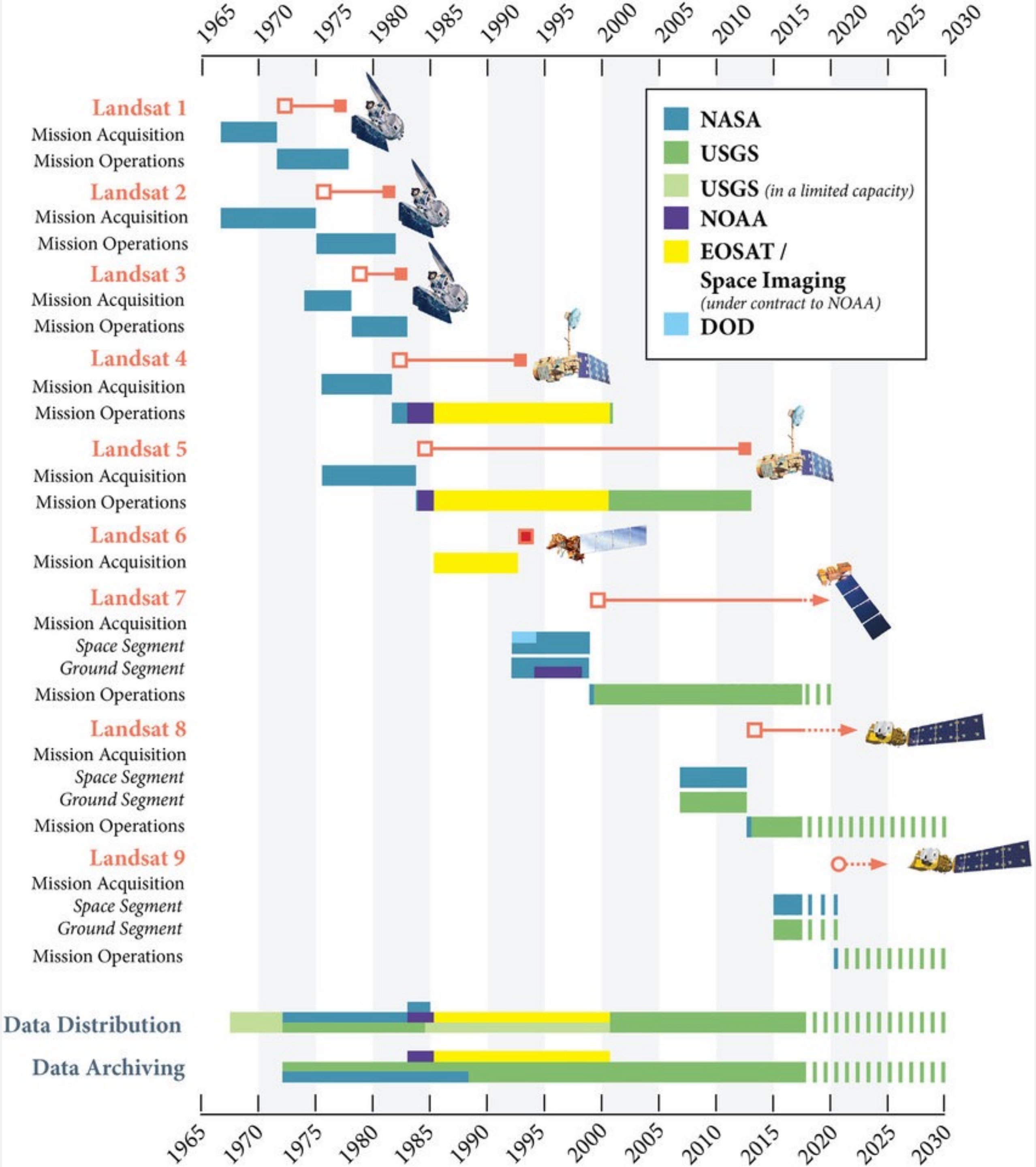

GPS system
Satellites
• atomic clocks
• radio transceiver
• antennae
• on-board computer
• solar panels
Users
well-trained
operator +
Satellite receiver(s)
• antenna
• RF unit
• computer
• battery
Control stations
• tracking of satellites
• orbit and time determination and prediction
• data upload

