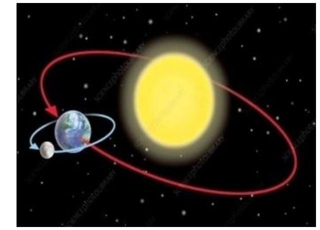
Lesson 7

Satellites and Orbits

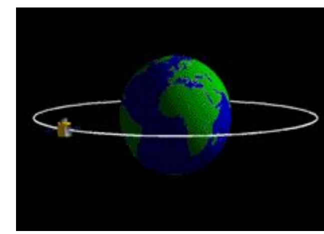
SATELLITE

ASTRONOMY: a celestial body orbiting the earth or another planet.



ARTIFICAL SATELLITE:

an artificial body placed in orbit round the earth or another planet in order to collect information or for communication.



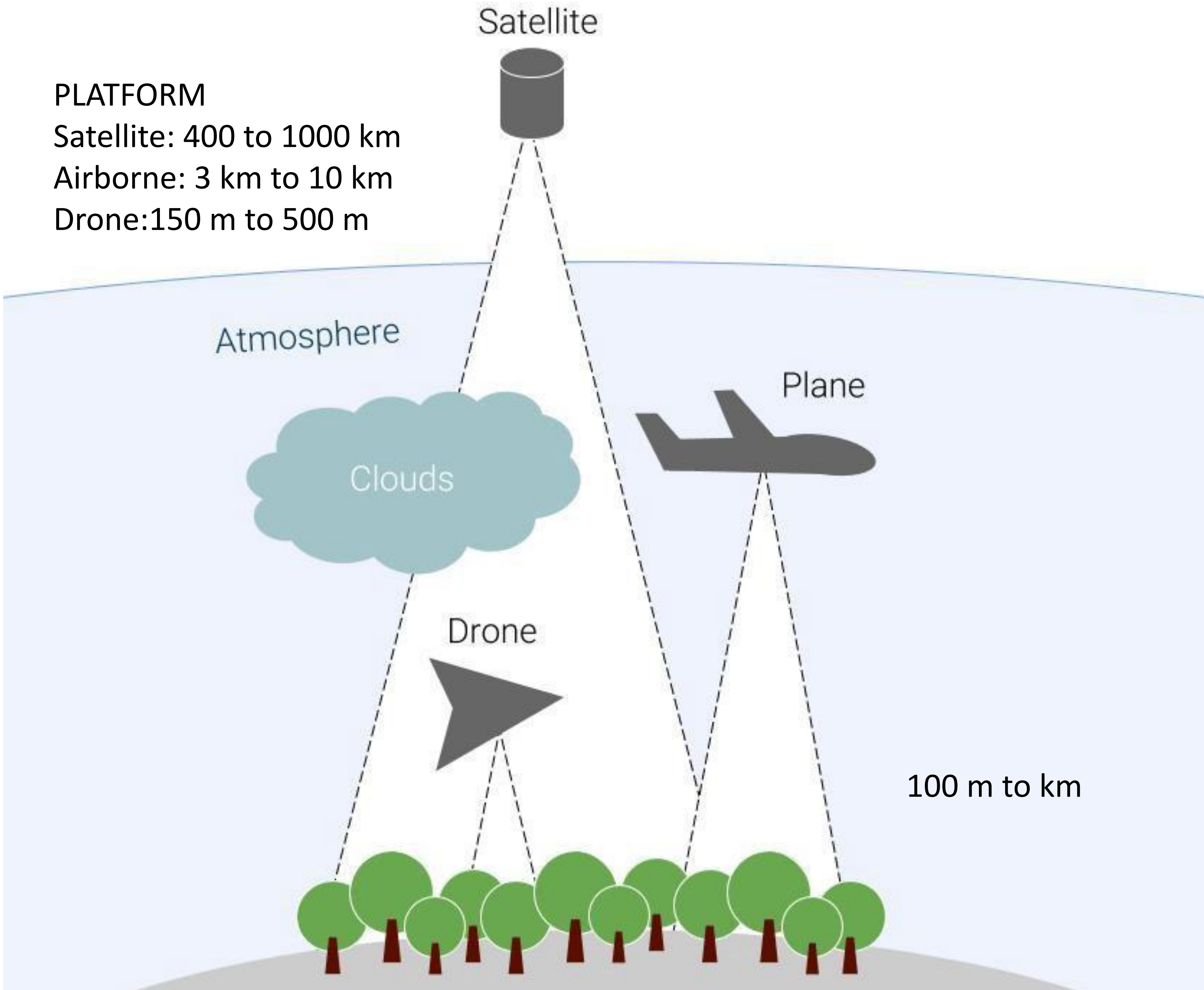
What Was the First Satellite in Space?

Sputnik 1 was the first satellite in space. The Soviet Union launched on 4th Oct 1957.

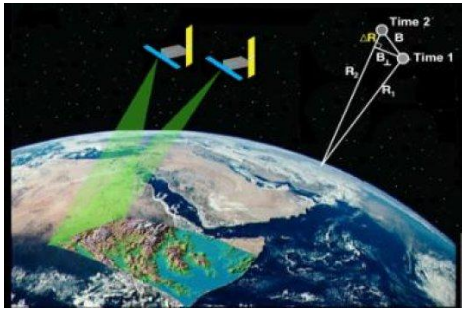
First Indian satellite:

Aryabhatta, 19April 1975 launched from Russia (After 18 years)

PLATFORM
Satellite: 400 to 1000 km
Airborne: 3 km to 10 km
Drone:150 m to 500 m



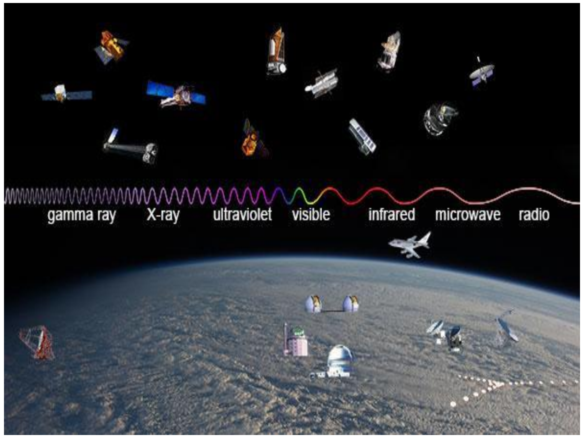
Why Are Satellites Important?

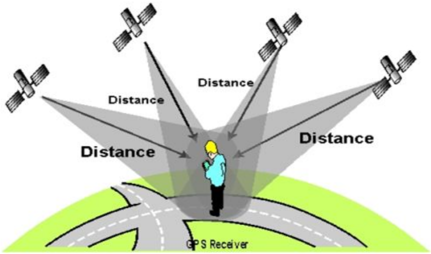


- Can see large areas of Earth at one time
- Synoptic view , repeated observation, any inaccessible location

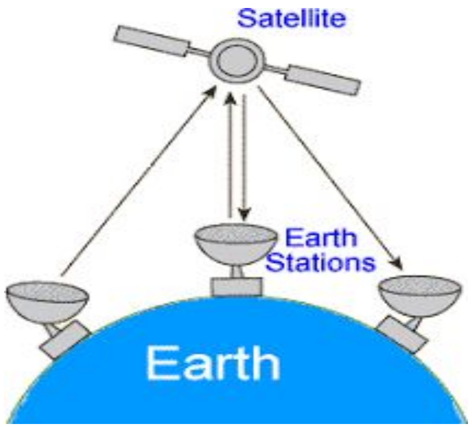
•

Can see into space



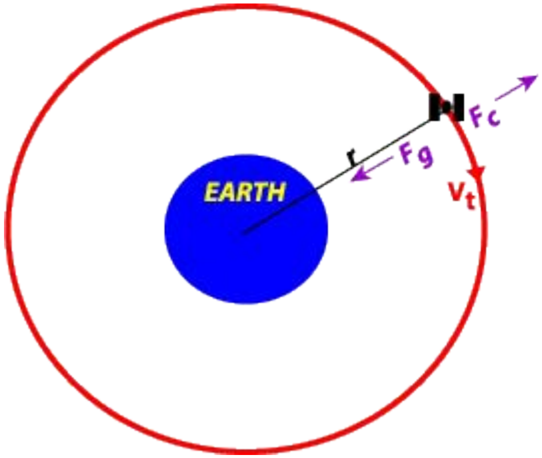


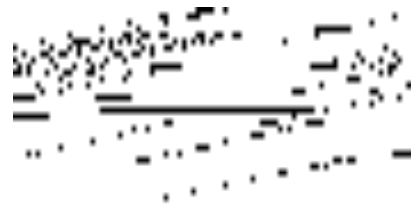
Can communicate



Can know position

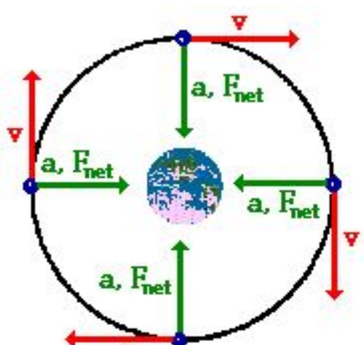
CIRCULAR MOTION





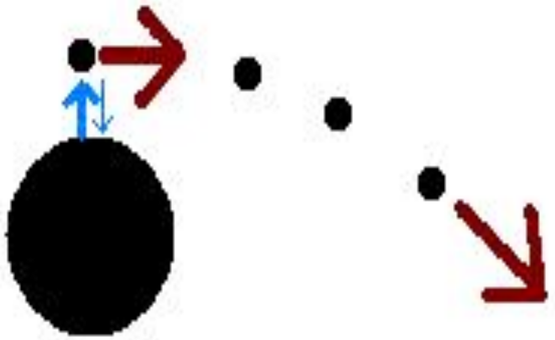
Gravitational Force

Centrifugal Force



Satellites encounter inward forces and accelerations and tangential velocities.

