Remote Sensing 1: GEOG 4/585

Lecture 3.2.

Platforms

Johnny Ryan (he/him/his)
jryan4@uoregon.edu
Office hours: Monday 15:00-17:00
in 165 Condon Hall

Required reading:
Principles of Remote Sensing pp 86-97
Principles of Remote Sensing pp 106-160

Overview

- Orbits
  - Geostationary orbits
  - Polar orbits
  - Sun-synchronous orbits
- Orbital debris
- Ground systems

Satellite orbits

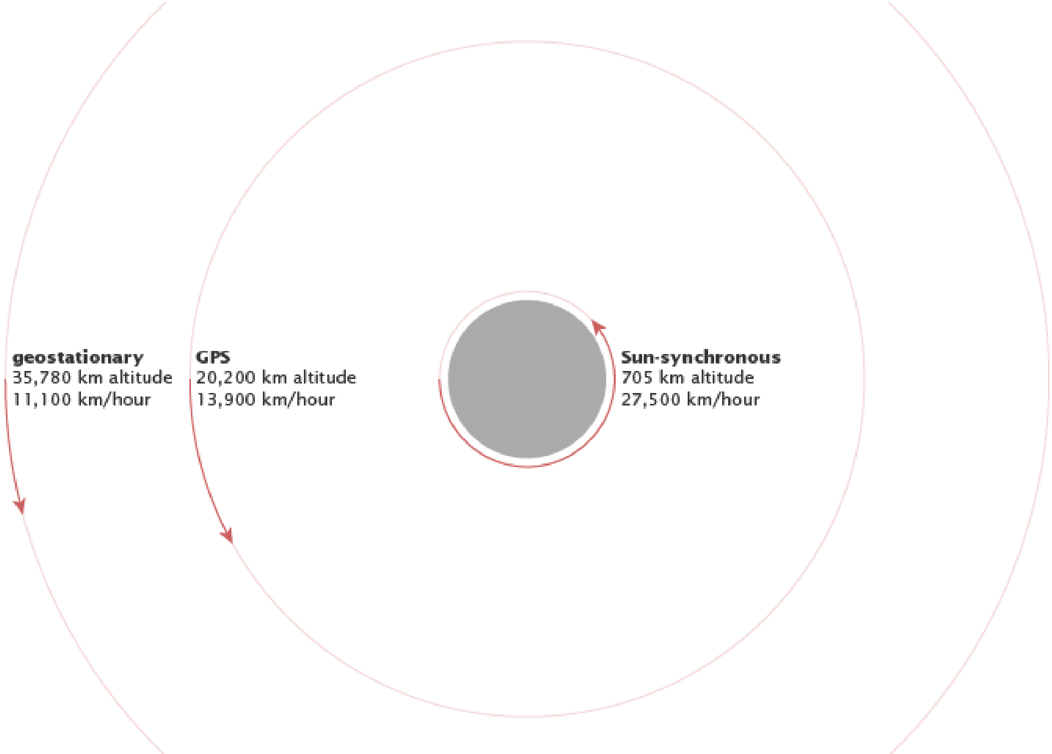
- Orbit: circular or elliptical path described by the satellite when it moves around Earth

- Important orbit characteristics:
  - Altitude
  - Period
  - Inclination angle
  - Regime

Spacecraft properties	
Spacecraft	Landsat 8
Spacecraft type	LEOStar
Bus	LEOStar-3
Manufacturer	Orbital Sciences (prime) Ball Aerospace (OLI) NASA GSFC (TIRS)
Launch mass	2,623 kg (5,783 lb)
Dry mass	1,512 kg (3,333 lb)
Start of mission	
Launch date	11 February 2013, 18:02:00 UTC
Rocket	Atlas V 401 (AV-035)
Launch site	Vandenberg, SLC-3E
Contractor	United Launch Alliance
Entered service	30 May 2013
Orbital parameters	
Reference system	Geocentric orbit[1]
Regime	Sun-synchronous orbit
Altitude	705 km
Inclination	98.22°
Period	98.8 minutes

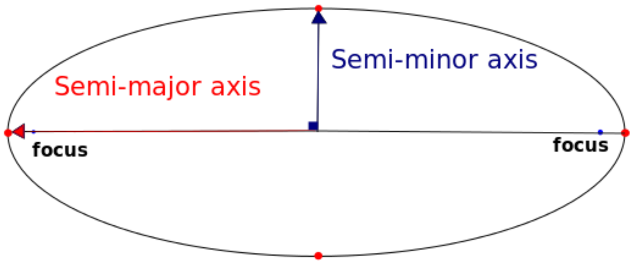
Orbital altitude and period

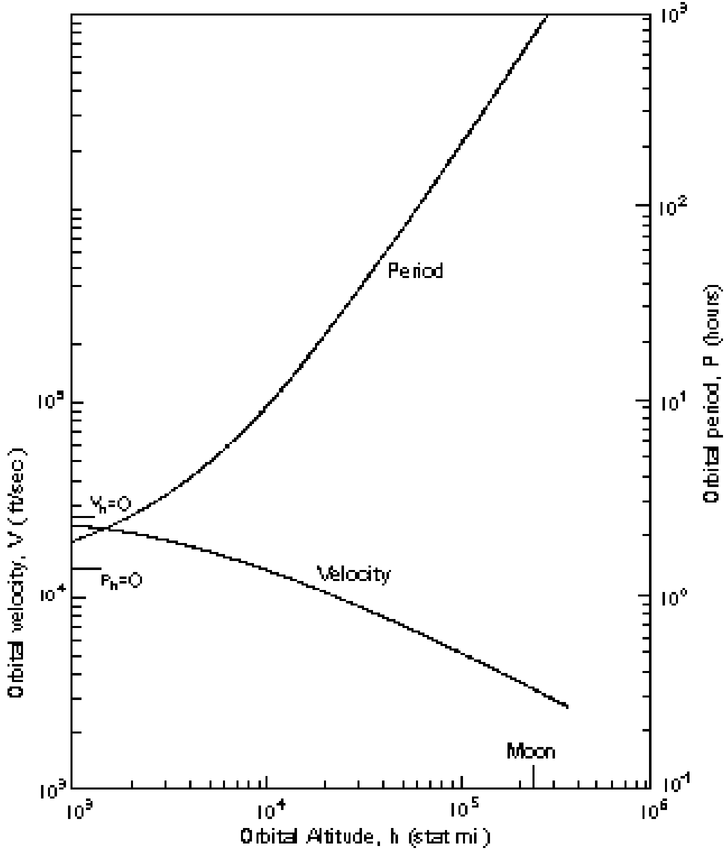
- Altitude: height above the average surface of the Earth's oceans
- Period: time it takes to orbit Earth