Satellites: Landsat & IRS

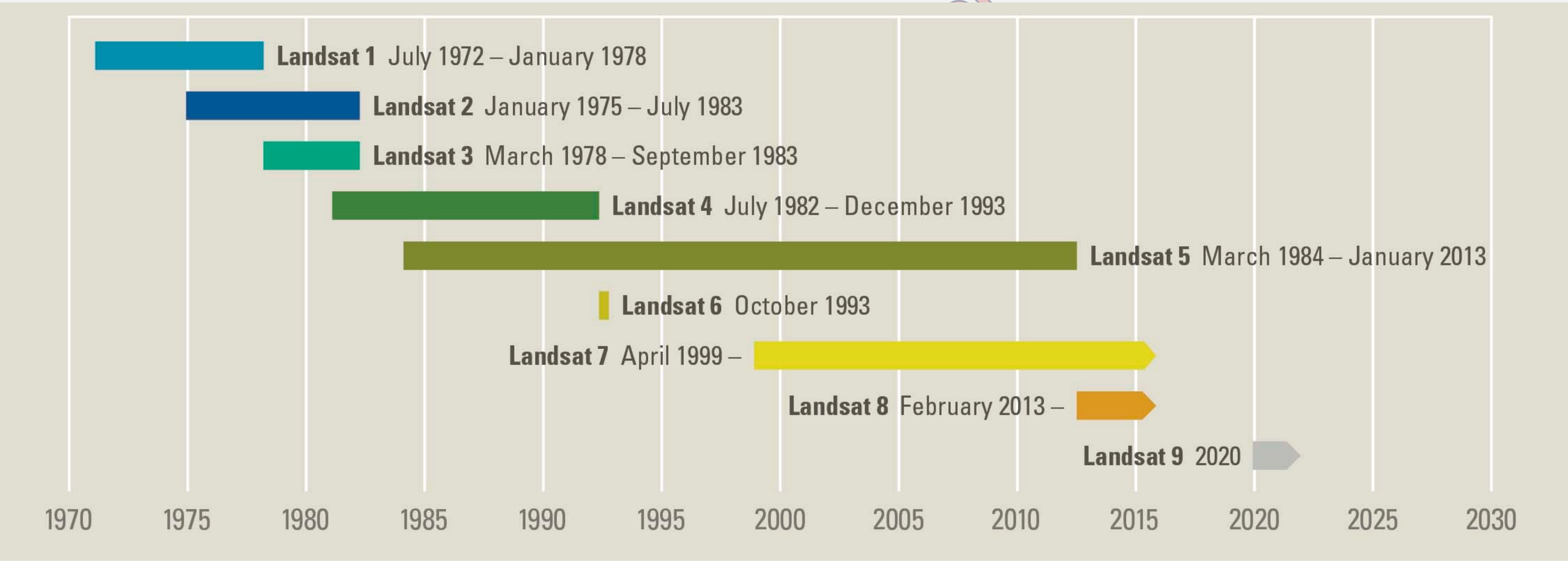
Landsat Missions: Imaging the Earth Since 1972




ETM+
Coarse Sun Sensors
Instrument
Aperture
+Z
Cooler
Door
(open)
Full
Aperture
Calibrator
Earth
Sensor
Assembly
Solar Array
(canted 20° from +Z axis)
S-Band Omni
(1 of 2)
+Y
-Velocity
Gimballed
X-Band
Antennas
+X
Nadir

