AE673A: Rocket and Missile Structures (2020-21)

Group: **IMOA** | Project Report

Voyager Interstellar Mission

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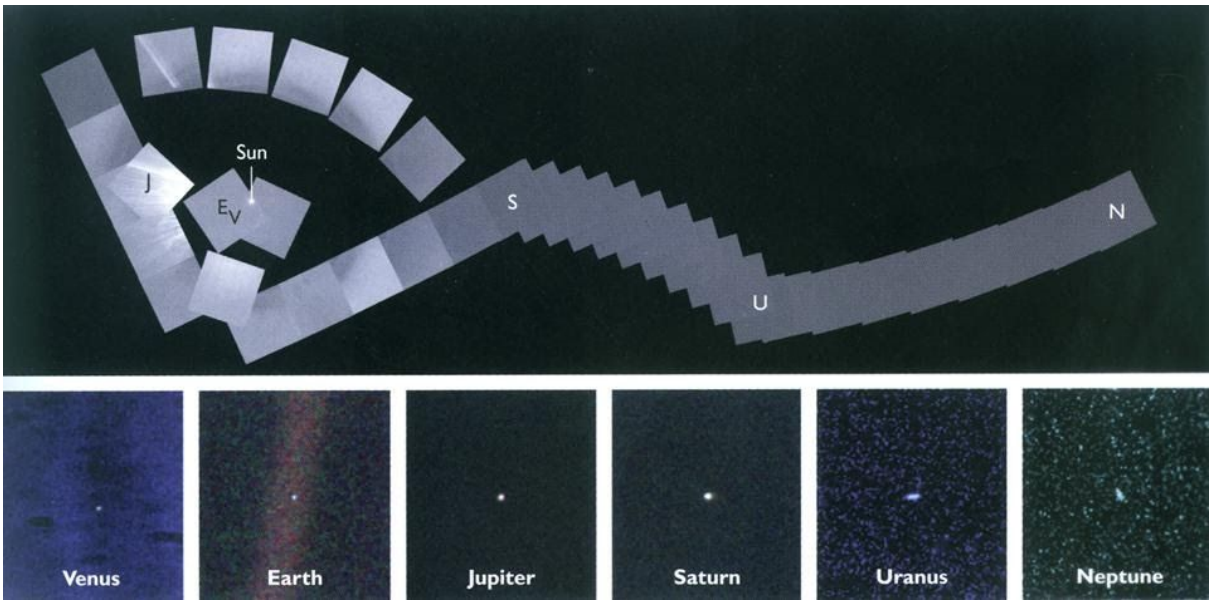


Part-A

Data for calculation:
30-Oct-1999 5:00 pm IST
Latitude: 22.2913
Longitude: 70.7930
Altitude: 140 (Sea Level)

Source: https://stellarium-web.org/p/observations

Solar Objects	RA	Declination	Altitude	Azimuth
Sun	**14h16m09.58s**	**-13°38'29.5"**	**+51°07'32.5"**	**+156°09'32.4"**
Mercury	15hr46m59.96s	-22°58'23.7''	+31°38'49.4''	+138°25'59.7''
Venus	11h23m06.58s	+4°11'58.4"	+57°18'17.6"	+240°30'58.6"
Mars	18h42m28.12s	-24°46'48.6''	-02°10'09.7''	+115°57'46.0''
Jupiter	01h50m13.03s	+09°42'15.2''	-56°54'01.0''	+344°15'18.6''
Saturn	2h50m29.21s	+13°37'16.2"	-47°02'44.7"	+324°51'56.3"
Neptune	20h15m23.37s	-19°32'31.1"	-20°35'23.1"	+103°25'30.3"
Moon	07h22m36.66s	+20°00'27.9''	+8°59'23.0	+288°01'50.3''
Uranus	21h02m12.33s	-17°36'07.2"	-30°40'39.0"	+97°51'48.2"

Upon Conversion of Sterillium values for Sun,
RA= -2.6226 rad
declination= -0.2381 rad