Kepler's Third Law

- *"the square of a planet's <u>orbital period</u> is proportional tc the cube of the <u>length of the</u> <u>semi-major axis</u> of its orbit'*





$$T^2 / R^3 = (4 * \pi^2) / (G * M_{Earth})$$

T = orbit period (s)

R = satellite radius (m)

G = gravitational constant (6.673×10^{-11} N m^2/kg^2)

M_{Earth} = mass of Earth (5.98×10^{24} kg)

Kepler's Third Law

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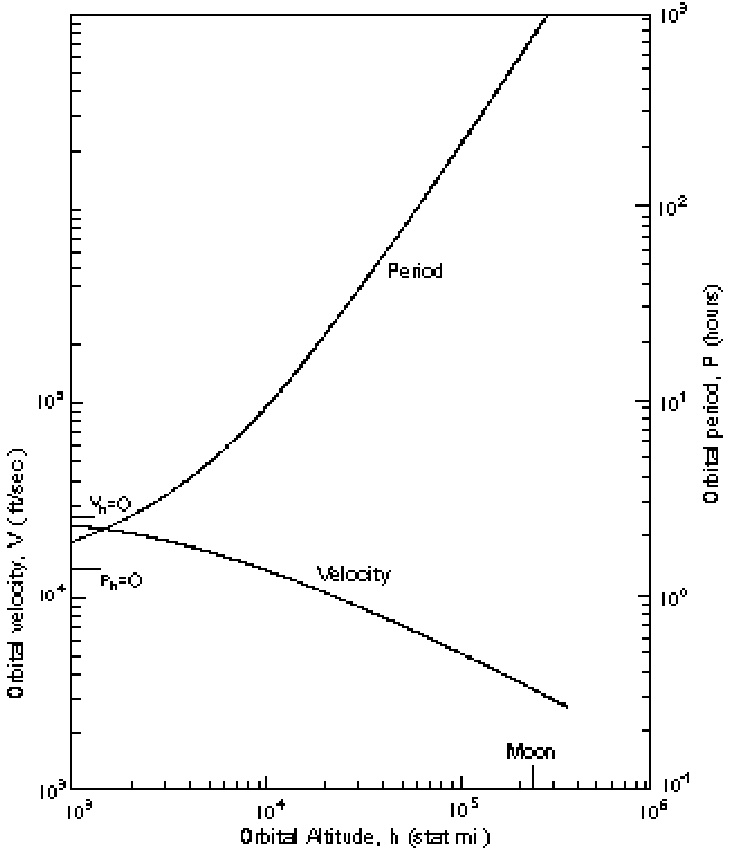
- A satellite closer to Earth will orbit faster with shorter period
- Period and speed only depend on radius of orbit and mass of Earth
- Period and speed do not depend on mass of satellite



Kepler's Third Law

$$T^2 / R^3 = (4 * \pi^2) / (G * M_{Earth})$$

T = ?

$R=R_{Earth}+R_{Sat} = 6.37 \times 10^6$ m + 7.05×10^5 = 7.075×10^6 m

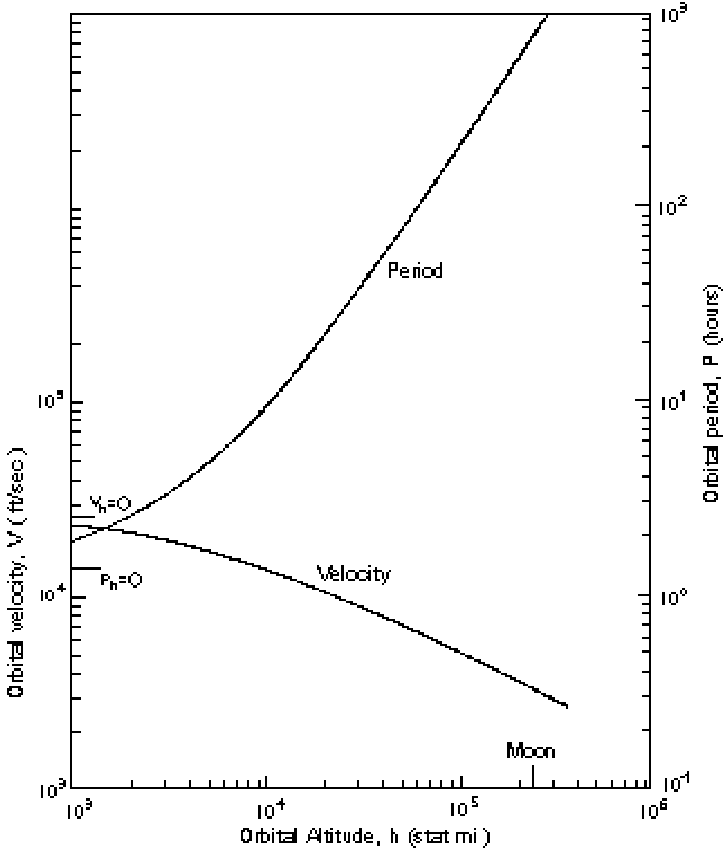
$G = 6.673 \times 10^{-11}$ N m²/kg²

$M_{Earth} = 5.98 \times 10^{24}$ kg

Landsat 8 orbit period

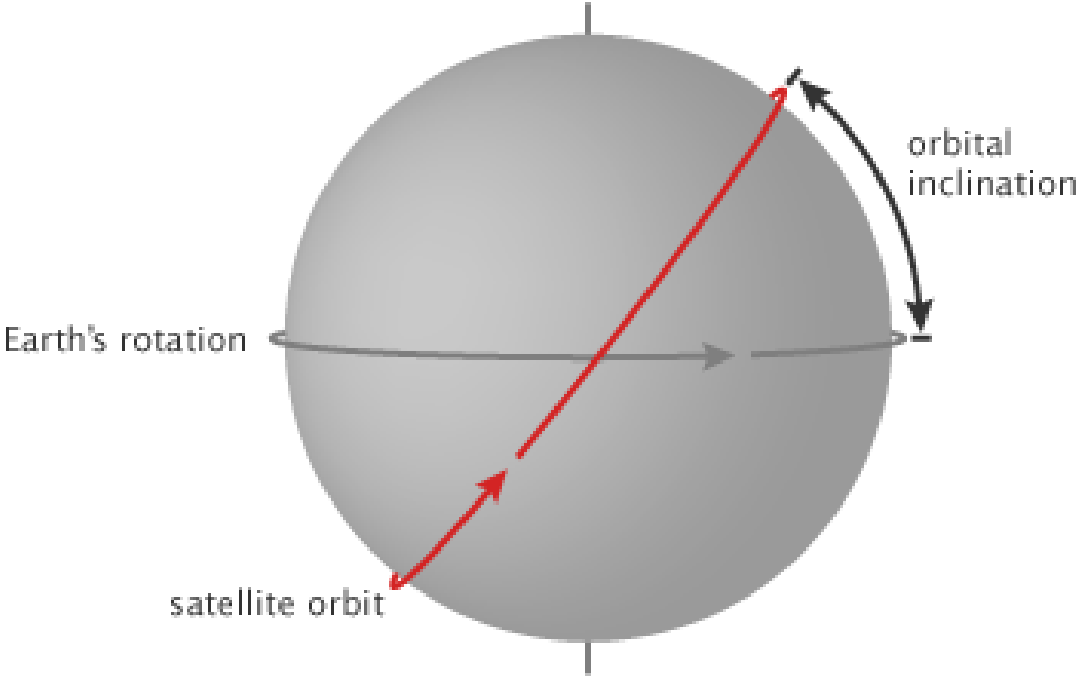
$T = SQRT[(4 * (3.1415)^2 * (7.075 \times 10^6\ m)^3) / ((6.673 \times 10^{-11}\ N\ m^2/kg^2) * (5.98 \times 10^{24}\ kg))]$