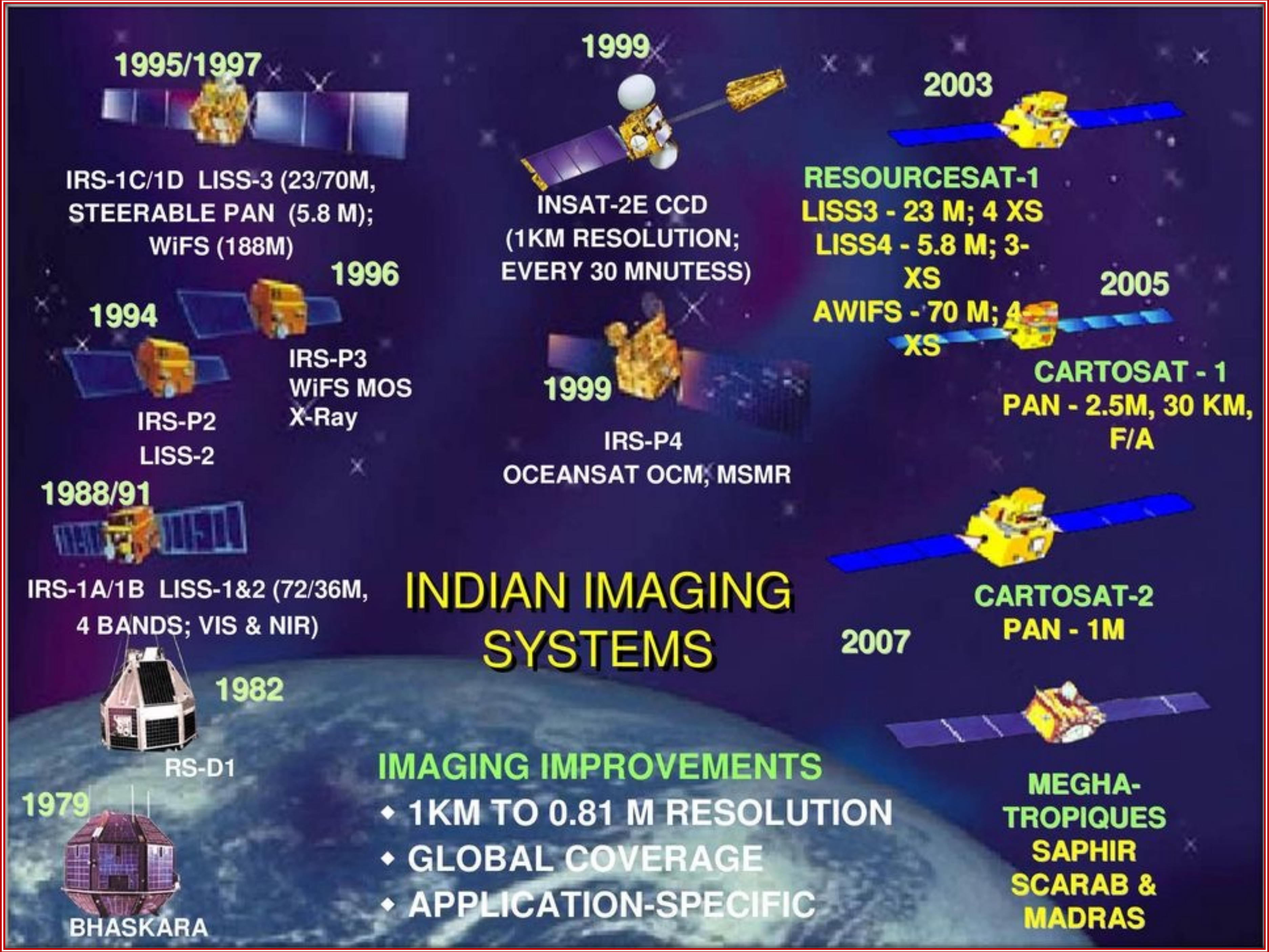


1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030
Landsat 1
Mission Acquisition
Mission Operations
Landsat 2
Mission Acquisition
Mission Operations
Landsat 3
Mission Acquisition
Mission Operations
Landsat 4
Mission Acquisition
Mission Operations
Landsat 5
Mission Acquisition
Mission 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