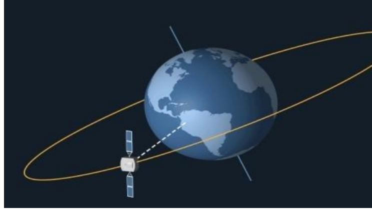
To stay in **orbit**, a **satellite** has to travel at a very high **velocity**, which depends on the height. So, typically, for a circular **orbit** at a height of 300 km above the Earth's surface, a **speed** of 7.8 km/s (28,000 km/h) is needed. At this **speed**, the **satellite** will complete one **orbit** around the Earth in 90 minutes.



Forward speed is much greater than gravity, object continues moving through space.

Gravity is much greater than forward speed, objects collide.

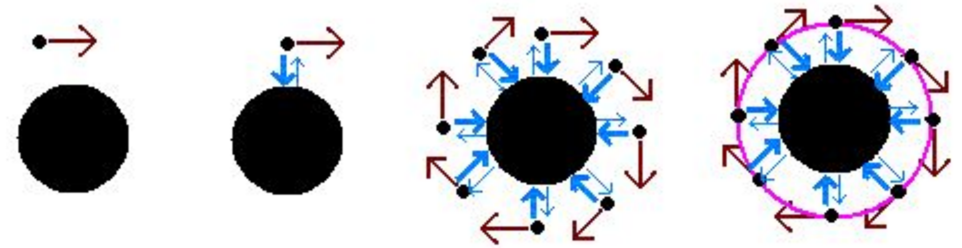
To stay in orbit, a satellite has to travel at a very high velocity, which depends on the height. So, typically, for a circular orbit at a height of 300 km above the Earth's surface, a speed of 7.8 km/s (28,000 km/h) is needed. At this speed, the satellite will complete one orbit around the Earth in 90 minutes.



WHAT IS AN ORBIT?

An orbit is a regular, repeating path that an object in space takes around another one. An object in an orbit is called a satellite.

Orbits are the result of a perfect balance between the forward motion of a body in space, such as a planet or moon, and the pull of gravity on it from another body in space, such as a large planet or star. An object with a lot of mass goes forward and wants to keep going forward; however, the gravity of another body in space pulls it in. There is a continuous tug-of-war between the one object wanting to go forward and away and the other wanting to pull it in.



Object speeds by a planet with a lot of momentum

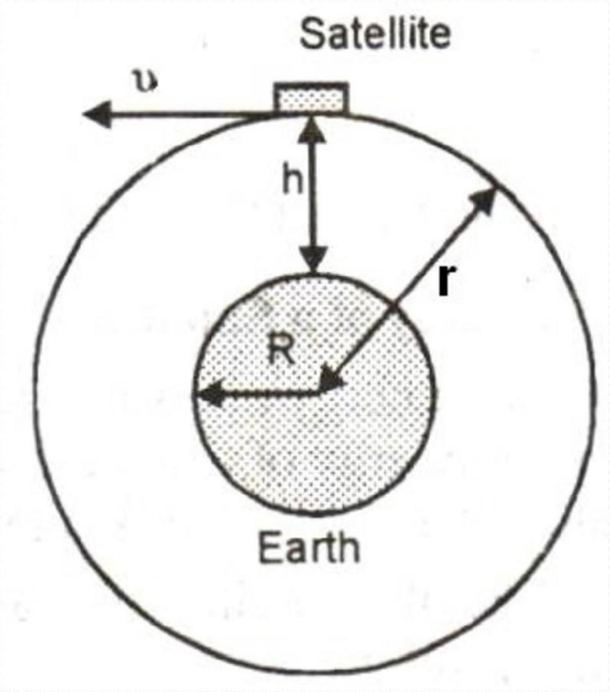
Gravity attracts the object to the planet and vice versa

Object continues to try to move forward, but is pulled down by gravity.

The result is a balance of forces pushing the object out and pulling it in, making a circular orbit.

ORBITAL VELOCITY

- The velocity with which a satellite moves in its closed orbit is called orbital velocity
- m- mass of the satellite   r – radius of the path   v- orbital velocity



- Gravitational force= Centrifugal force

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$v = \sqrt{\frac{GM}{r}}$$

Orbital period: Time taken by a satellite to compete one revolution in its orbit around the earth is called orbital period.

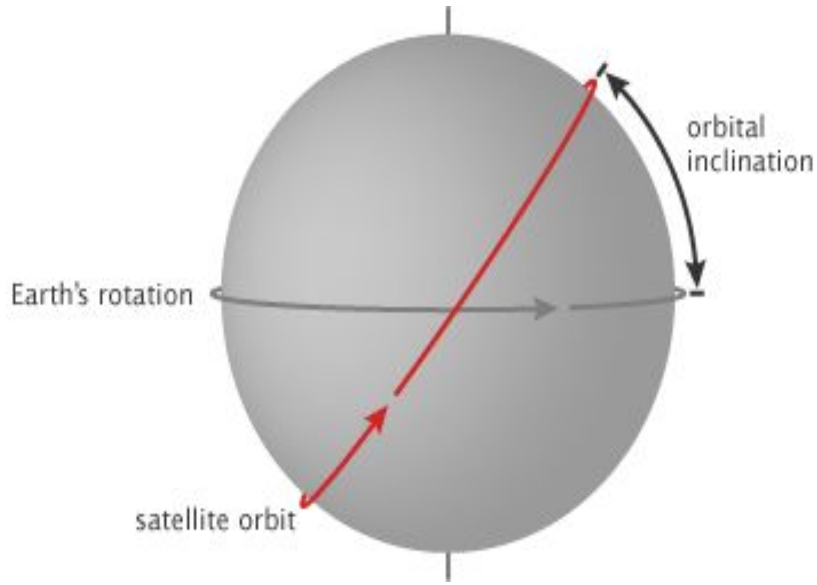
$$T = 2\pi r\sqrt{\frac{r}{gR_e^2}} \qquad \text{where} \quad r = R_e + h$$

It varies from around 100 minutes for a near-polar earth observing satellite to 24 hours for a geo-stationary satellite.

Altitude: Altitude of a satellite is its heights with respect to the surface immediately below it. Depending on the designed purpose of the satellite, the orbit may be located at low (160-2000 km), moderate, and high (~36000km) altitude.

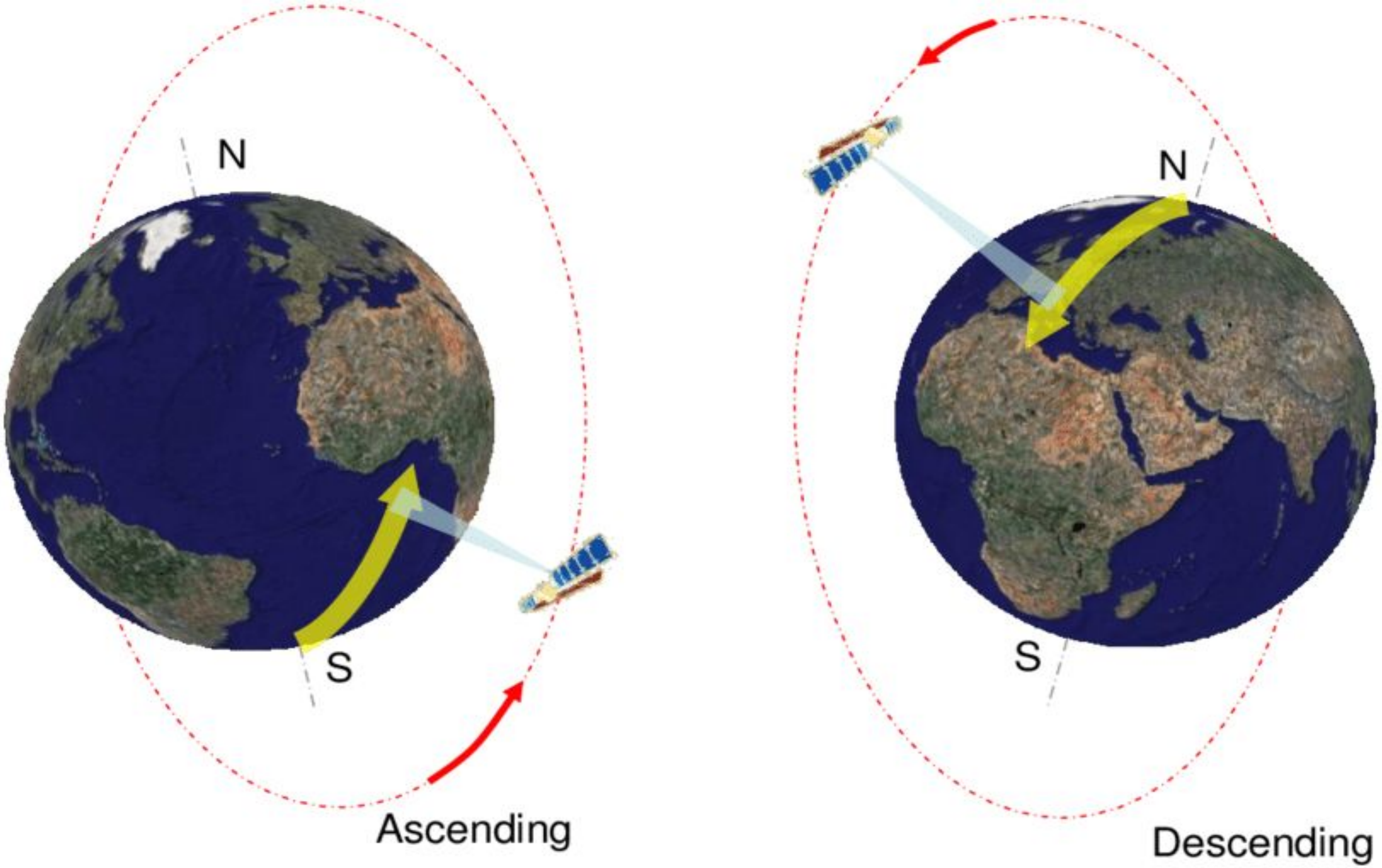
$R_e = 6378\,\text{km}$ $\qquad$ $g = 9.81 m/s^2$ gravitational acceleration.