T = 5919 s = 1.64 hrs = 98 minutes



Orbital inclination

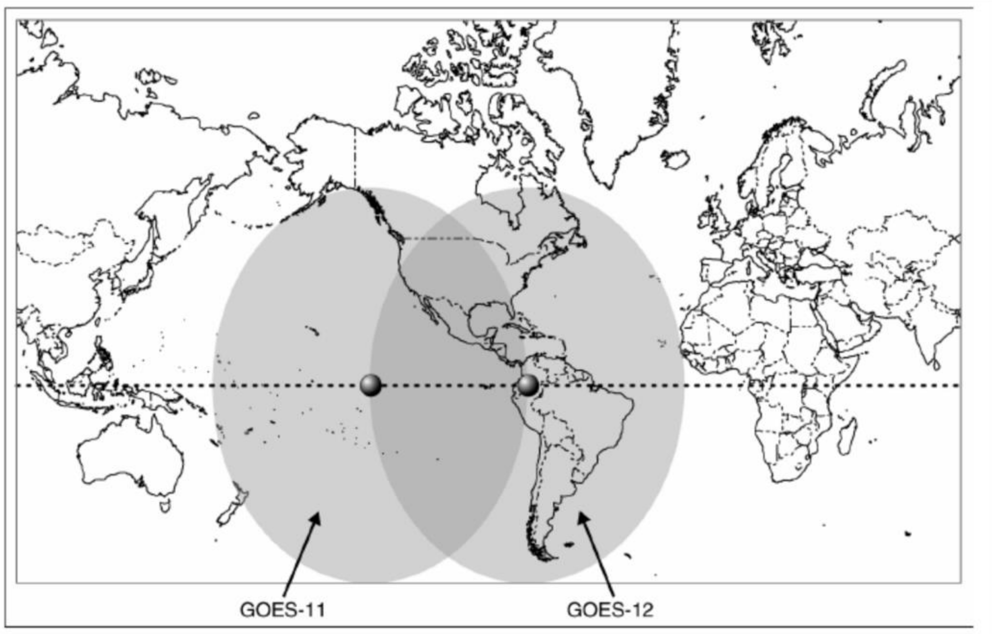
- Angle between the plane of an orbit and the equator



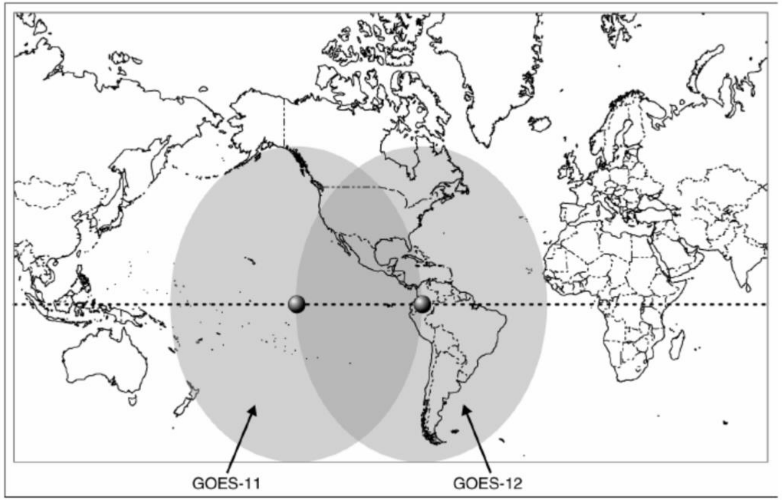
Geostationary orbits

- Altitude ~36,000 km (“high Earth orbit”)
- Period = 23 hours 56 minutes
- Inclination = 0 degrees

- Satellite is therefore stationary with respe to a location on Earth



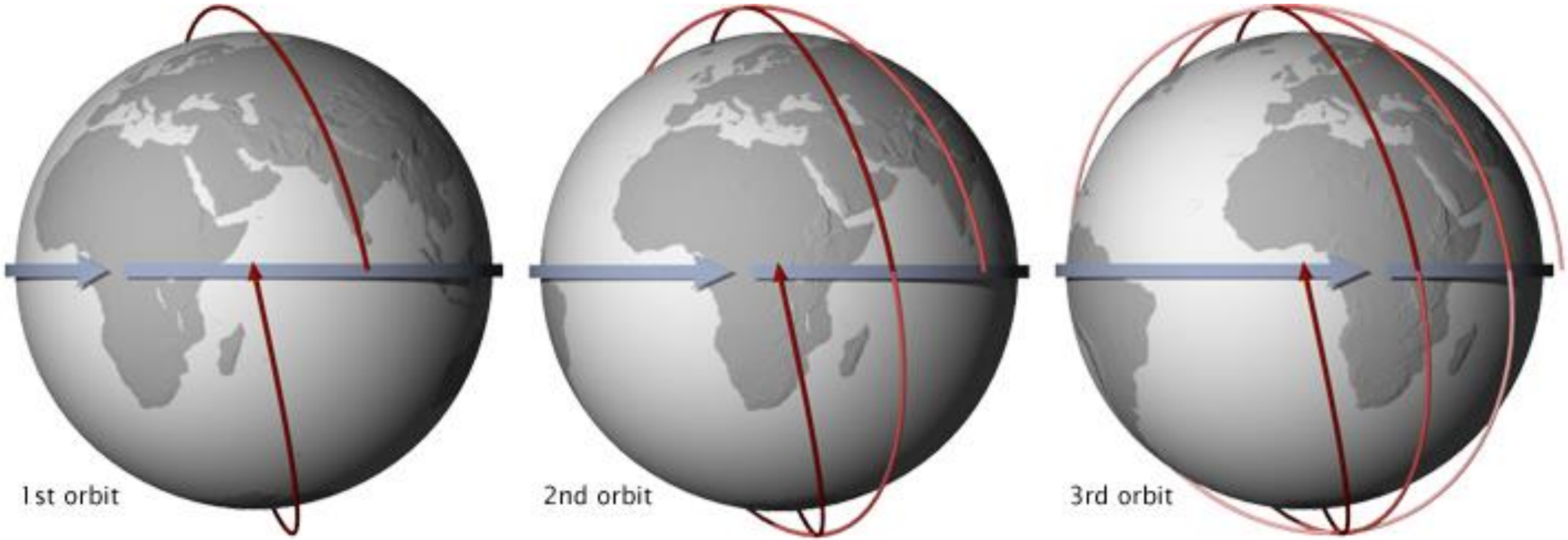
NOAA's Geostationary Operational Environment Satellite (GOES)