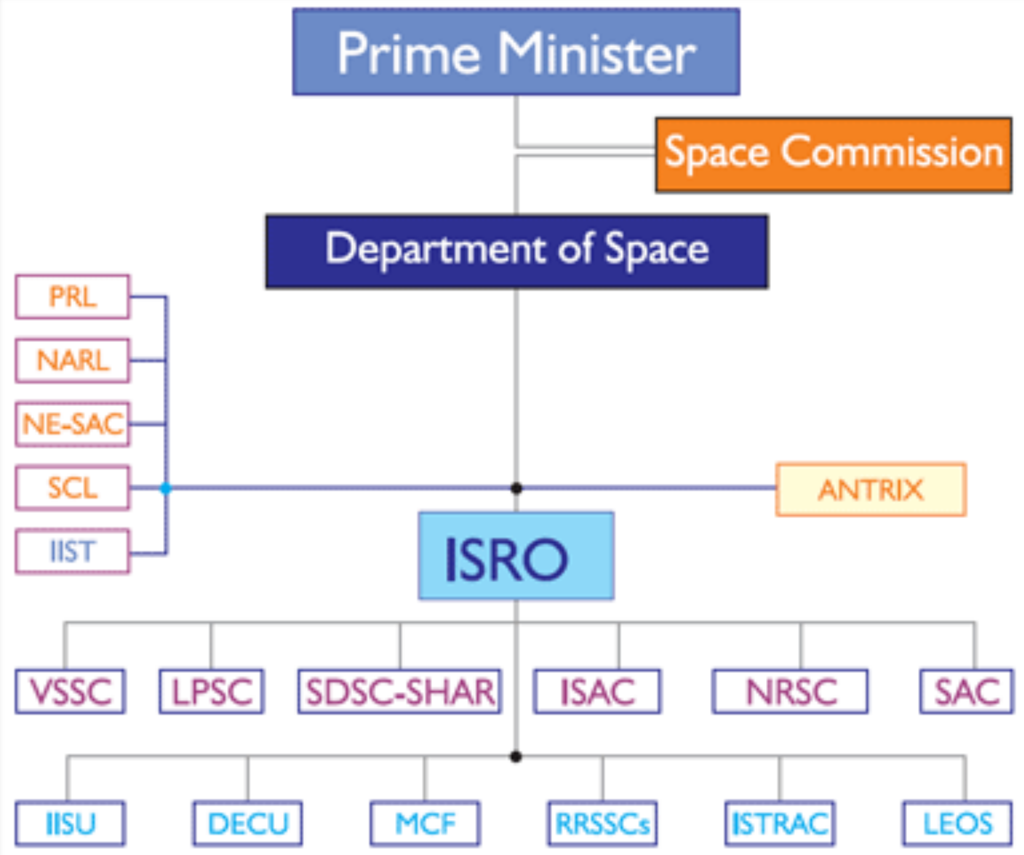

Landsat 1 July 1972 – January 1978
Landsat 2 January 1975 – July 1983
Landsat 3 March 1978 – September 1983
Landsat 4 July 1982 – December 1993
Landsat 5 March 1984 – January 2013
Landsat 6 October 1993
Landsat 7 April 1999 –
Landsat 8 February 2013 –
Landsat 9 2020
1970
1975
1980
1985
1990
1995
2000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

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, 1^0K 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

