

The Pale Blue Dot A Perspective of the Earth from Space

Presentation by Sara Wofford, 4 March 2020

Images courtesy of NASA/JPL

Facts about Voyager and its photos are from the NASA/JPL image databases and mission pages at the NASA web site (

https://www.nasa.gov/multimedia/imagegallery) and (https://voyager.jpl.nasa.gov/)

With deep gratitude to Carl Sagan and all the space exploration missions, especially Voyager and Apollo

Perspectives from Space

The farther we get from Earth and look back, the more humbled we are by our tiny and very non-central place in the vastness of the cosmos.

Just a few examples:

- Apollo 8: "Earthrise", photographed from Lunar orbit (the first human crewed mission to orbit the Moon), 239,000 miles (385,000 km) from Earth (24 Dec 1968)
- Voyager 1: First photo with Earth and Moon in the same frame, 7.25 million miles (11.67 million km) from Earth (18 Sep 1977)
- Voyager 1: "Pale Blue Dot", part of the "Family Portrait" of the Solar System, 3.76 billion miles (6.05 billion km) from Earth (14 Feb 1990)

(For many more, see:

<u>https://www.planetary.org/explore/space-topics/earth/pics-of-earth-by-plan</u> <u>etary-spacecraft.html</u>

Earthrise: Apollo 8

- Photo by astronaut Bill Anders
- Taken from orbit around the Moon on Christmas Eve, 24 December 1968, 239,000 miles (385,000 km) from Earth
- Handheld camera with telephoto zoom lens through spacecraft window
- 50 years later to the day (24 Dec 2018), Anders said, "We set out to explore the moon and instead discovered the Earth." (<u>https://www.space.com/42848-e</u> <u>arthrise-photo-apollo-8-legacy-bi</u> <u>ll-anders.html</u>



Earthrise: Apollo 8

Onboard audio recording of Apollo 8 crew while taking this photo, with imagery compiled from Apollo 8 and Lunar Reconnaissance Orbiter photos and incorporated into a simulation by NASA's Goddard Scientific Visualization Studio.

(Showing YouTube channel; Original video: <u>https://svs.gsfc.nasa.gov</u> /cgi-bin/details.cgi?aid=4 129



Voyager Missions

- Voyager 1 & 2 (identical probes) were launched in 1977
- Instruments include wide and narrow field cameras, charged particle sensors, spectrometers, radio transceivers, etc.
- NASA sends instructions to the probes' computers to use rockets to change trajectory or facing, and to turn instruments on or off
- The probes radio all data back to Earth
- Both probes carry the "Golden Record", containing sounds and images from Earth, just in case a probe is found by an intelligent alien being



Voyager Missions

- The three computers on each probe use a total of about 68 KB of memory and perform calculations at about 8 MHz
 - Your cell phone is hundreds of thousands of times more powerful
- 63.5 MB of data storage on tape
- The probes are powered by radioisotope thermoelectric generators
 - They started with about 400 watts of power, and lose about 4 watts per year
 - Both probes are still operational, over 40 years after launch
 - They will probably run out of power sometime around 2025
- The probes are now about 140 AU away from the Sun
 - 1 AU is the distance from Earth to the Sun, about 93 million miles (150 million km)
 - Pluto orbits an average of about 39 AU from the Sun
- It now takes about 20 hours to send a radio signal one way



Mission status: https://voyager.jpl.nasa.gov/mission/status/

Voyager Missions

- The Voyager missions were designed to take advantage of a rare alignment of the outer planets that would enable visiting all four giant planets (Jupiter, Saturn, Uranus, Neptune) with a minimum of fuel and travel time
- The primary mission for both probes was a flyby of Jupiter and Saturn
- Voyager 1 would image Saturn's moon Titan, which would then take it on a path out of the solar system
- Voyager 2 would continue on to Uranus & Neptune before leaving the solar system
- Instruments were designed to continue measurements in interstellar space in case the probes lasted that long – which they did!
- Both probes are now in the interstellar medium, outside the solar wind, travelling around 36,000 mph (58,000 kph), or about 3.4 AU per year



Earth and Moon Photographed by Voyager 1

- On its way to Jupiter, on 18 September 1977, Voyager 1 turned its camera toward Earth and gave us the first ever image with the Earth and Moon naturally together in the same photo frame
- 7.25 million miles (11.67 million km) from Earth (about 1/7th the distance to the orbit of Mars), 13 days after launch
- As with most photos taken with astronomical instruments, this one was made by combining three separate images taken through different colored filters to obtain a natural color image
- The portion of the image with the Moon had to be brightened by a factor of three to make it bright enough to see along with the Earth
- The Moon is also well beyond the Earth in this view

https://www.nasa.gov/multimedia/imagegallery/image_featu re_2041a.html



Carl Sagan and the Solar System Family Portrait

- Voyager 1 finished its planetary mission to Saturn in late 1980
- Planetary scientist & educator Carl Sagan was on the Voyager 1 imaging & science teams and was on the committee that chose content for the Golden Record
- He asked that a set of photos of the solar system, including the Earth, be taken then so that we could see from that remote perspective
- But even at that distance, the Sun was still so bright that team engineers feared damaging the camera's sensitive detectors
- So the photos had to wait for over 9 years



Solar System Family Portrait by Voyager 1

- Finally, on 14 February 1990, the photos were taken
- Voyager 1 was 40 AU from the Earth (nearly 4 billion miles, or 6 billion km) and 32 degrees above the plane in which the planets orbit (the ecliptic)
- NASA attempted to photograph all the planets
 - Mercury was too close to the Sun
 - Mars was only a thin crescent and hence undetectable
 - Pluto was too dim & distant to try
 - The other six planets were imaged
- Voyager sent back 60 frames taken in various filters between March and May



Solar System Family Portrait by Voyager 1: Full Mosaic, Wide Field Camera



When this mosaic was printed at full size and displayed on an auditorium wall at NASA/JPL, it spanned a distance of 20 ft.

I had to shrink this digital version to 1/3 size to fit it on this slide

Solar System Family Portrait by Voyager 1: Individual Photos of Planets, Narrow Field Camera

- Different sets of filters were used for each planet to optimize each image
- Uranus and Neptune required long exposures, during which the space probe was moving, so those images are smeared



Earth As a Pale Blue Dot

- Here it is
- The rays come from sunlight scattered within the camera itself
- Can you see the Earth?
- How about now?
- The Earth's actual extent covered only 12/100ths of a pixel. So it is unresolved, a point of light, like any star we see with our naked eyes.



Earth As a Pale Blue Dot: Magnified

Blue, because of sunlight reflected from our oceans and scattered through our atmosphere.

Pale, because that blue light is mixed with white light reflected from our clouds.

"That's here. That's home. That's us."

– Carl Sagan



Carl Sagan's Reflections

In 1994, Carl Sagan wrote a book inspired in part by his feelings about this photograph and the perspective it offers. The book is titled <u>Pale Blue</u> <u>Dot: A Vision of the</u> <u>Human Future in Space</u>.



Carl later recorded himself reading the chapter containing his reflections on the Pale Blue Dot.

What Does It Mean To You?

- What are your thoughts?
- How do you feel when you see the Earth from this distant perspective?
- What can we do to ensure that we do not destroy ourselves or the ecosystems in which we live?
- Is there hope for us? Can we save us from ourselves?
- What else do these images evoke for you?