- Communications satellites
- Weather satellites

Polar orbits

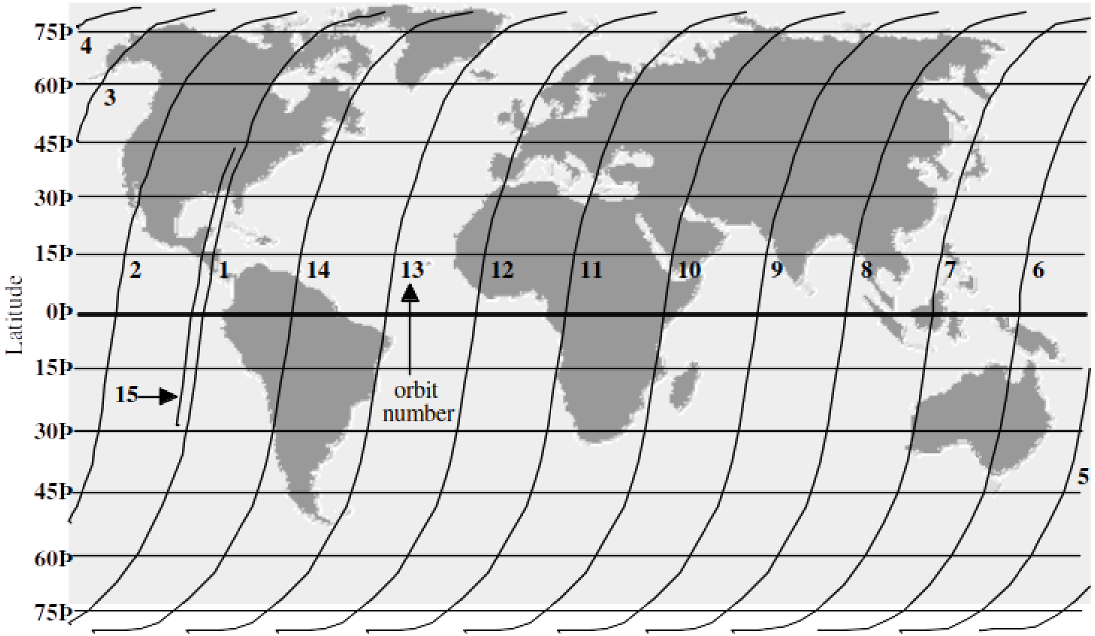
- High inclination angles of between 80-100 degrees
- Altitude 600-1000 km (“low Earth orbit”)
- Often sun-synchronous (assuring consistent illumination conditions)



Sun-synchronous orbit

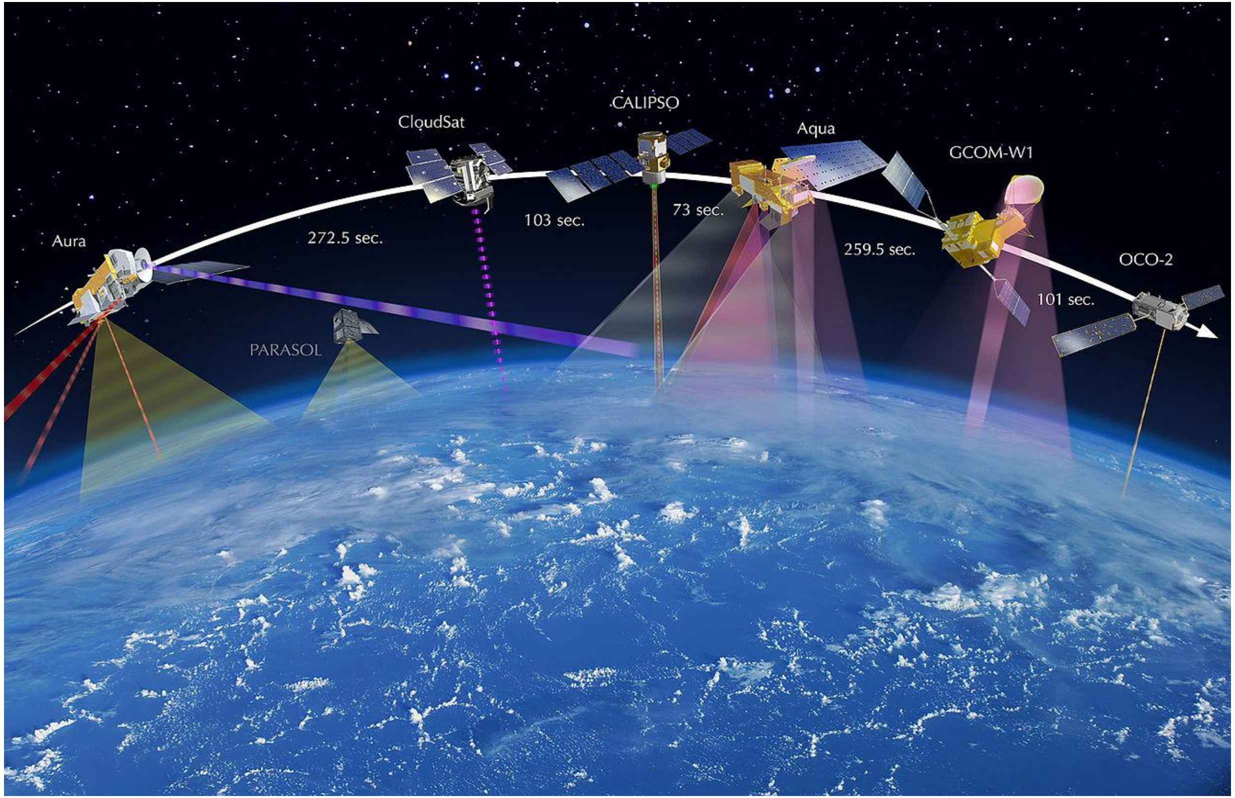
Polar orbit: Landsat program

- Orbit: 705 km, sun-synchronous
- Inclination: 98 degrees ~10 a.m. equatorial crossing time