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



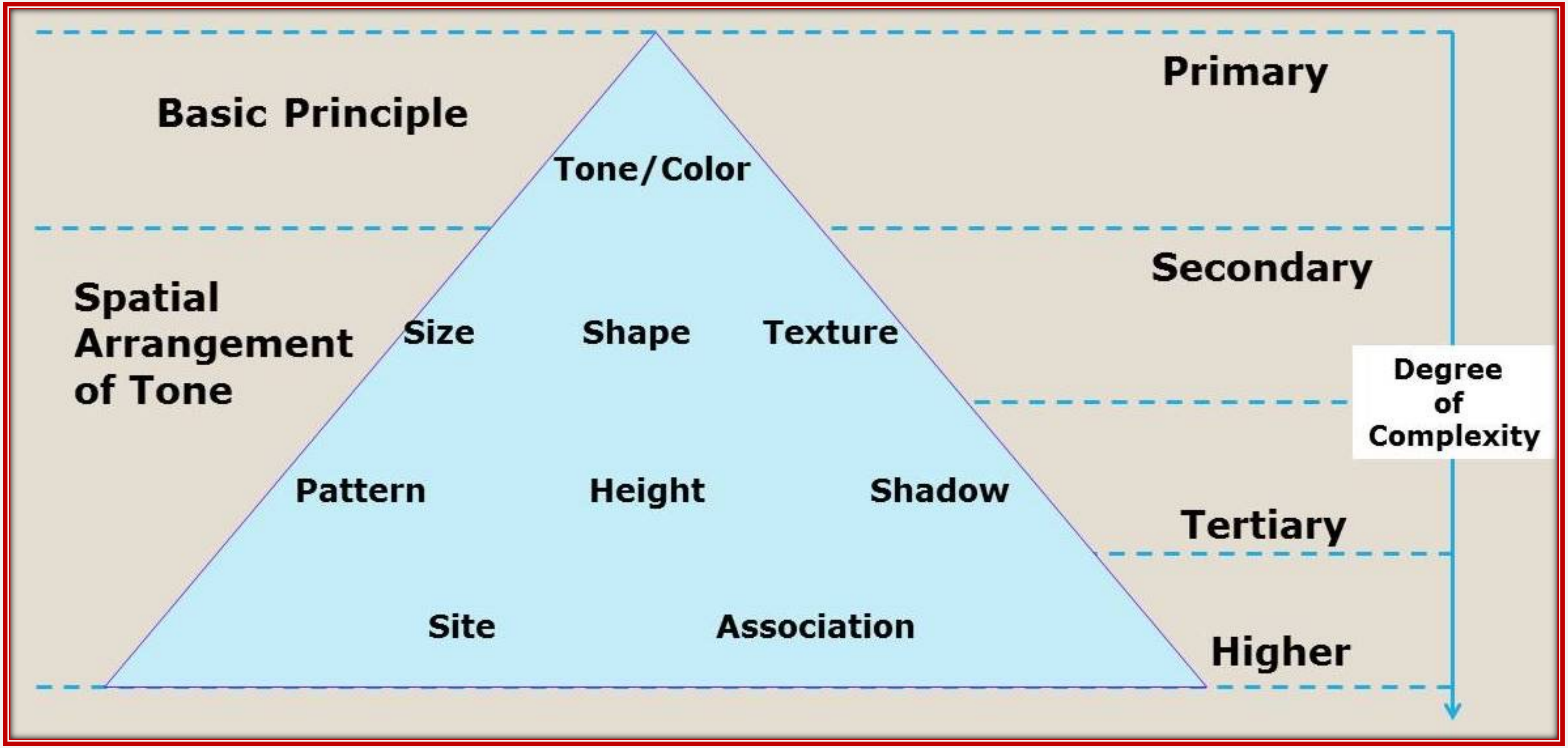
1995/1997
IRS-1C/1D LISS-3 (23/70M, STEERABLE PAN (5.8 M); WiFS (188M)
1999
INSAT-2E CCD (1KM RESOLUTION; EVERY 30 MNUTESS)
2003
RESOURCESAT-1
LISS3 - 23 M; 4 XS
LISS4 - 5.8 M; 3-XS
AWIFS - 70 M; 4 XS
1996
IRS-P3
WiFS MOS
X-Ray
1994
IRS-P2
LISS-2
1999
IRS-P4
OCEANSAT OCM, MSMR
2005
CARTOSAT - 1
PAN - 2.5M, 30 KM, F/A
1988/91
IRS-1A/1B LISS-1&2 (72/36M, 4 BANDS; VIS & NIR)
INDIAN IMAGING SYSTEMS
CARTOSAT-2
PAN - 1M
2007
1982
RS-D1
1979
BHASKARA
IMAGING IMPROVEMENTS
• 1KM TO 0.81 M RESOLUTION
• GLOBAL COVERAGE
• APPLICATION-SPECIFIC
MEGHA-TROPIQUES
SAPHIR
SCARAB &
MADRAS



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

Bases of Visual Interpretation :

Remote Sensing Image


Basic Principle
Spatial Arrangement of Tone
Tone/Color
Size
Shape
Texture
Pattern
Height
Shadow
Site
Association
Primary
Secondary
Tertiary
Higher
Degree of Complexity

THANKS