Part-B

Below is the MatLab code for finding RA and Declination of sun

```
[RA,delta] = SolarAzElq('1999-10-30 11:30:00',22.2913,70.7930,140);
fprintf('RA = %f rad \n',RA)
fprintf('dec = %f rad \n',delta)

function [RA,delta] = SolarAzElq(UTC,Lat,Lon,Alt)
if nargin<4 || isempty(Alt), Alt = 0; end
d2r = pi/180; %radiance to degrees conversion factor
r2d = 180/pi; %radiance to degrees conversion factor
if ischar(UTC)
UTC = cellstr(UTC);
end
if iscell(UTC)
UTC = reshape(datenum(UTC(:),'yyyy-mm-dd HH:MM:SS'),size(UTC));
end
[year,month,day,hour,min,sec] = datevec(UTC);
if ndims(UTC)>2 %#ok<ISMAT>
year = reshape(year ,size(UTC));
month = reshape(month,size(UTC));
day = reshape(day ,size(UTC));
hour = reshape(hour ,size(UTC));
min = reshape(min ,size(UTC));
sec = reshape(sec ,size(UTC));
end
[jd,UTH] = juliandate(year,month,day,hour,min,sec);
day = jd - 2451543.5;
w = 282.9404 + 4.70935e-5 * day;
e = 0.016709 - 1.151e-9 * day;
M = mod(356.0470 + 0.9856002585 * day, 360);
L = w + M;
oblecl = (23.4393 - 3.563e-7 * day)*d2r;
E = M + r2d*e.*sin(M*d2r).*(1+e.*cos(M*d2r));
x = cos(E*d2r)-e;
year = sin(E*d2r).*sqrt(1-e.^2);
r = sqrt(x.^2 + year.^2);
v = atan2(year,x)*r2d;
lon = v + w;
xeclip = r.*cos(lon*d2r);
yeclip = r.*sin(lon*d2r);
zeclip = 0;
xequat = xeclip;
yequat = yeclip.*cos(oblecl) + zeclip*sin(oblecl);
zequat = yeclip.*sin(0.409115648642983) + zeclip*cos(oblecl);
```

```
r = sqrt(xequat.^2 + yequat.^2 + zequat.^2) - (Alt/149598000);
RA = atan2(yequat,xequat); % in radians
delta = asin(zequat./r); % in radians
end
```

Values found from matlab code:
RA = -2.5434 rad
Declination = -0.2395 rad

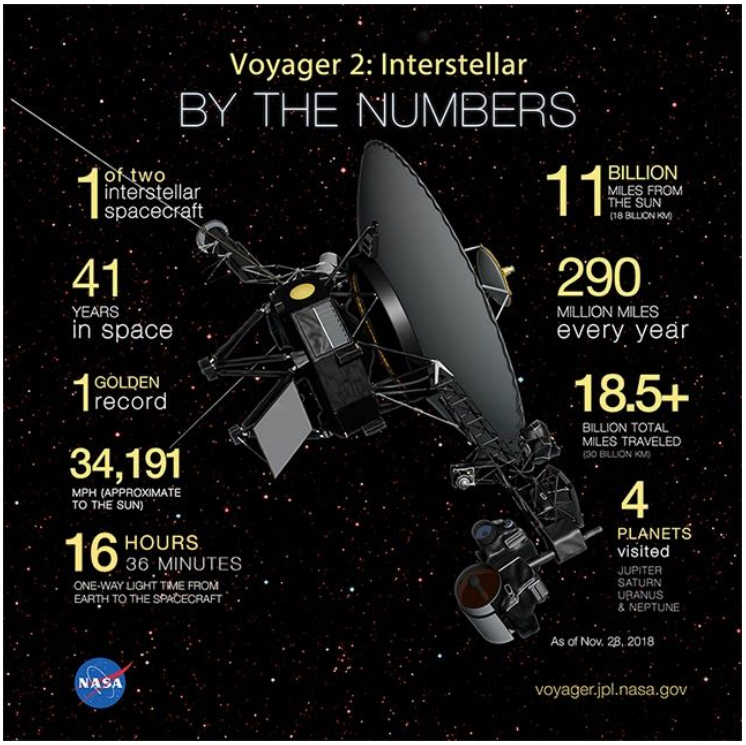
RA and Declination values of Sun calculated from MATLAB code are approximately the same as found from Sterillium.