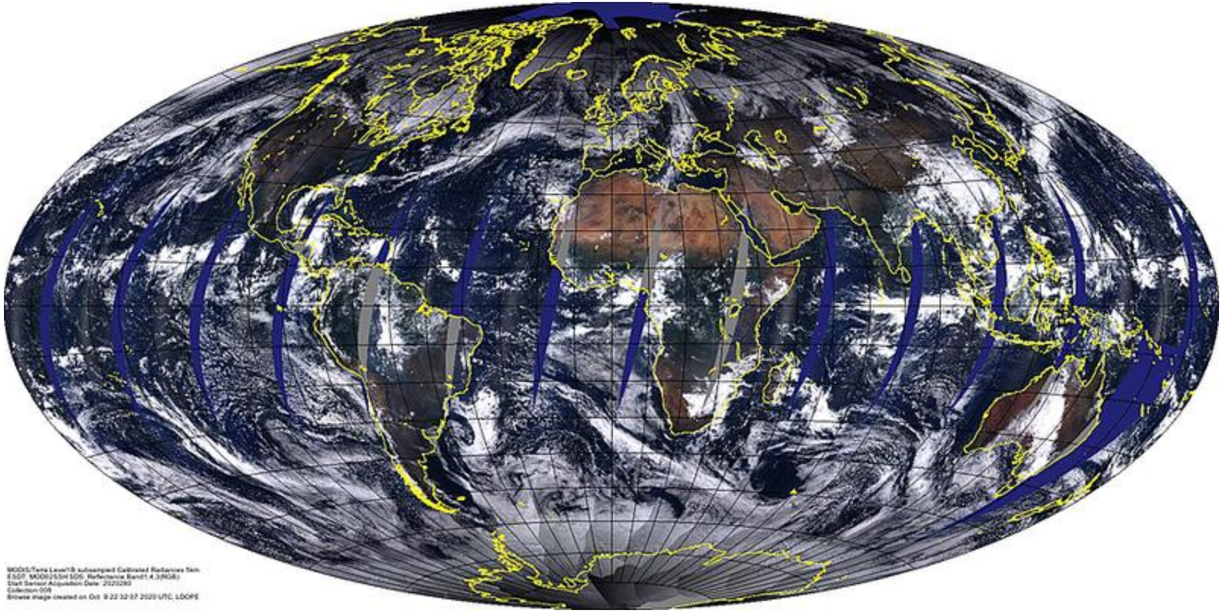
Polar orbit: A-Train

- Orbit: 705 km, sun-synchronous
- Inclination: 98 degrees ~1:30 pm equatorial crossing time



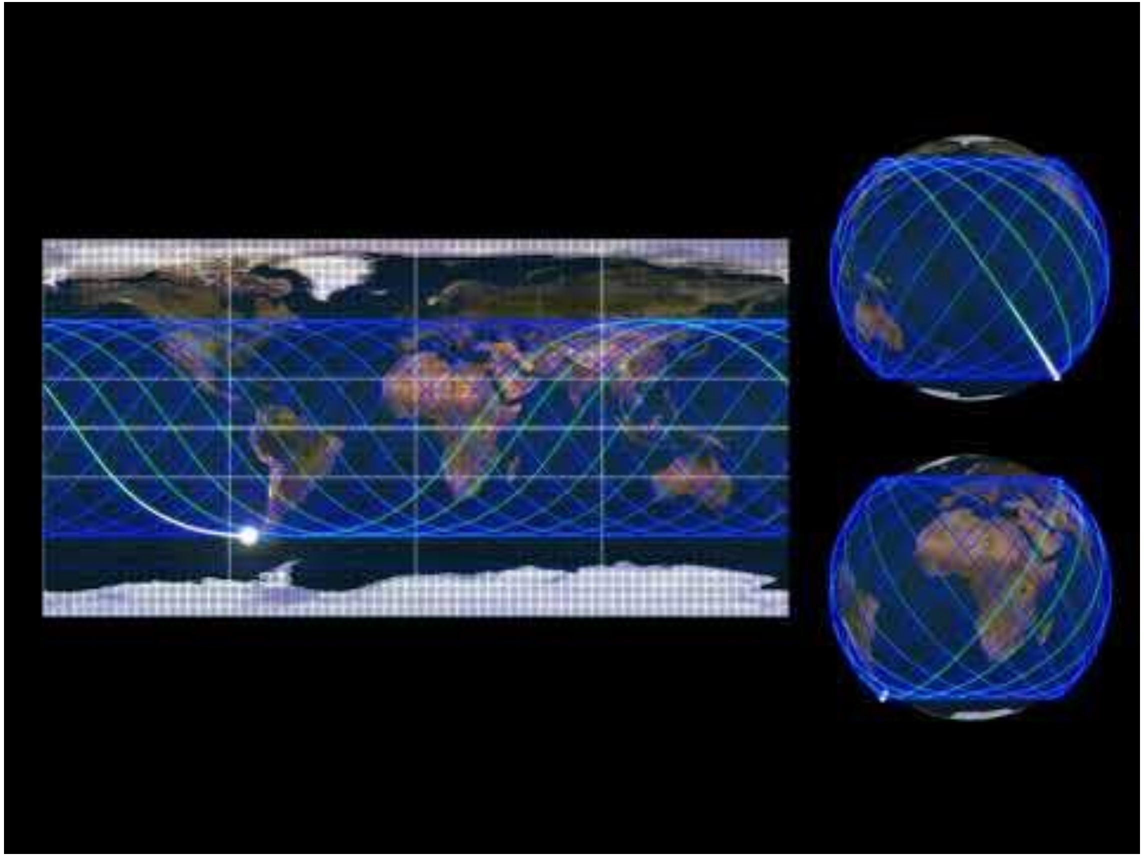
Polar orbit: Terra and Aqua (MODIS)

- Onboard NASA’s EOS Aqua (launched 2002) and Terra (launched 1999) satellites
- Altitude: 705 km
- Inclinction: 98 degrees,
- Regime: sun-synchronous, 1:30 p.m. and 10:30 a.m. equatorial crossing time



Polar orbit: International Space Station

- Altitude: 370 - 460 km
- Inclination: 51.6 degrees
- Period: 93 minutes



Orbits and trade-offs

Geostationary

Advantages

- Always looking at same place over the Earth surface
- Can achieve very high temporal resolution, e.g. 15 minutes

Disadvantages

- 50x further from Earth than polar orbiting satellites
- Coarser spatial resolution