Inclination is the angle of the orbit in relation to Earth's equator. A satellite that orbits directly above the equator has zero inclination. If a satellite orbits from the north pole (geographic, not magnetic) to the south pole, its inclination is 90 degree



Orbital inclination is the angle between the plane of an orbit and the equator. An orbital inclination of 0° is directly above the equator, 90° crosses right above the pole, and 180° orbits above the equator in the opposite direction of Earth's spin.

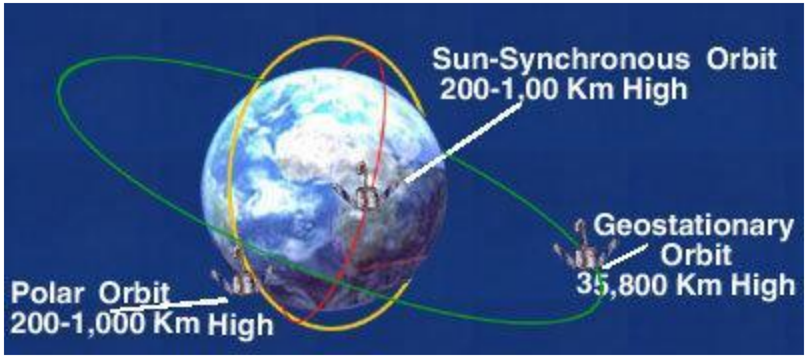
ASCENDING and DESCENDING orbits



ORBIT TYPE:

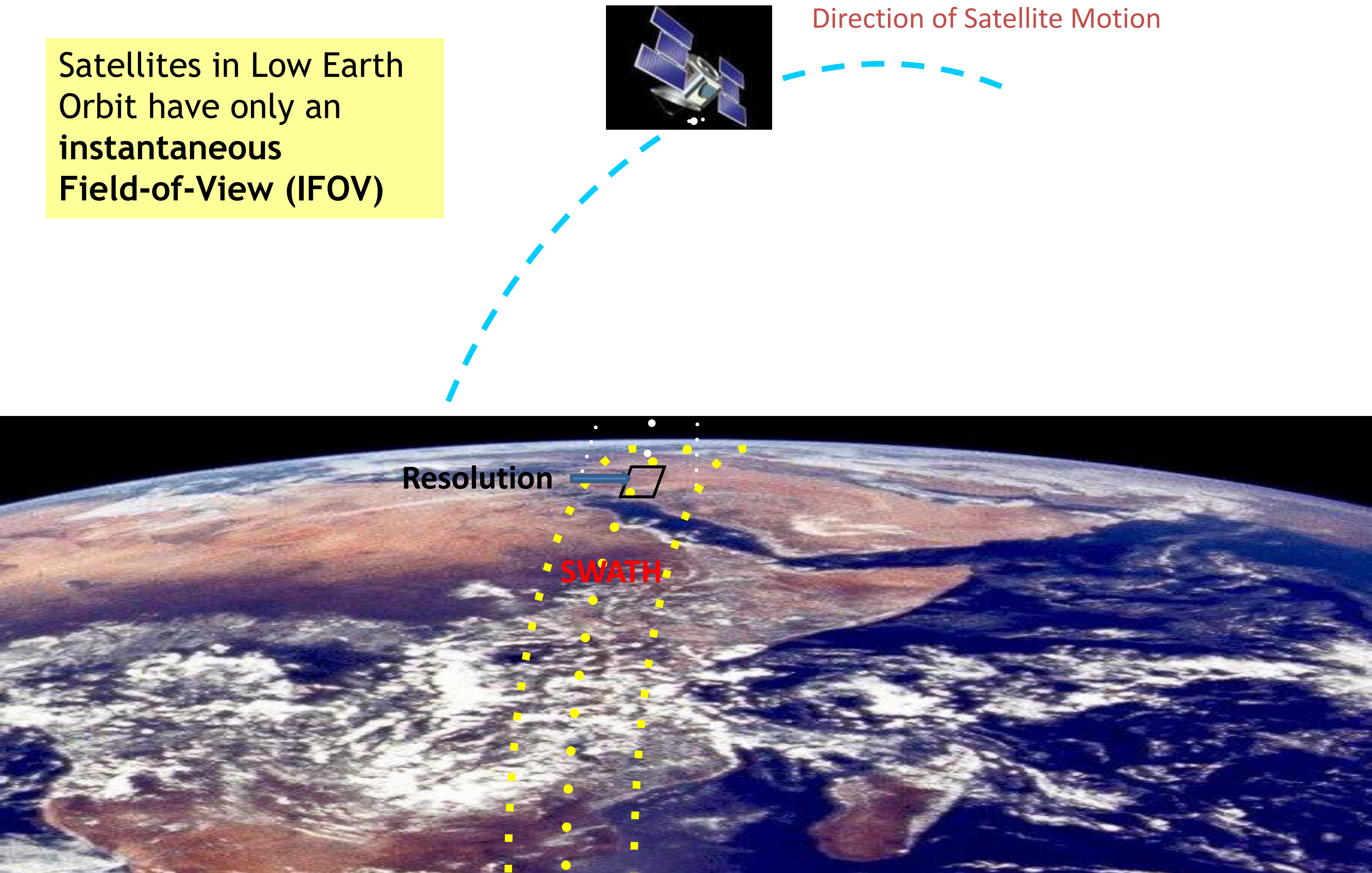
When a satellite is launched into the space, it moves in a well defined path around the Earth, which is called the orbit of the satellite. Gravitational pull of the Earth and the velocity of the satellite are the two basic factors that keep the satellites in any particular orbit. Spatial and temporal coverage of the satellite depends on the orbit. There are three basic types of orbits in use.

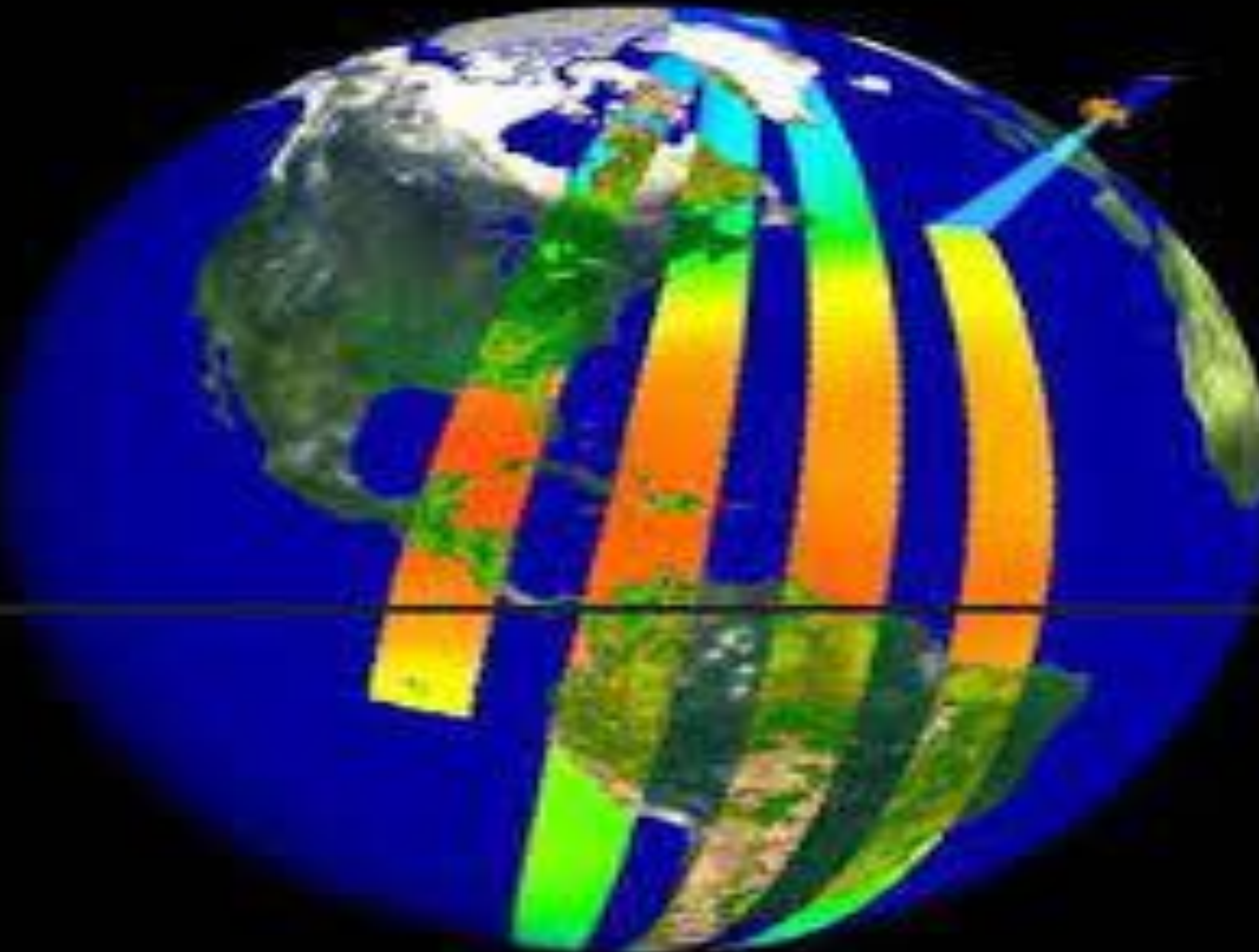
- Geo-synchronous orbits
- Polar or near polar orbits
- Sun-synchronous orbits



LEO Field-of-View (FOV)

