rimini meeting

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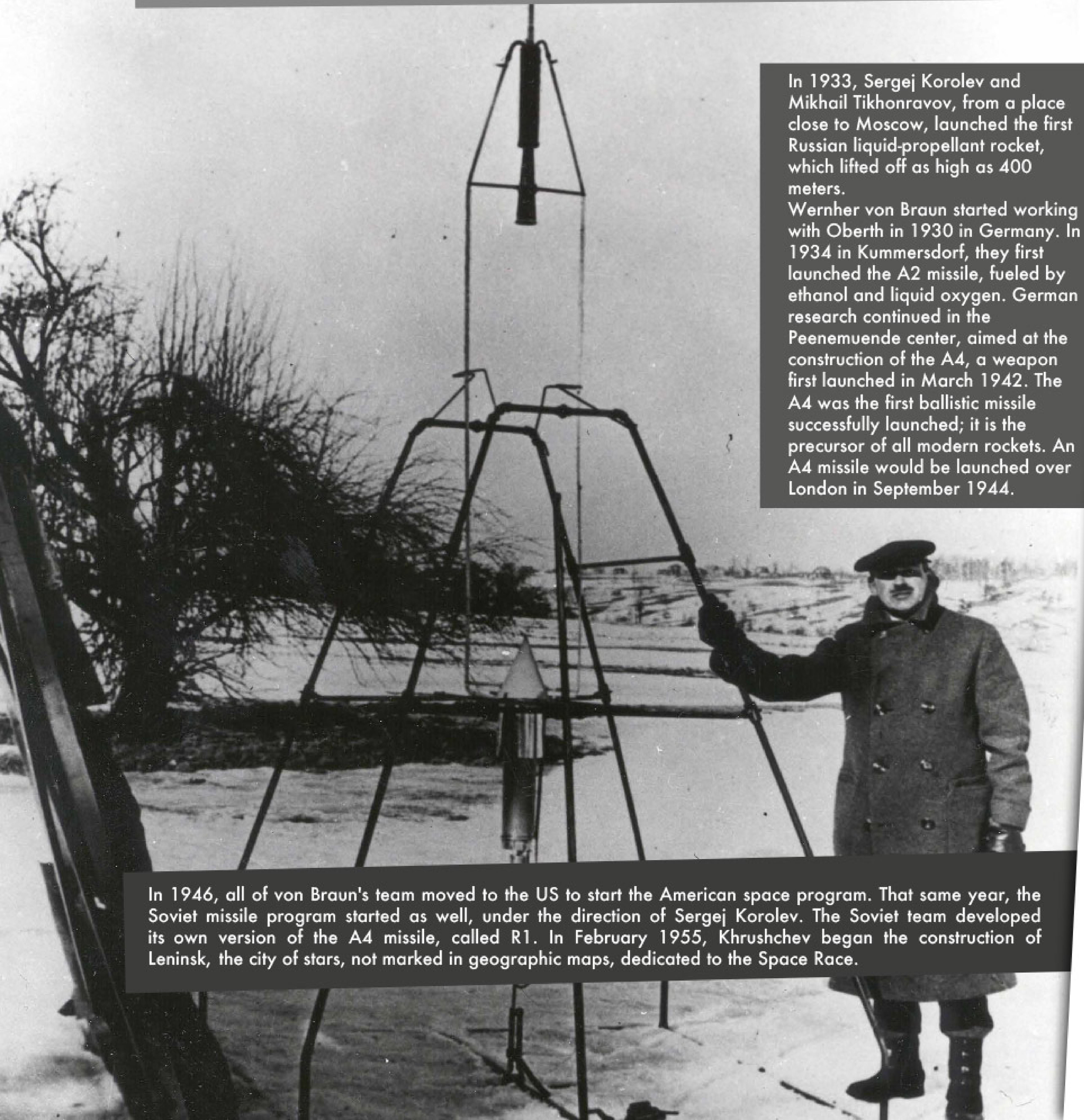
EXPLORERS

LAUNCH PAD

After the invention of gunpowder (China, 3rd century BC), there was no substantial advancement in the construction of rockets until World War I: a “body” where combustion takes place and a “pole” to stabilize its direction.
In the first half of 1900, futuristic ideas of space flights started to become a reality thanks to the studies and experiments of the three “fathers of rocketry”: Konstantin Tsiolkovsky, Robert Goddard and Hermann Oberth.