Polar

Advantages

- Higher spatial resolution (<m to few km), depending on instrument and swath width
- Global coverage due to combination of orbit path and rotation of Earth
- Consistent angle of sunlight
- If swath width is wide (2300 km), repeat time could be as short as 1 day e.g. MODIS

Disadvantages

- If swath width is narrow (185 km) repeat time is longer e.g. 16 days for Landsat

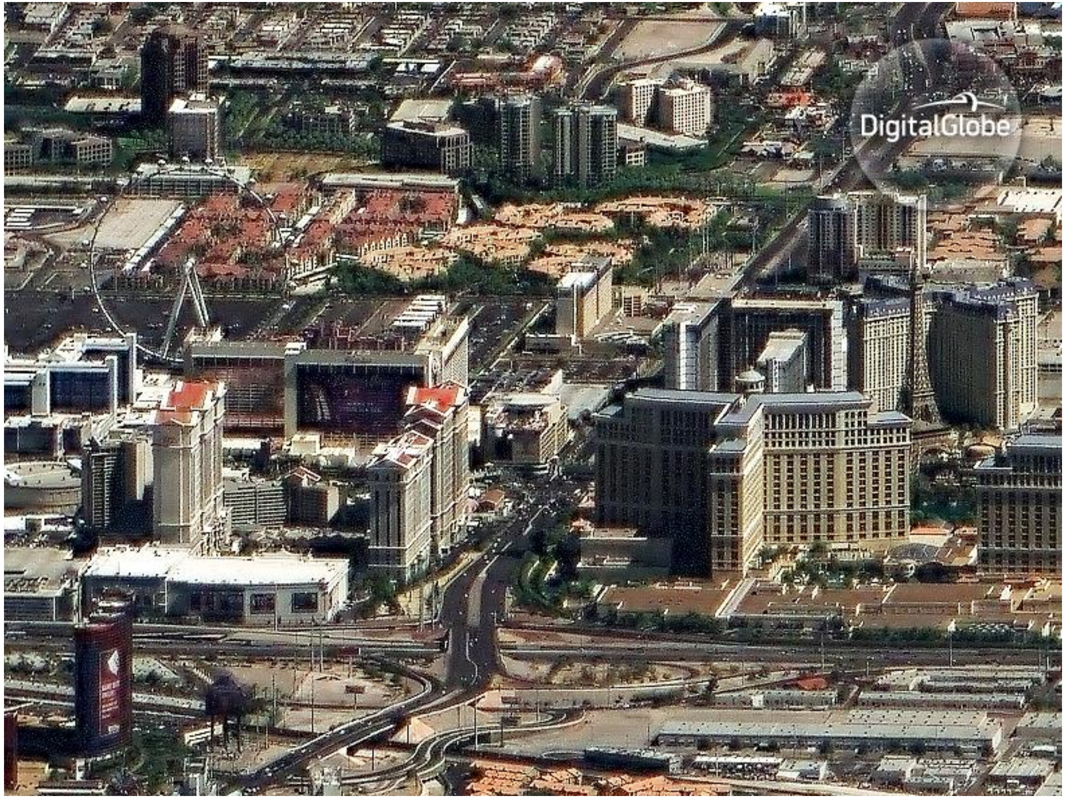
WorldView-4

Start of mission	
Launch date	11 November 2016, 18:30:33 UTC
Rocket	Atlas V 401 (AV-062)
Launch site	Vandenberg, SLC-3E
Contractor	United Launch Alliance
Entered service	26 November 2016 [4]
End of mission	
Disposal	Declared unrecoverable
Declared	7 January 2019
Orbital parameters	
Reference system	Geocentric orbit[5]
Regime	Sun-synchronous orbit[3]
Perigee altitude	609.95 km (379.01 mi)
Apogee altitude	613.28 km (381.07 mi)
Inclination	97.98°
Period	96.93 minutes
Repeat interval	3 days [6]
Main telescope	
Name	GeoEye Imaging System-2
Diameter	1.1 m (3 ft 7 in) [7]
Wavelengths	Panchromatic: 450-800 nm Multispectral: 450-920 nm [3]
Resolution	Panchromatic: 31 cm (12 in) Multispectral: 124 cm (49 in)

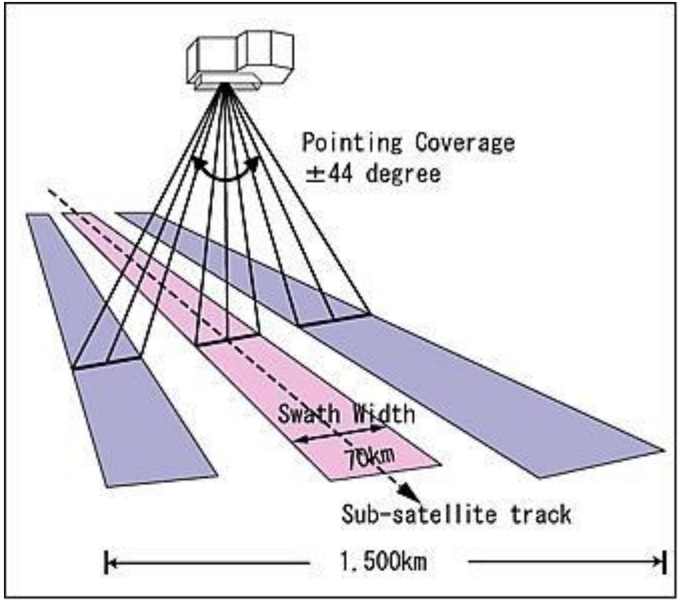
- Swath width: 13. 1km
- Spatial resolution: 0.31 m / pixel
- Sun-synchronous orbit at ~610 km

- Repeat interval: 3 days?!