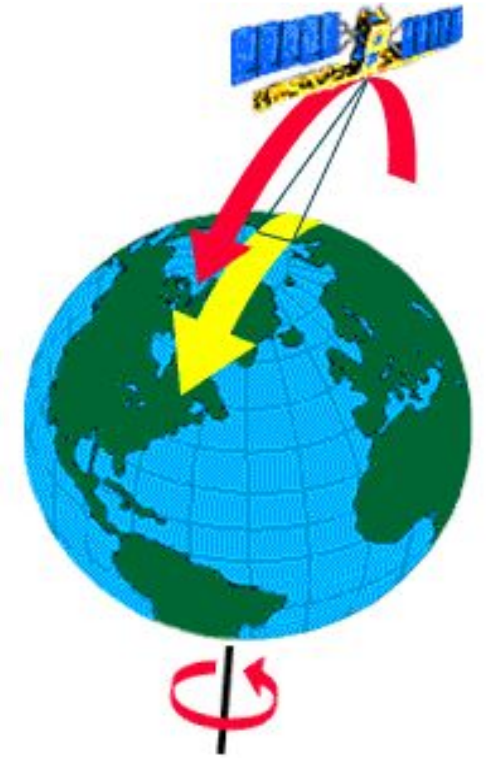
Satellites in Low Earth Orbit have only an **instantaneous Field-of-View (IFOV)**





ORBITS

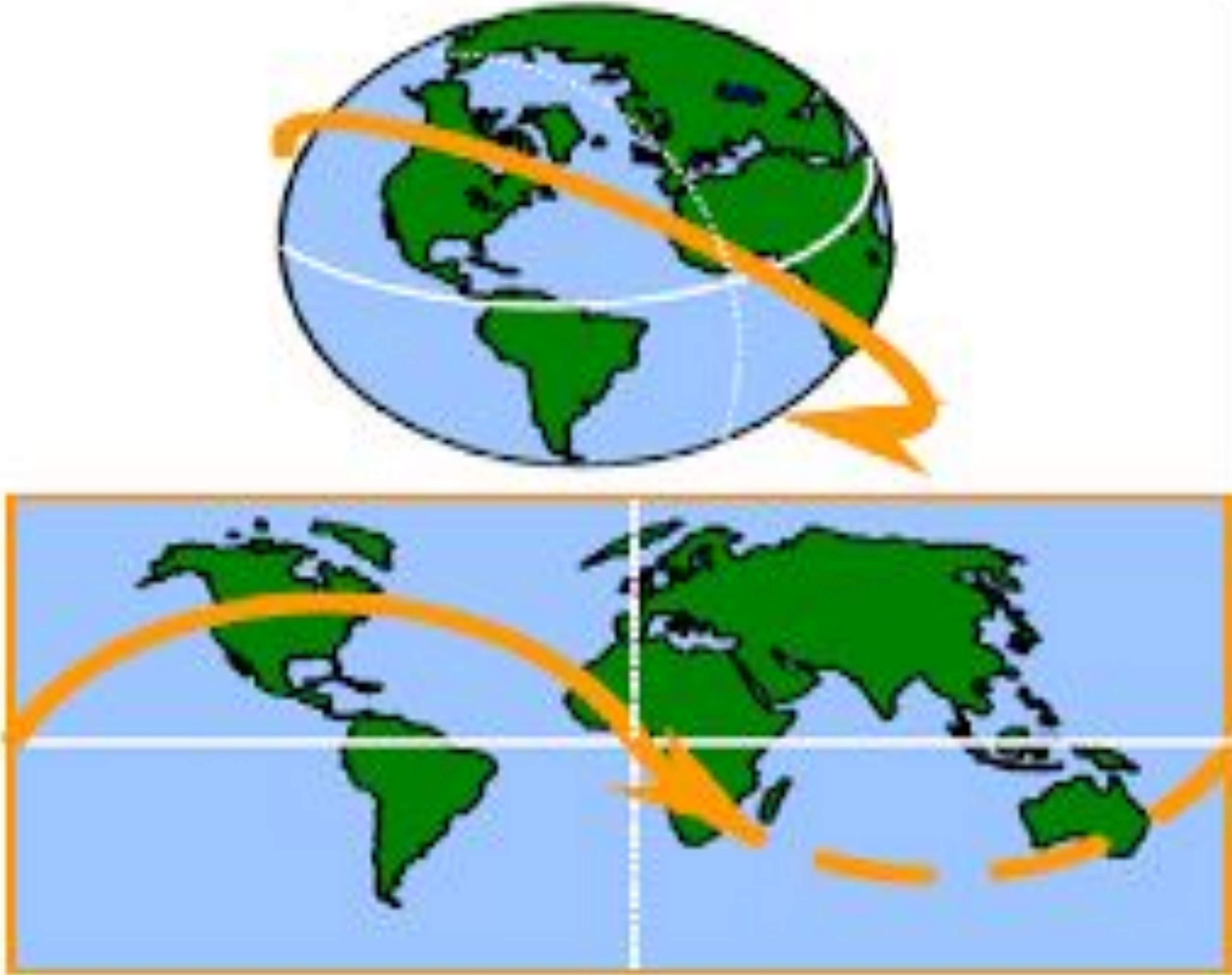
Temporal resolution:
Time interval between two successive visits of the satellite for the same place



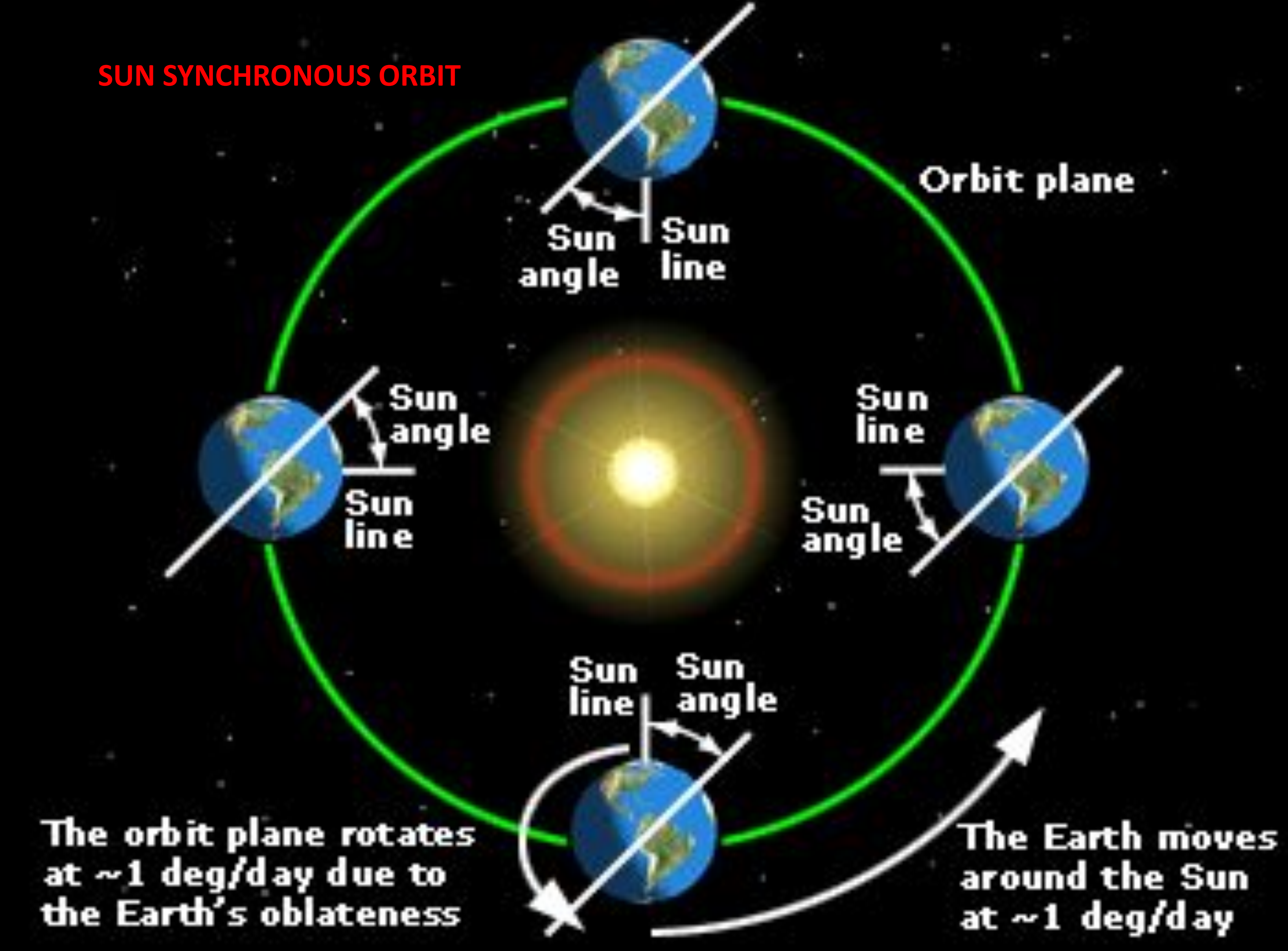
Near Polar orbit

(appr. 500-1000 km)