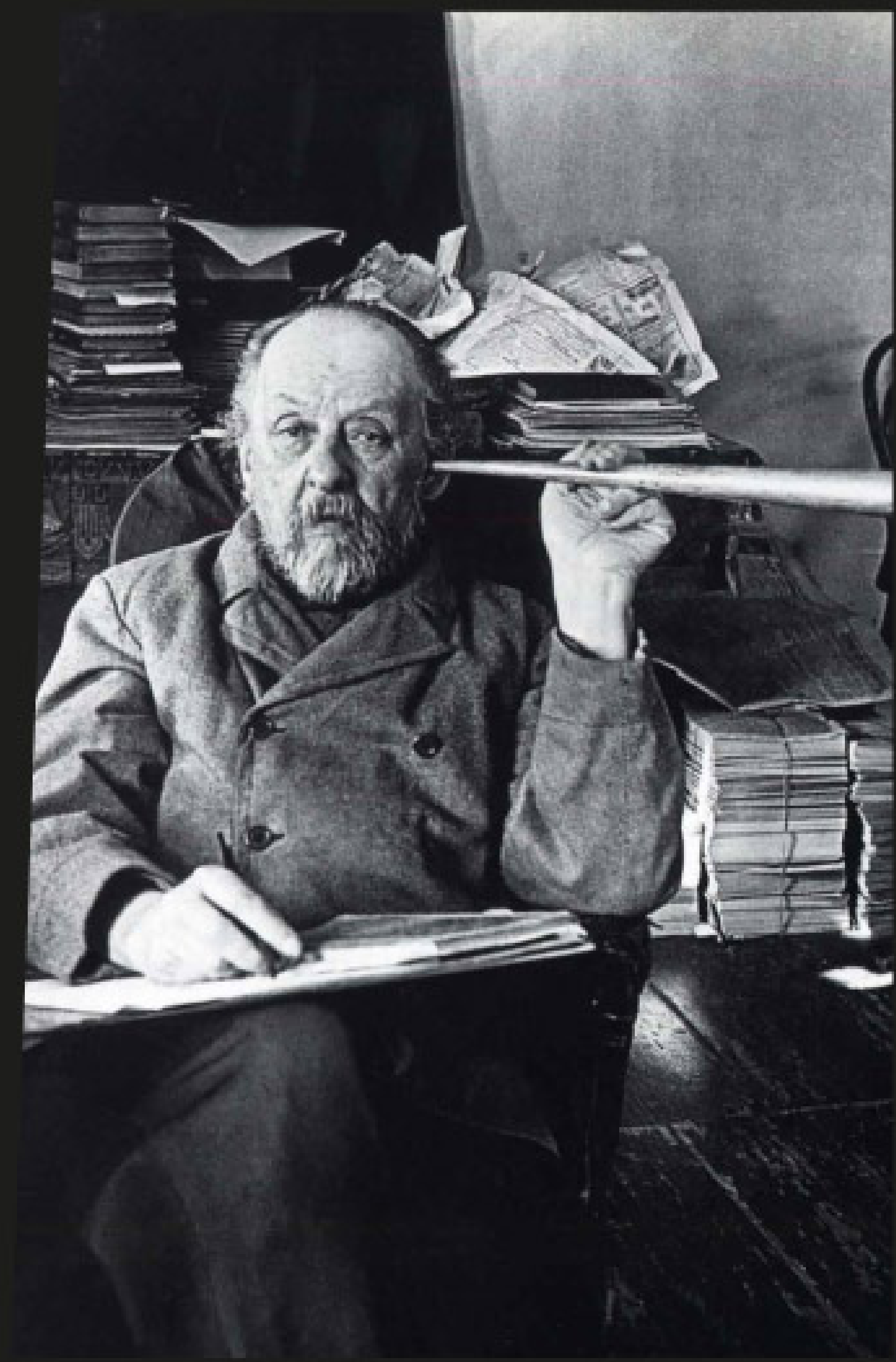
The three of them came to similar conclusions while carrying out independent research. In particular, Goddard became convinced of the necessity of a liquid fuel propellant and in 1962 in Alburn (USA), he launched a rocket that flew 46 meters, about the same distance as the Wright brothers covered with their first flight.