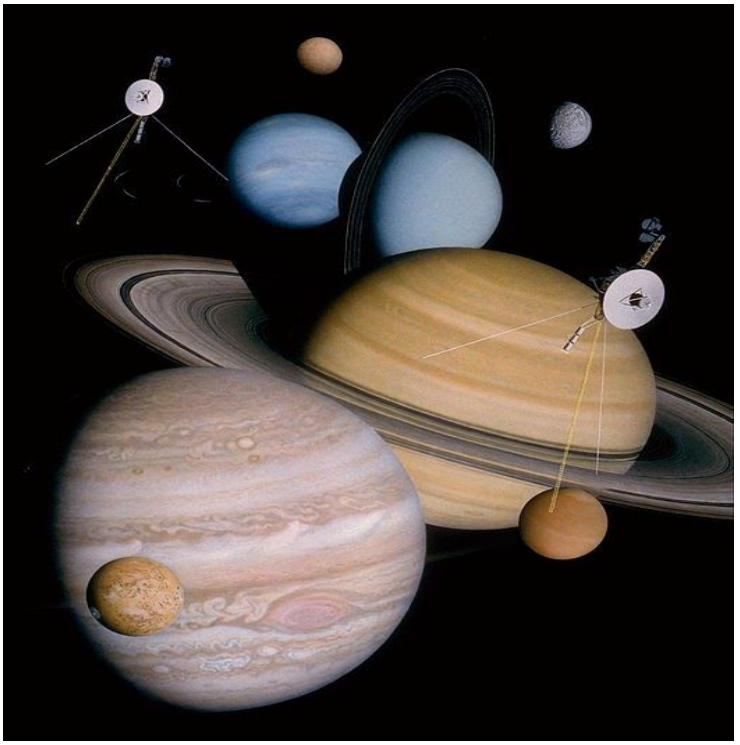
PART - C
Voyager Interstellar Mission

NASA initiated the Voyager mission to study Jupiter, Saturn Uranus and Neptune via two robotic probes Voyager 1 and Voyager 2 in 1977 due to their favourable alignment which is achieved every 175 years. The probes were built at Jet Propulsion Laboratory with combined funding of $865M (and $30M for Interstellar extension) from NASA and Cape Canaveral. The mission was extended three times.

The primary mission was completed in 1989 when Voyager 2 achieved flyby of Neptune. The Voyager Interstellar Mission (VIM) was the extension of the mission. The Heliophysics department of NASA considered this to be a viable mission to study interstellar magnetic fields beyond the heliopause boundary. Many parts were shut down to conserve power for the mission. The two spacecraft continue to operate, with some loss in subsystem redundancy but retain the capability to return scientific data from a full complement of Voyager Interstellar Mission (VIM) science instruments. Both Voyagers have reached interstellar space and will continue to send data for up to few more years until their electric system and attitude propellants are exhausted. Both spacecraft are still sending scientific information about their surroundings through the Deep Space Network, or DSN

Voyager Interstellar Mission





Voyager-1

Mission:

The primary mission of Voyager 1 was to explore Jupiter and Saturn and their moons. Scientists wanted to take readings of both planet's atmospheres to find out more about them.

Discoveries:

- Images sent by Voyager 1 revealed that each satellite has a unique appearance, the most remarkable discovery being an active volcano on Io (a moon of the Jupiter).
- It also discovered Thebe and Metis, two previously unknown moons of Jupiter, later named.
- Looking back at Jupiter as it was backlit by the Sun, Voyager 1 also discovered that the planet is surrounded by a thin ring.
- At Saturn, Voyager 1 found five new moons and a new ring called the G-ring.

Facts:

- Saturn's gravity imparted enough acceleration on Voyager 1 that it achieved escape velocity from the solar system.
- More than 41 years after its launch, several of the spacecraft's instruments are still returning useful data about conditions on the very edges of the solar system and even beyond.
- In August 2012, Voyager 1 crossed the heliopause, the boundary between the heliosphere, the bubble-like region of space created by the Sun, and the interstellar medium.
- It is expected that Voyager 1 will continue to return data from interstellar space until about 2025.
- And just in case it may one day be found by an alien intelligence, Voyager 1 and its twin carry gold plated records that contain information about its home planet, including recordings of terrestrial sounds, music and greetings in 55 languages. Instructions on how to play the record are also included.