1st orbit
2nd orbit
3rd orbit



SUN SYNCHRONOUS ORBIT



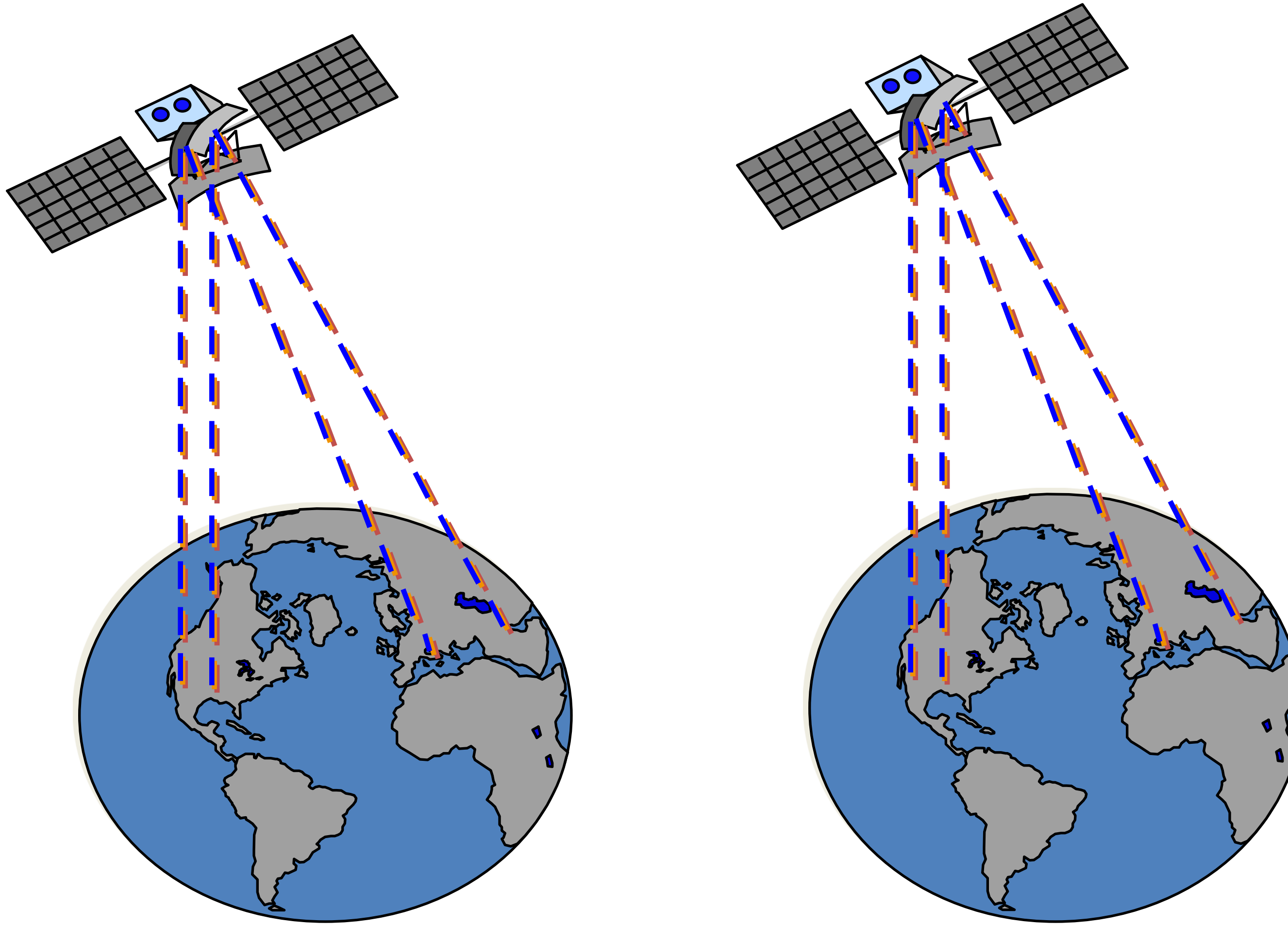
REMOTE SENSING: High resolution REPEATED OBSERVATIONS

Polar Orbits

Satellite

DAY 1

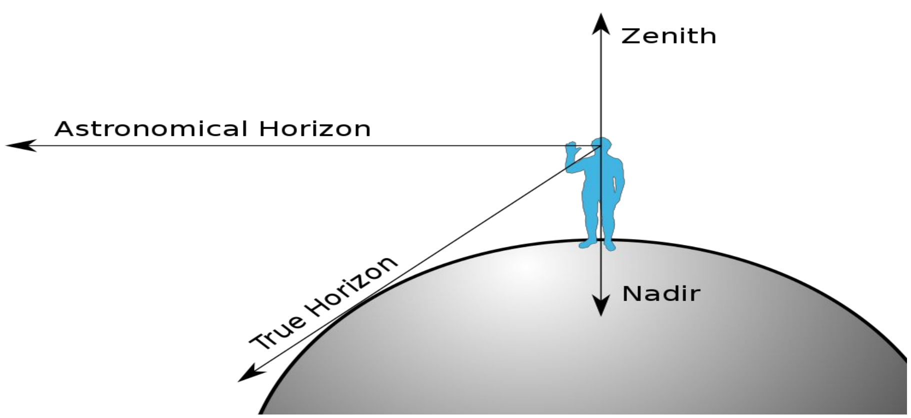
DAY 1+n

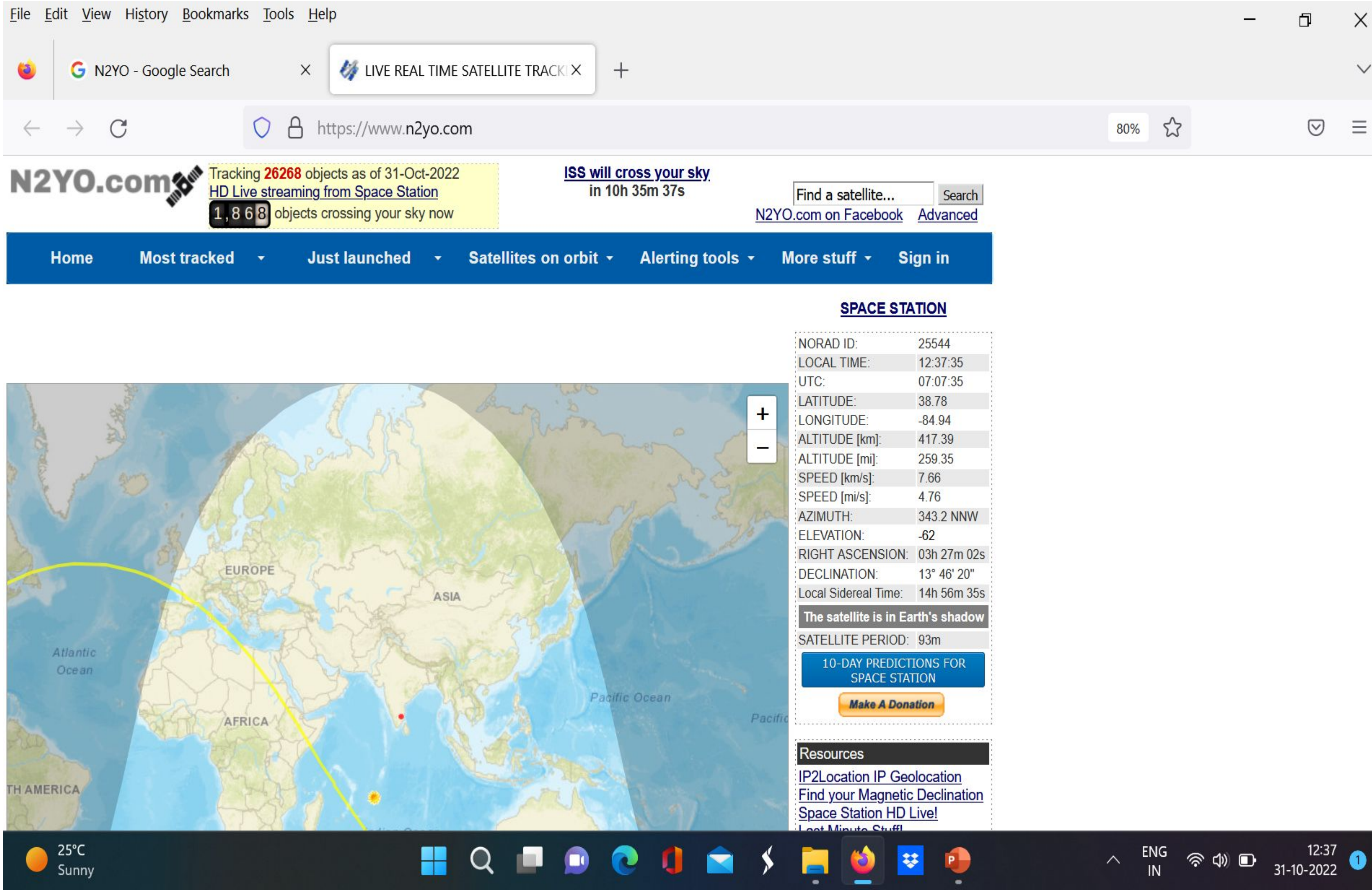


Nadir, ground track and zenith: Nadir is the point of interception on the surface of the Earth of the radial line between the center of the Earth and the satellite. This is the point of shortest distance from the satellite to the earth's surface.

Any point just opposite to the nadir, above the satellite is called zenith.