Pointing capabilities



Las Vegas, NV



Landsat 9

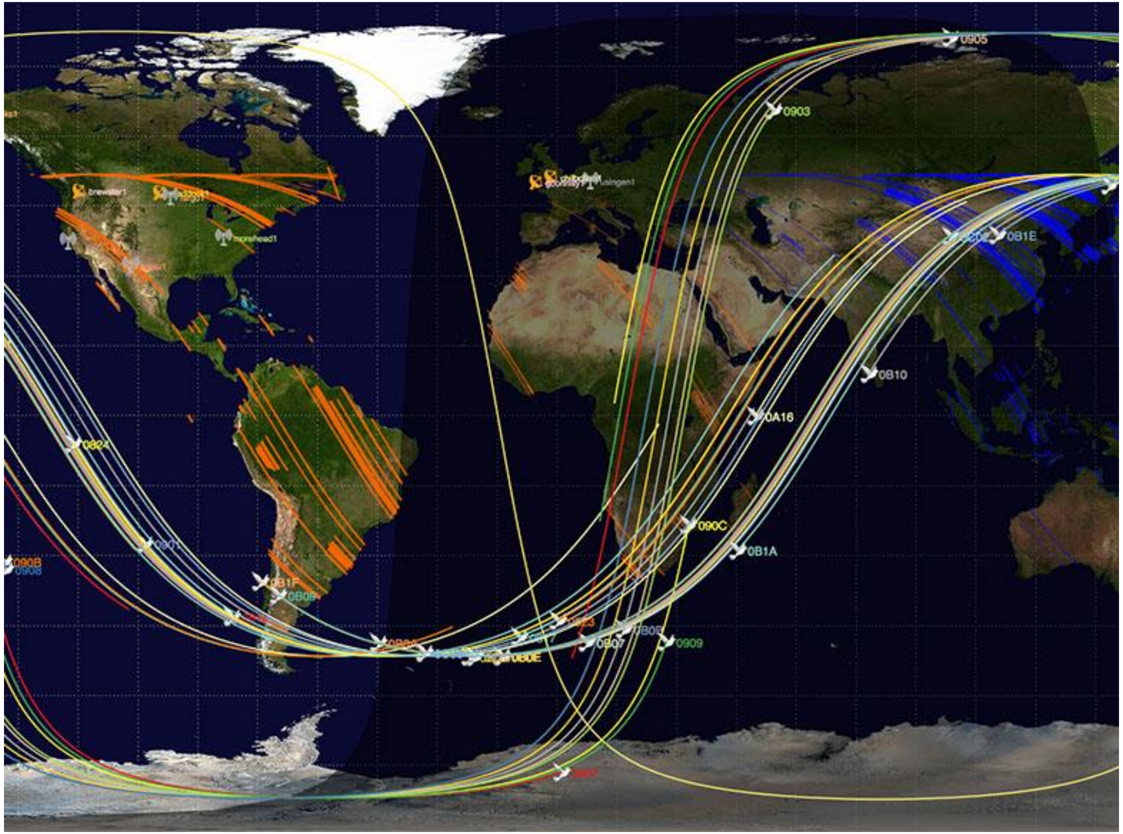
- Launched September 27, 2021

Landsat 9

Planet’s CubeSat constellation

	International Space Station Orbit	Sun Synchronous Orbit
Inclination	52°	98°
Expected Lifetime	1 year per satellite; constellation is replenished over time	2-3 years per satellite; constellation is replenished over time
Orbital Insertion Altitude	420km	475km (target altitude for future SSO launches
Equator Crossing Time	Varies	9:30-11:30am local solar time
Sensor Type	Bayer-masked CCD camera	Bayer-masked CCD camera
Spectral Bands	Red: 610-700nm Green: 500-590nm Blue: 420-530nm	Red: 610-700nm Green: 500-590nm Blue: 420-530nm
Ground Sampling Distance (Nadir)	2.7m - 3.2m	3.7m - 4.9m
Mission Continuity	Maintain up to 55 satellite constellation (continually replenishing/upgrading satellites)	Maintain 100-150 satellite constellation (continually replenishing/upgrading satellites)

Planet’s CubeSat constellation



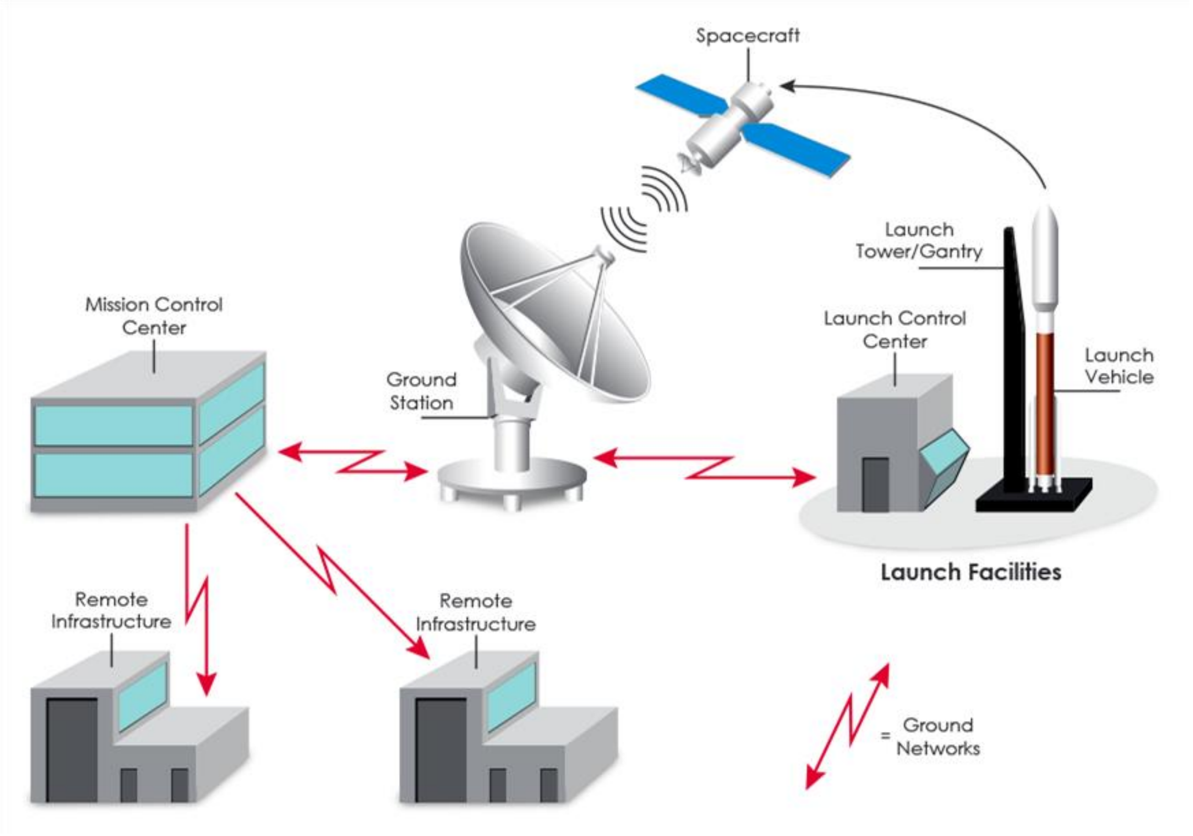
Orbital debris

- There are approximately 23,000 pieces of debris larger than a softball orbiting the Earth

- They travel at speeds up to 17,500 mph, fast enough to do serious damage a satellite or a spacecraft

- We now have a debris tracking program and maneuver satellites if there is a risk