Technical Specifications:

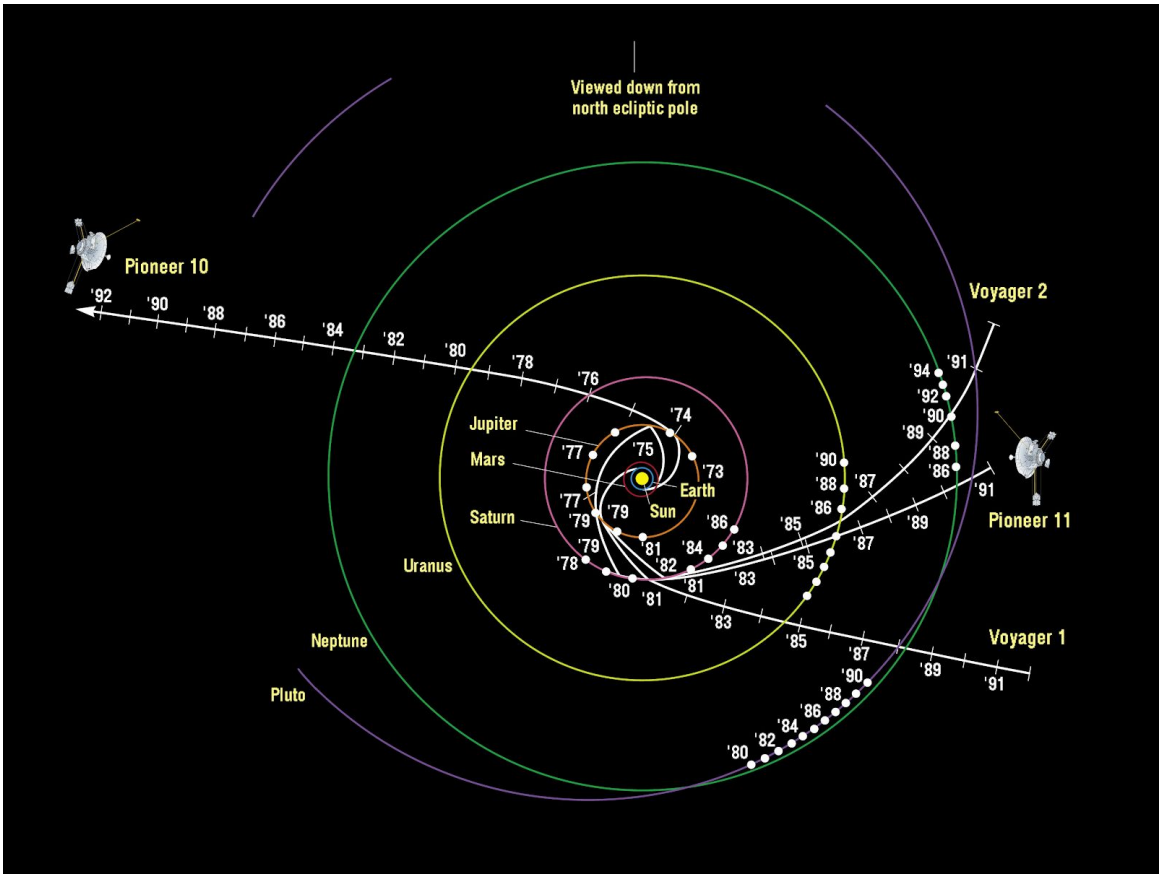
- **Weight:** 721.9 kilograms
- **Power:** 3 RTG Thermoelectric generators powered by plutonium-238 initially 470 W. Now ~250W.
- **Systems:**
    - Imaging system
    - Infrared interferometer spectrometer
    - Ultraviolet spectrometer

- Triaxial fluxgate magnetometer
- Plasma spectrometer
- Low-energy charged particles detectors
- Cosmic Ray System (CRS)
- Photopolarimeter System (PPS)
- Plasma Wave System (PWS)

Key Dates:

- **Sept. 5, 1977:** Launch by Titan 3E
- **March 5, 1979:** Jupiter flyby
- **Nov. 12, 1980:** Saturn flyby
- **Feb. 17, 1998:** Became the most distant human-made object after overtaking NASA's Pioneer 10
- **Jan. 1, 1990:** Voyager Interstellar Mission (VIM) officially began
- **Aug. 16, 2006:** 100 astronomical units reached
- **Aug. 1, 2012:** Voyager 1 enters interstellar space

Path:



Voyager-2

Mission:

The primary mission of Voyager 2 was Jupiter Flyby, Saturn Flyby, Uranus Flyby, Neptune Flyby and studying them up close. Voyager 2 also was designed to find and study the edge of our solar system.