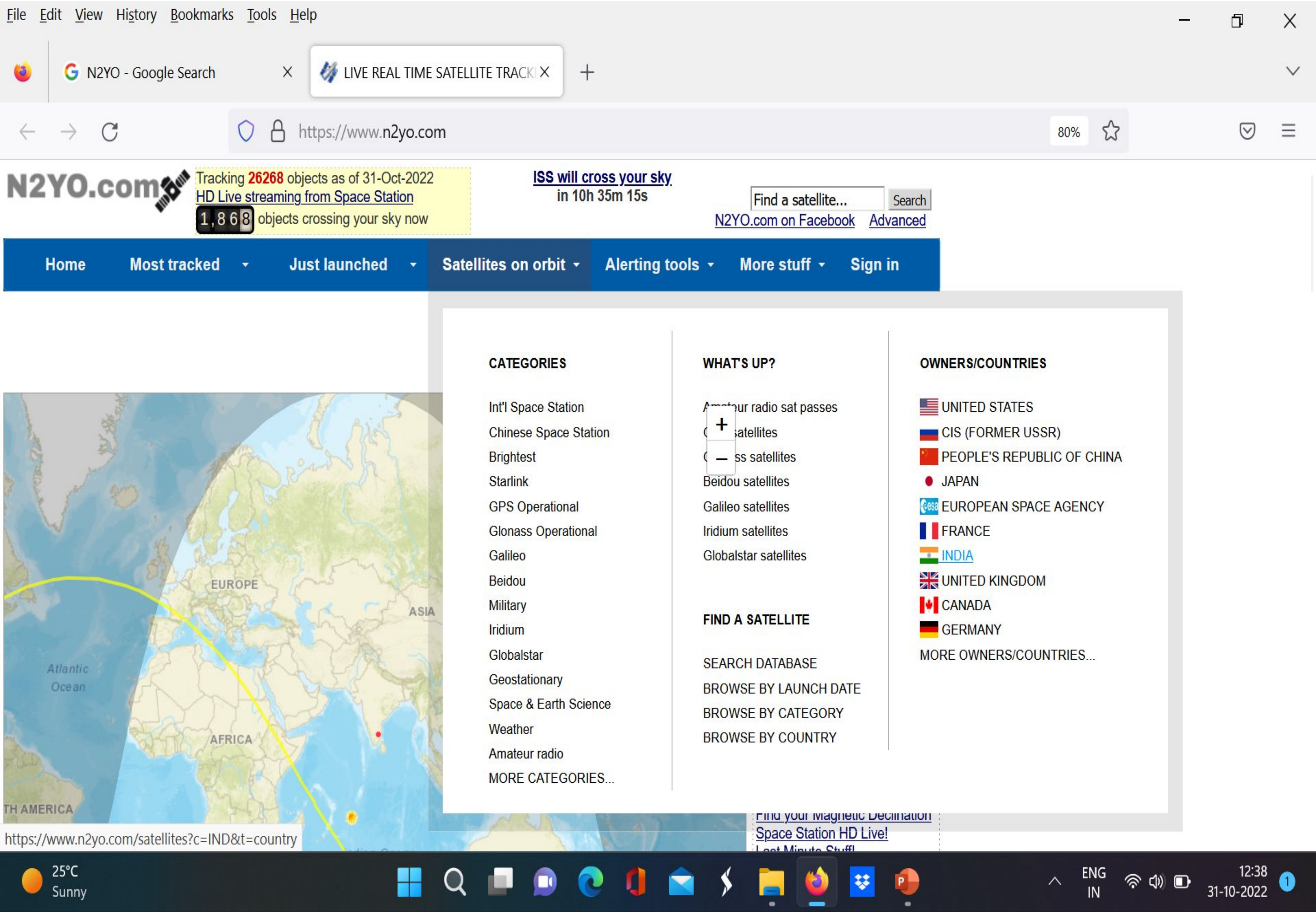
The circle on the earth's surface described by the nadir point as the satellite revolves is called the ground track. In other words, it is the projection of the satellites orbit on the ground surface.





https://www.n2yo.com/

Cartosat 2A	28 April 2008	PSLV-C9	In Service
IMS 1	28 April 2008	PSLV-C9	Mission Completed
RISAT-2	20 April 2009	PSLV-C12	In Service
Oceansat-2	23 September 2009	PSLV-C14	In Service
Cartosat-2B	12 July 2010	PSLV-C15	In Service
Resourcesat-2	20 April 2011	PSLV-C16	In Service
Megha-Tropiques	12 October 2011	PSLV-C18	Mission Completed
RISAT-1	26 April 2012	PSLV-C19	Mission Completed
SARAL	25 Feb 2013	PSLV-C20	In Service
Cartosat-2C	22 June 2016	PSLV-C34	In Service
ScatSat-1	26 September 2016	PSLV-C35	In Service
RESOURCESAT-2A	07 Dec 2016	PSLV-C36	In Service
Cartosat-2D	15 Feb 2017	PSLV-C37	In Service
Cartosat-2E	23 June 2017	PSLV-C38	In Service
Cartosat-2F	12 Jan 2018	PSLV-C40	In Service
RISAT-2B	22 May 2019	PSLV-C46	In Service
Cartosat-3	27 Nov 2019	PSLV-C47	In Service
RISAT-2BR1	11 Dec 2019	PSLV-C48	In Service
EOS-1 (RISAT-2BR2)	07 Nov 2020	PSLV-C49	In Service
EOS-3 (GISAT-1)	12 Aug 2021	GSLV-F10	Crashed, due to launch failure of GSLV
EOS-4 (RISAT-1A)	14 Feb 2022	PSLV-C52	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N2YO.com
Tracking 26268 objects as of 31-Oct-2022
HD Live streaming from Space Station
1,868 objects crossing your sky now
ISS will cross your sky
in 10h 35m 15s
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Just launched
Satellites on orbit
Alerting tools
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CATEGORIES
Int'l Space Station
Chinese Space Station
Brightest
Starlink
GPS Operational
Glonass Operational
Galileo
Beidou
Military
Iridium
Globalstar
Geostationary
Space & Earth Science
Weather
Amateur radio
MORE CATEGORIES...
WHAT'S UP?
Beidou satellites
Galileo satellites
Iridium satellites
Globalstar satellites
FIND A SATELLITE
SEARCH DATABASE
BROWSE BY LAUNCH DATE
BROWSE BY CATEGORY
BROWSE BY COUNTRY
OWNERS/COUNTRIES
UNITED STATES
CIS (FORMER USSR)
PEOPLE'S REPUBLIC OF CHINA
JAPAN
EUROPEAN SPACE AGENCY
FRANCE
INDIA
UNITED KINGDOM
CANADA
GERMANY
MORE OWNERS/COUNTRIES...
EUROPE
ASIA
Atlantic
Ocean
AFRICA
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25°C
Sunny
ENG
IN
12:38
31-10-2022

SATELLITES BY COUNTRIES AND ORGANIZATIONS

INDIA

The table is sortable. Please click on the header for ascending/descending sorting.

Name	NORAD ID	Int'l Code	Launch date	Period [minutes]	Action
CMS-02	52903	2022-067A	June 22, 2022	1436.1	TRACK IT
SHAKUNTALA	52173	2022-033S	April 1, 2022	94.3	TRACK IT
INS-2TD	51658	2022-013C	February 14, 2022	95	TRACK IT
EOS-4	51656	2022-013A	February 14, 2022	95.2	TRACK IT
SDSAT	47721	2021-015W	February 28, 2021	94	TRACK IT
SINE	47702	2021-015D	February 28, 2021	94.1	TRACK IT
CMS-01	47256	2020-099A	December 17, 2020	1436.1	TRACK IT
RISAT-2BR2	46905	2020-081A	November 7, 2020	96.1	TRACK IT
GSAT 30	45026	2020-005A	January 16, 2020	1436.1	TRACK IT
RISAT-2BR1	44857	2019-089F	December 11, 2019	96.1	TRACK IT
CARTOSAT 3	44804	2019-081A	November 27, 2019	94.8	TRACK IT
RISAT 2B	44233	2019-028A	May 22, 2019	96.1	TRACK IT
EMISAT	44078	2019-018A	April 1, 2019	99.7	TRACK IT
GSAT 31	44035	2019-007B	February 5, 2019	1436.1	TRACK IT

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Tracking 22376 objects as of 23-Feb-2021
HD Live streaming from Space Station
2,54 objects crossing your sky now

ISS will cross your sky
in 7h 9m 34s

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SATELLITES BY COUNTRIES AND ORGANIZATIONS

INDIA

The table is sortable. Please click on the header for ascending/descending sorting.

Name	NORAD ID	Int'l Code	Launch date	Period [minutes]	Action
CMS-01	47256	2020-099A	December 17, 2020	1436.1	TRACK IT
RISAT-2BR2	46905	2020-081A	November 7, 2020	96.1	TRACK IT
GSAT 30	45026	2020-005A	January 16, 2020	1436.1	TRACK IT
RISAT-2BR1	44857	2019-089F	December 11, 2019	96	TRACK IT
CARTOSAT 3	44804	2019-081A	November 27, 2019	94.8	TRACK IT
RISAT 2B	44233	2019-028A	May 22, 2019	96.1	TRACK IT
EMISAT	44078	2019-018A	April 1, 2019	99.7	TRACK IT
GSAT 31	44035	2019-007B	February 5, 2019	1436.1	TRACK IT
KALAMSAT-V2/PSLV	43948	2019-006B	January 24, 2019	93.4	TRACK IT
GSAT 7A	43864	2018-104R	December 16, 2018	1436.1	TRACK IT
GSAT 11	43824	2018-100B	December 4, 2018	1436.1	TRACK IT
HYSIS	43719	2018-096A	November 29, 2018	97.4	TRACK IT
GSAT 29	43698	2018-089A	November 14, 2018	1436.1	TRACK IT

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2,585 objects crossing your sky now

ISS will cross your sky
in 7h 14m 27s

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SPACE STATION

NORAD ID:	25544
LOCAL TIME:	20:26:42
UTC:	14:56:42
LATITUDE:	38.81
LONGITUDE:	-52.75
ALTITUDE [km]:	422.52
ALTITUDE [mi]:	262.54
SPEED [km/s]:	7.66
SPEED [mi/s]:	4.76
AZIMUTH:	319.8 NW
ELEVATION:	-48.4
RIGHT ASCENSION:	19h 44m 09s
DECLINATION:	10° 01' 09"
Local Sidereal Time:	06h 02m 37s

The satellite is in day light

SATELLITE PERIOD:	93m

10-DAY PREDICTIONS FOR SPACE STATION

Make A Donation

Resources

IP2Location IP Geolocation
Find your Magnetic Declination
Space Station HD Live!
Last Minute Stuff!