Ground systems

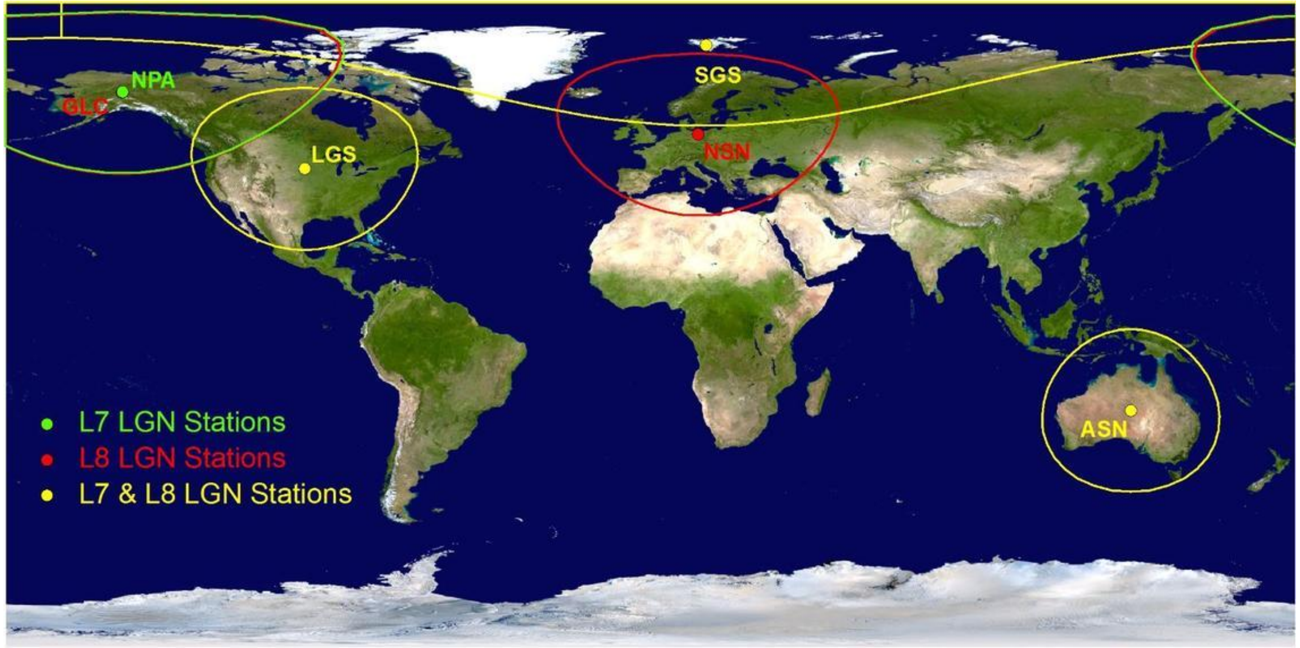


Ground stations

- Receive and transmit data to satellite using radiowaves

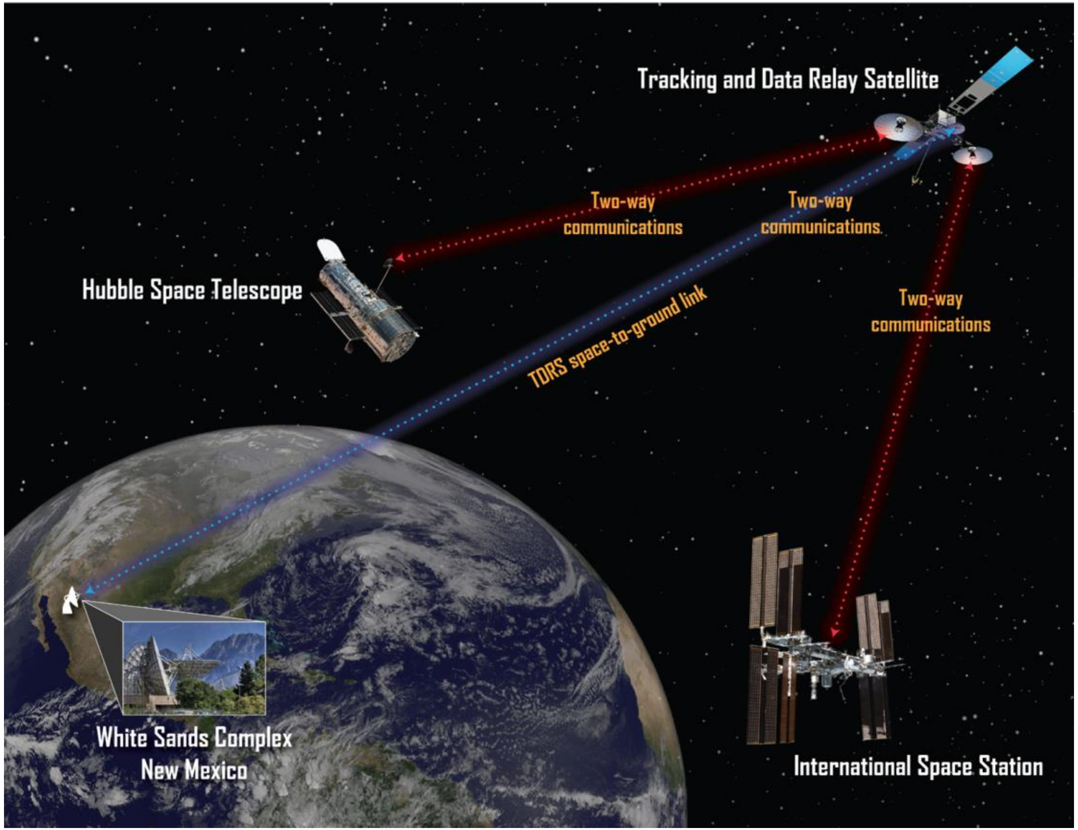
Landsat program ground station network

- 4-5 facilities are responsible for downlinking the satellite telemetry (via S-band Radio Frequency (RF) link) and science data (via X-band RF link)



Landsat program ground station network

- Tracking and Data Relay Satellite (TDRS) are a number of geostationary satellites that provide near continuous relay and tracking services



Mission control centers

- Responsible for day-to-day operations, provide commands to ground stations, make decisions about data is formatted, stored, and distributed

NASA Goddard Space Flight Center, MD

People

- Scientists, engineers, computer programmers, systems administrators, support staff, technicians, contractors and others all work to make the these missions a success.

- Science team: group of competitively selected scientists who help define and implement the mission’s science goals. They provide guidance and advice to the control center to ensure the mission meets its science requirements.

Today’s lab

Lab Assignment #3: Analyzing spectral reflectance curves

Objectives:

- We will investigate differences in NDVI and spectral reflectance curves between two irrigation districts in Central Oregon in July 2021.

Deadline: October 19 Tuesday 11:59 pm