Discoveries:

- Voyager 2 imaged the satellite Io (a moon of Jupiter), and conducted a 10-hour volcano watch of the moon, confirming Voyager 1's finding that it harboured active volcanoes
- Voyager 2 revealed the Great Red Spot on Jupiter to be a complex storm system, and also imaged several smaller storms
- Voyager 2 also discovered a previously unknown moon, later named Adrastea, orbiting Jupiter just outside its rings

Facts:

- Saturn's gravity altered Voyager 2's trajectory to send it to encounter Uranus in January.
- Voyager 2 picked up a gravity assist at Uranus to send it to its final planetary encounter with Neptune.
- Several of the spacecraft's instruments have been turned off to conserve power, beginning with the imaging system in 1998.
- It is expected that Voyager 2 will continue to return data from interstellar space until about 2025.
- Voyager 2 like its twin carries a gold plated record that contains information about its home planet, including recordings of terrestrial sounds, music and greetings in 55 languages. Instructions on how to play the record are also included.

Technical Specifications:

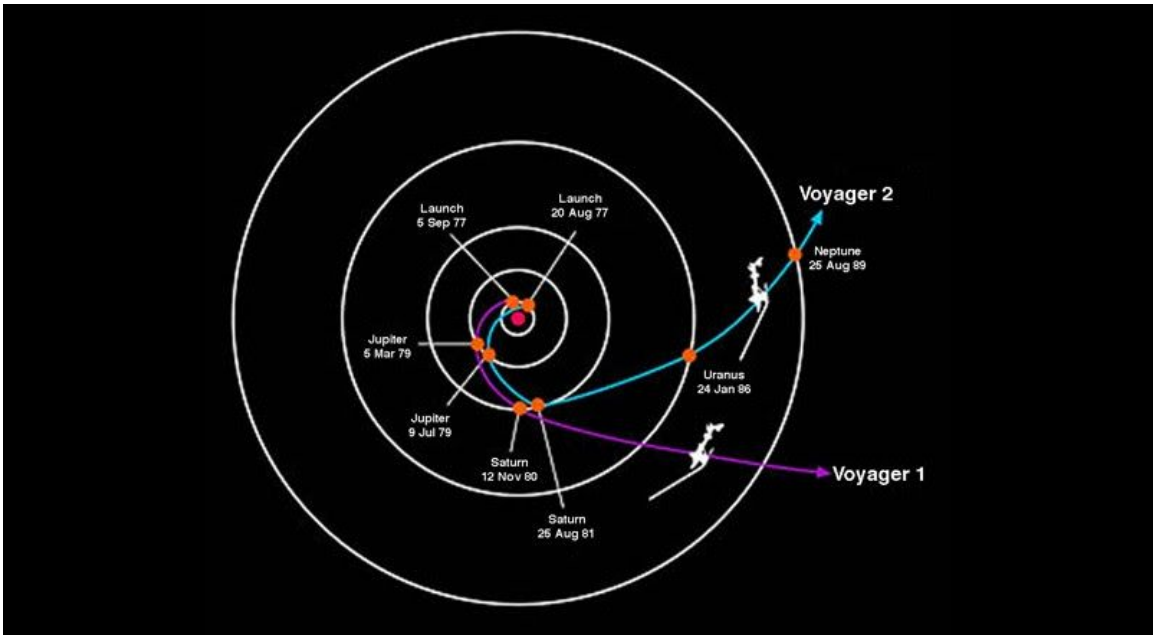
- **Weight:** 721.9 kilograms
- **Power:** 3 RTG Thermoelectric generators powered by plutonium-238 initially 470 W. Now ~250W.
- **System**:
    - Imaging Science System (ISS)
    - Ultraviolet Spectrometer (UVS)
    - Infrared Interferometer Spectrometer (IRIS)
    - Planetary Radio Astronomy Experiment (PRA)

- Photopolarimeter (PPS)
- Triaxial Fluxgate Magnetometer (MAG)
- Plasma Spectrometer (PLS)
- Low-Energy Charged Particles Experiment (LECP)
- Plasma Waves Experiment (PWS)
- Cosmic Ray Telescope (CRS)
- Radio Science System (RSS)