Your current location

Your IP address:	117.196.103.202
Latitude:	23.03333°
Longitude:	72.61667°

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Tracking **19840** objects as of 4-Sep-2019
HD Live streaming from Space Station
2,262 objects crossing your sky now

ISS will cross your sky
in 1h 14m 25s

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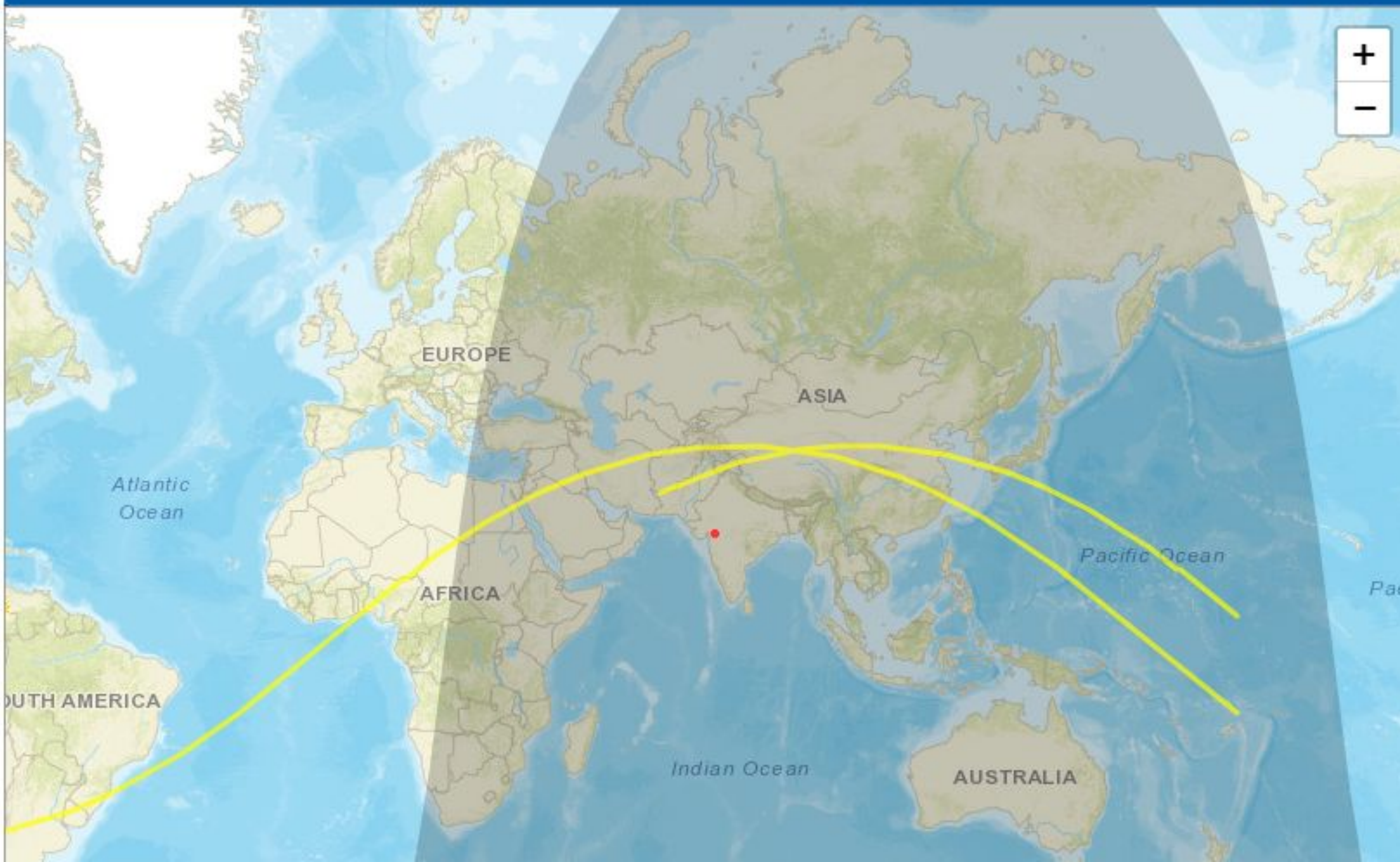
Home | **Most tracked** | **Just launched** | **Satellites on orbit** | **Alerting tools** | **More stuff** | **Sig**



RISAT 2B

NORAD ID:	44
LOCAL TIME:	22
UTC:	16
LATITUDE:	-3
LONGITUDE:	-1
ALTITUDE [km]:	56
ALTITUDE [mi]:	35
SPEED [km/s]:	7.
SPEED [mi/s]:	4.
AZIMUTH:	12
ELEVATION:	-8
RIGHT ASCENSION:	07
DECLINATION:	-2
Local Sidereal Time:	20

The satellite is in da

SATELLITE PERIOD:	96

10-DAY PREDICTION
RISAT 2B

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WHERE ARE THE N2YO.COM VISI ×

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Like 20K

Tracking **19840** objects as of 4-Sep-2019
HD Live streaming from Space Station
0 objects crossing your sky now

ISS will cross your sky
in 1h 18m 27s

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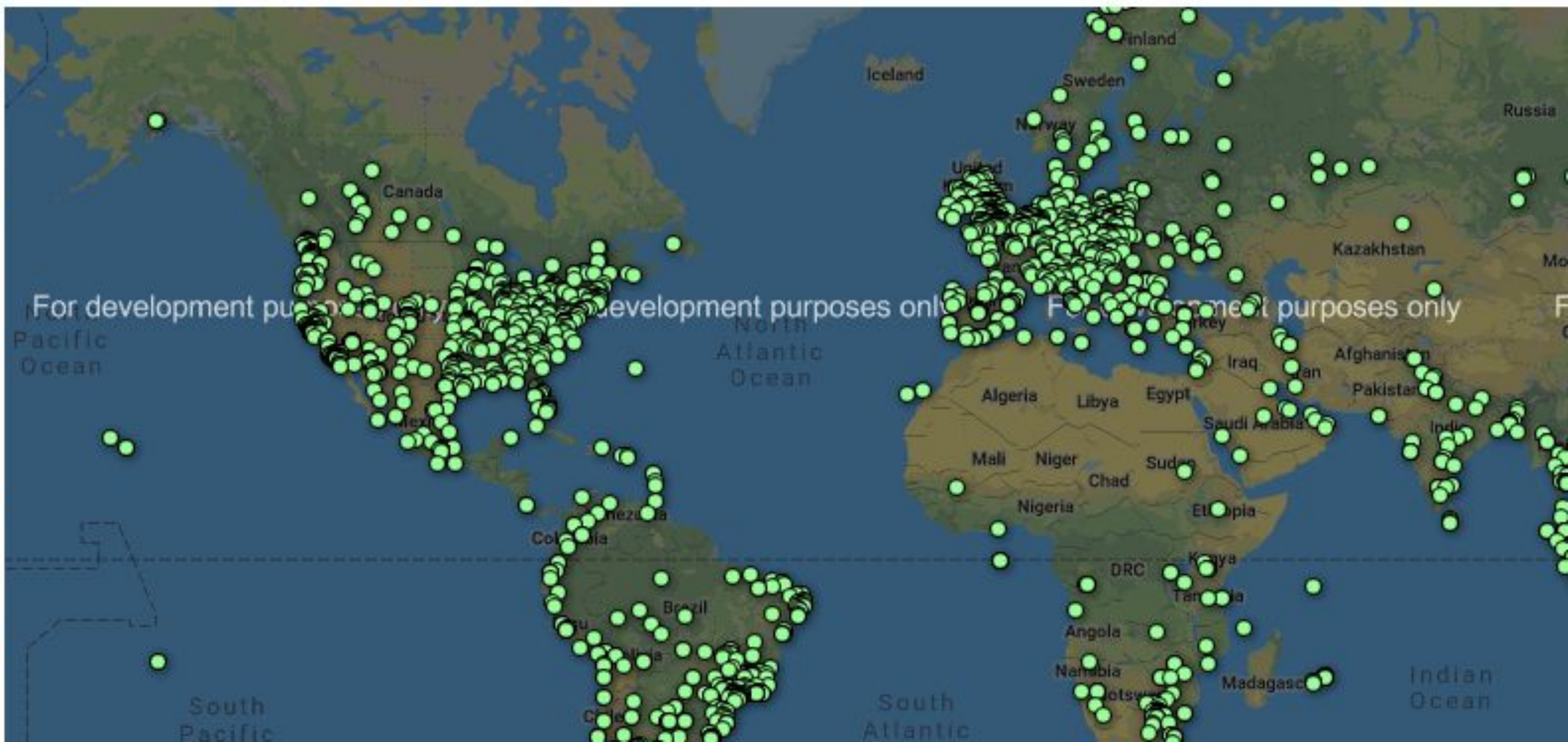
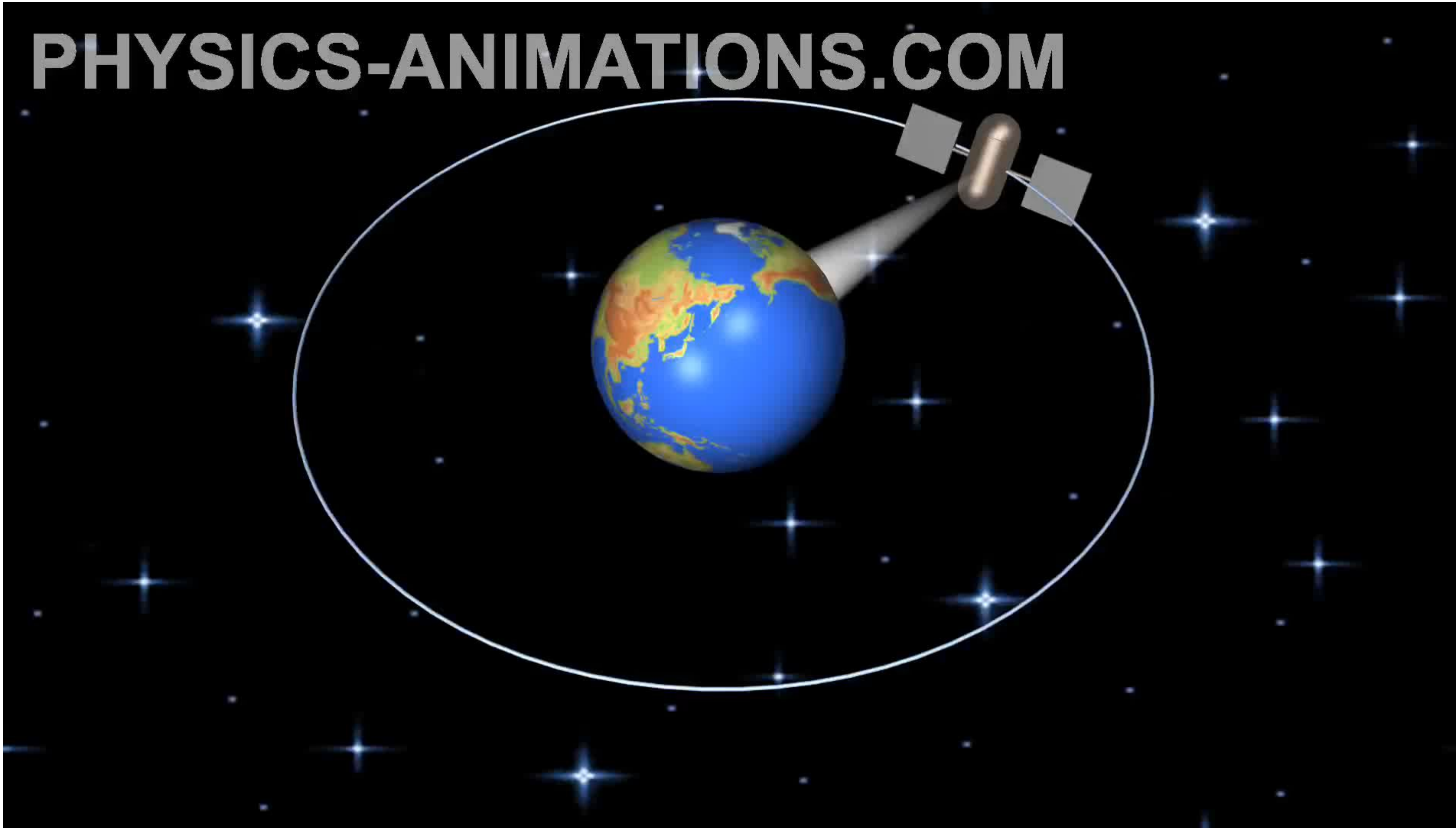
- Live Satellite Images
- Track Cell Phone Location
- Live Satellite Maps
- Satellite Tracking
- Watch Live Satellite TV
- Track A Cell Phone
- Mobile Location