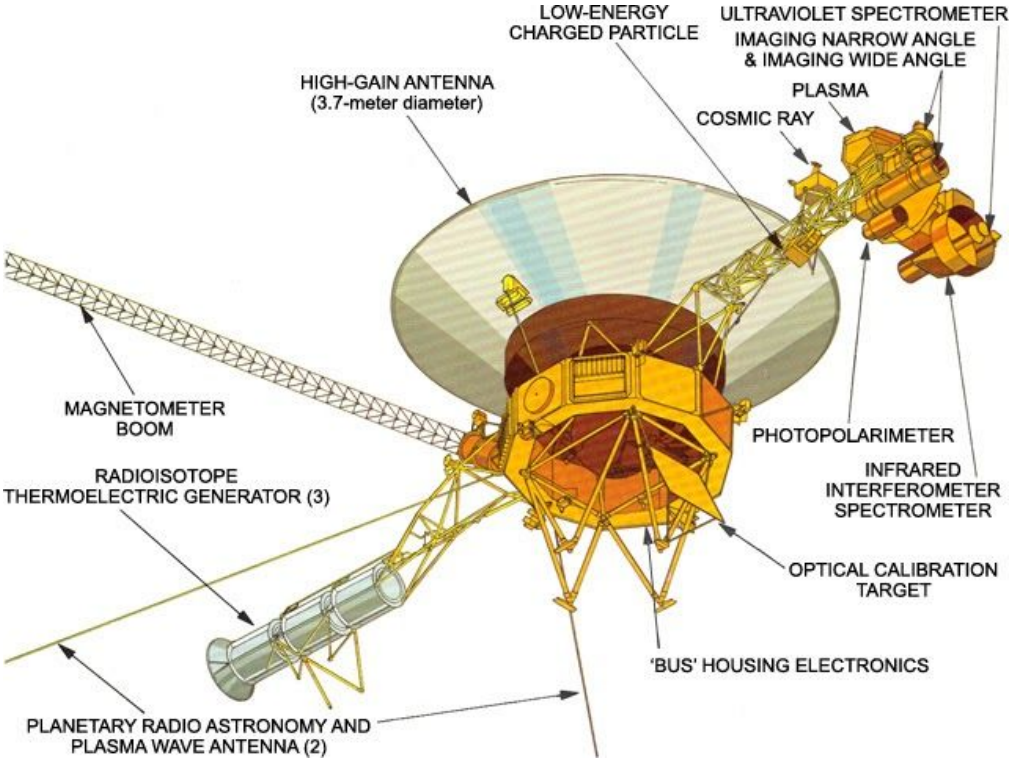
Key Dates

- **Aug. 20, 1977**: Launch by Titan3E
- **July 9, 1979**: Jupiter flyby
- **Aug. 26, 1981**: Saturn flyby
- **Jan. 24, 1986**: Uranus flyby
- **Aug. 25, 1989**: Neptune flyby
- **Dec. 10, 2018:** Entered interstellar space
- **July 8, 2019:** Voyager 2 successfully fired its trajectory correction maneuver thrusters

Path:

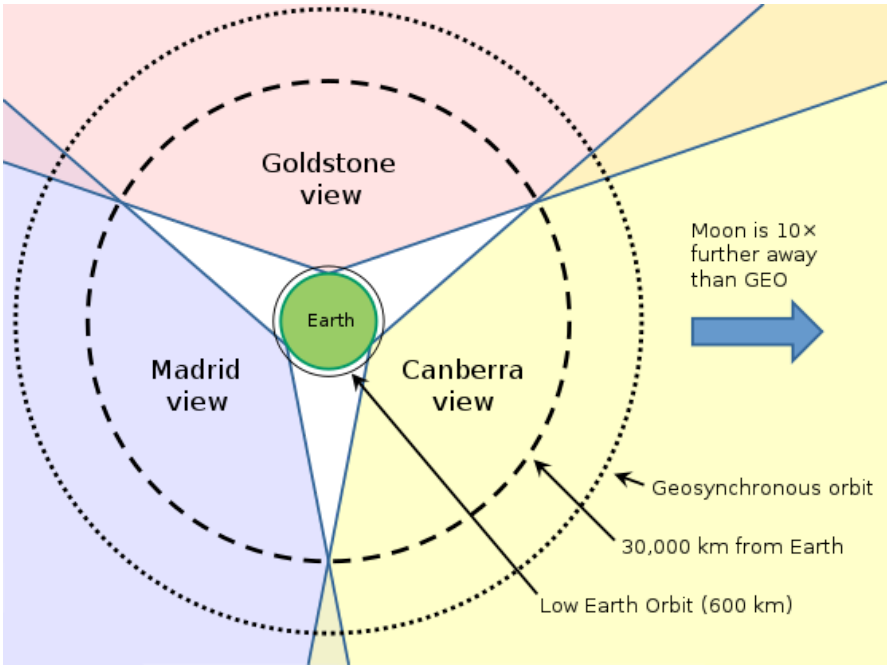


Instrument Status:



Communication

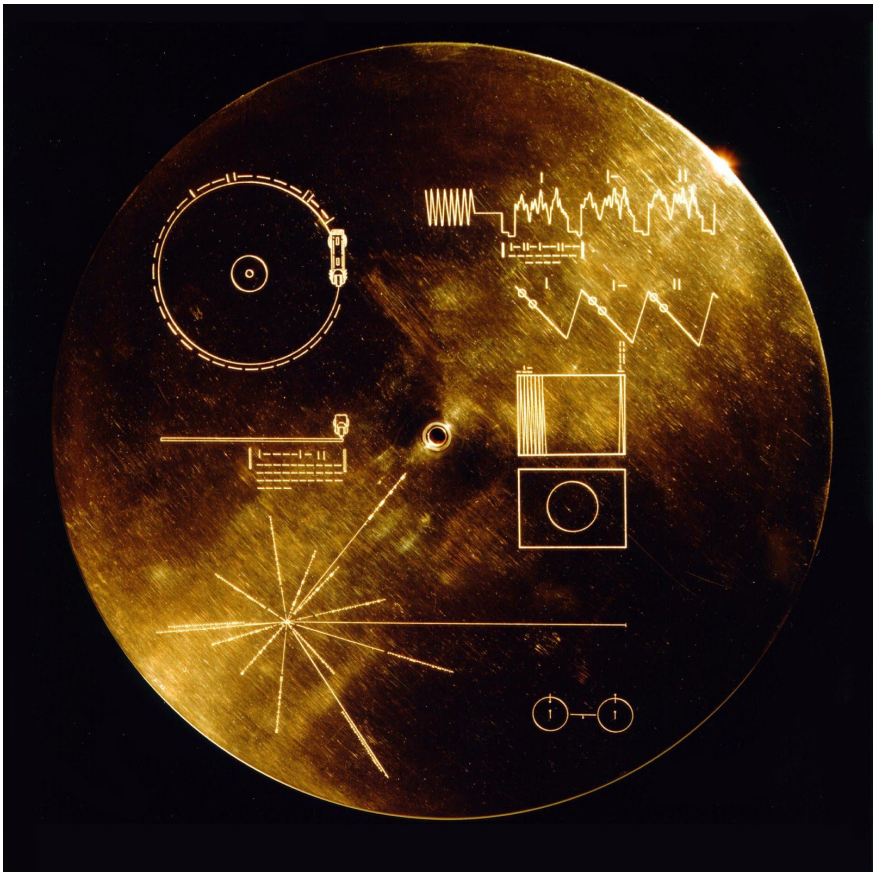
Voyagers are the farthest man made objects we are able to communicate. To achieve this ~20 Billion km communication, takes almost 20-24hrs to send and receive the signals. Radio waves of nearly 20KW are sent to these space probes which are received with their huge 12 ft antennas. The return communication occurs with the 20 W signals sent by these probes which gets diminished to 10^-19 order. NASA uses the Deep Space Network



which contains three equally spaced antennas around the earth each containing 70 meters antennas and multiple 34 meters antennas to detect feeble signals from these probes. The data rate keeps decreasing and by 2030s there will be no power left for communication.

The Golden Record

Pioneers 10 and 11 both carried small metal plaques to identify their time and place of origin in case it might find spacefarers in the distant future. With this example in mind, NASA placed a kind of time capsule, aimed to communicate the story of our world to extraterrestrials. The Voyager message is carried by a phonograph record, a 12-inch (30cm in diameter) gold-plated copper disk containing sounds and images selected to portray the diversity of life and culture on Earth.



The content of the record was selected by NASA committee. It has a variety of natural sounds, such as those made by winds, thunder, birds and other animals. It contains 115 images encoded in analog form, music with a total duration of 90 minutes and spoken greetings from people of Earth in 55 different languages . Each record is encased in a protective aluminum jacket, together with a cartridge and a needle. Instructions, in symbolic language, explain the origin of the spacecraft and indicate how the record is to be played.

Resources

- Wikipedia Voyager Space Programme
- Nasa 40 Yrs Voyager
- Nasa Solar System
- JPL Voyager
- Google Images