WHERE ARE THE N2YO.COM VISITORS COMING FROM?

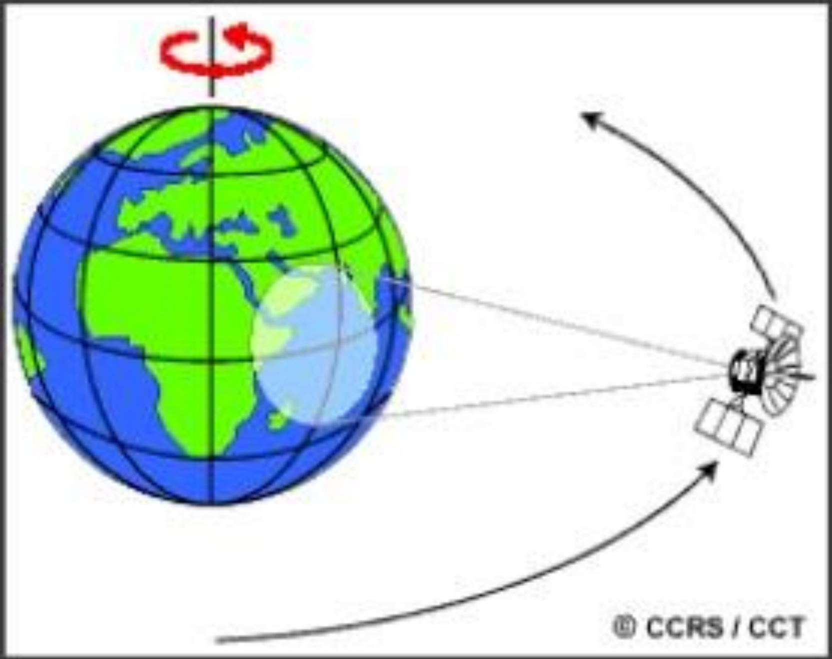
You could zoom in and click on the green dots to see what individual cities are. The geolocation information has been collect the **past 3 days**.





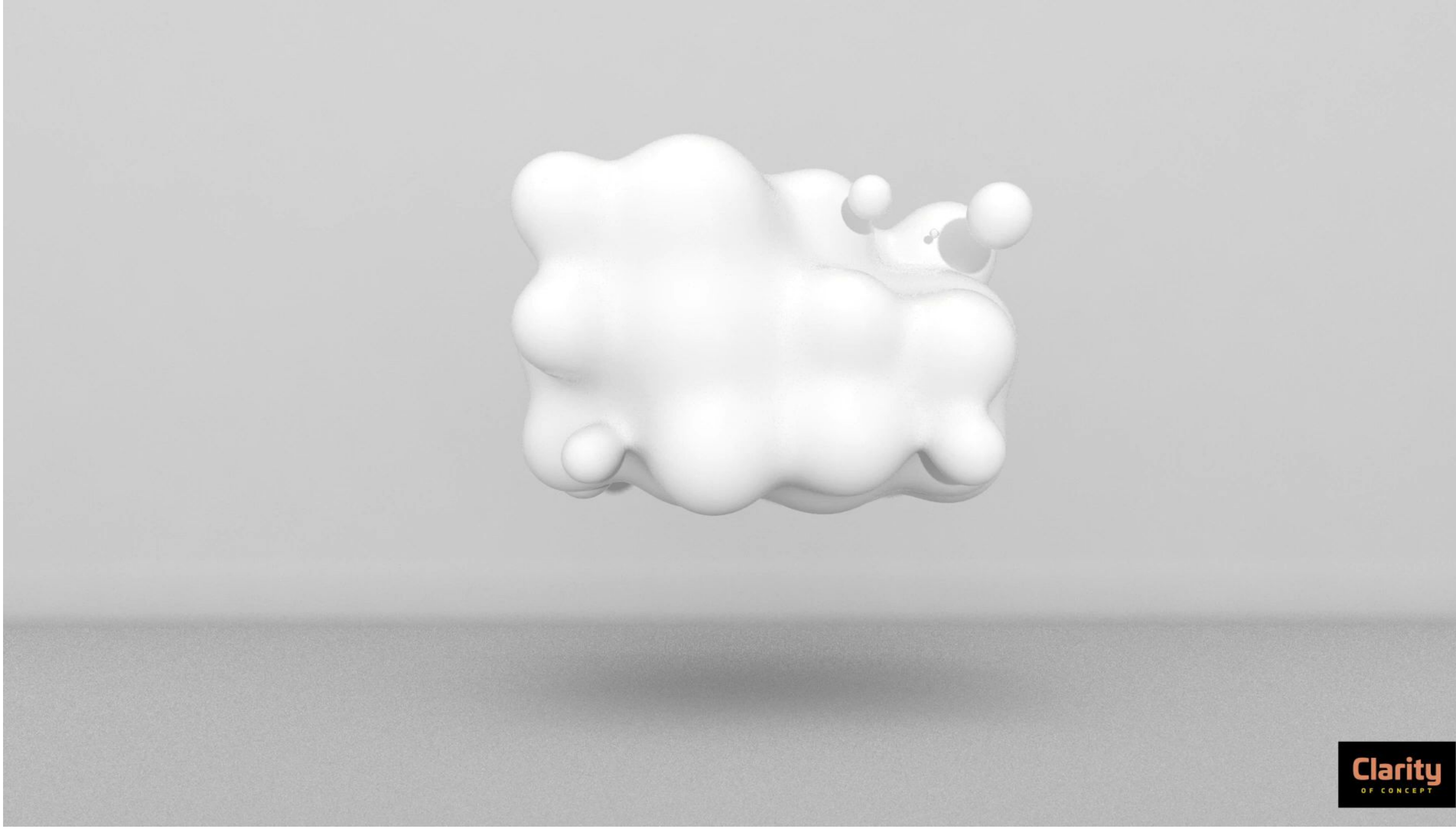
https://www.youtube.com/watch?v=sj7zsGkpZxg

Geostationary Satellites



- In high altitude orbit (~35,800 km)
- Orbital period of satellite matches rotational speed of Earth
- Continuously observe same area on Earth
- Very high temporal resolution (minutes – hours)
- Usually used to monitor meteorological conditions and severe storm development, including hurricanes, tornadoes, and floods

Graveyard orbit 300 km above GEO: About 22000 objects



https://www.youtube.com/watch?v=H-gaSnxP60A

Type of Orbits

Geosynchronous Orbits. A geosynchronous orbit (GEO) is a circular, low orbit about Earth having a period of 23 hours 56 minutes 4 seconds--that is, the same amount of time it takes for the Earth to turn, so as the Earth spins, the satellite moves in time with it. Geosynchronous means "in time with the Earth." A spacecraft in geosynchronous stays over the same line of longitude. (A line of longitude marks one slice of the world from north to south pole.) Often a satellite in geosynchronous orbit stays above the same spot on Earth. When it does, it is called geostationary. This orbit is ideal for certain kinds of communication satellites, or meteorological (weather) satellites that have a job to do over one part of the world.

Polar Orbits. Polar orbits are useful for spacecraft that carry out mapping or surveillance operations. A satellite in polar orbit goes around the Earth from pole to pole. The planet spins underneath it as the satellite goes from north to south. This gives the spacecraft access to virtually every point on the surface. The Magellan spacecraft used a nearly-polar orbit at Venus. When the planet rotated once, all 360 degrees longitude had been exposed to Magellan's surveillance.

Suns-Synchronous Orbits. orbit can be designed so that the orbit changes slowly in time with the planet moving around the Sun, and in time with the planet's rotation so that the spacecraft is always at the same angle to the Sun. This is called a Sun-synchronous orbit. On Earth, this would work out so that the orbit always passes a low point at the same local time every day. This can be useful if instruments on board depend on a certain angle of solar illumination on the surface

Question Bank:

1. What do you mean by polar and geosynchronous orbit?

2. What do you mean by orbit of a satellite ?

2. Explain the following terms in orbital remote sensing:

- **Orbital period**
- **Ascending and descending orbit**
- **Orbit inclination**
- **Sun Synchronous satellite**

3. Explain difference between drone, aircraft and satellite remote sensing