In 1933, Sergej Korolev and Mikhail Tikhonravov, from a place close to Moscow, launched the first Russian liquid-propellant rocket, which lifted off as high as 400 meters.
Wernher von Braun started working with Oberth in 1930 in Germany. In 1934 in Kummersdorf, they first launched the A2 missile, fueled by ethanol and liquid oxygen. German research continued in the Peenemuende center, aimed at the construction of the A4, a weapon first launched in March 1942. The A4 was the first ballistic missile successfully launched; it is the precursor of all modern rockets. An A4 missile would be launched over London in September 1944.

In 1946, all of von Braun's team moved to the US to start the American space program. That same year, the Soviet missile program started as well, under the direction of Sergej Korolev. The Soviet team developed its own version of the A4 missile, called R1. In February 1955, Khrushchev began the construction of Leninsk, the city of stars, not marked in geographic maps, dedicated to the Space Race.

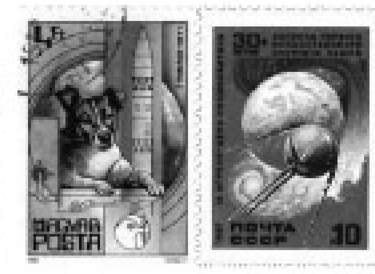
Sergej Korolev



Konstantin Tsiolkovsky

Hermann Oberth

SPUTNIK



October 4 1957 | October 4 1957 | October 4 1957

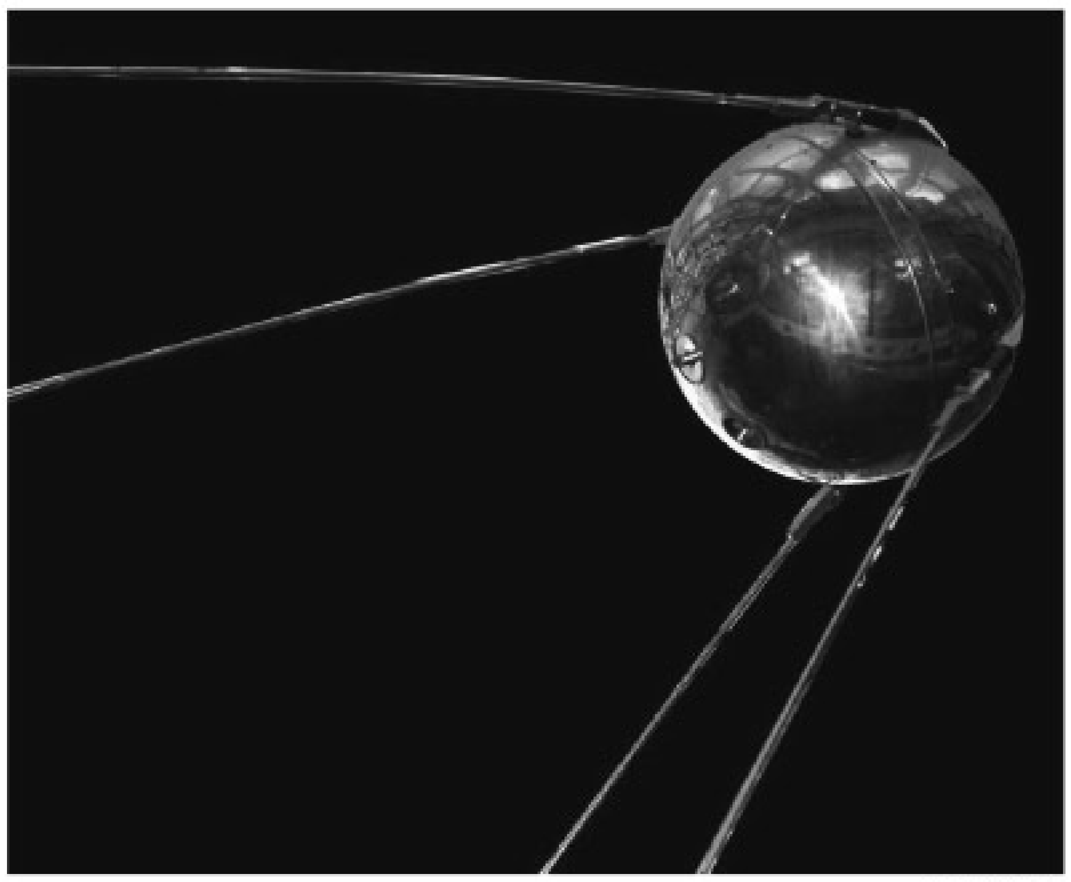
THE SPACE AGE BEGINS

OCTOBER 4 1957

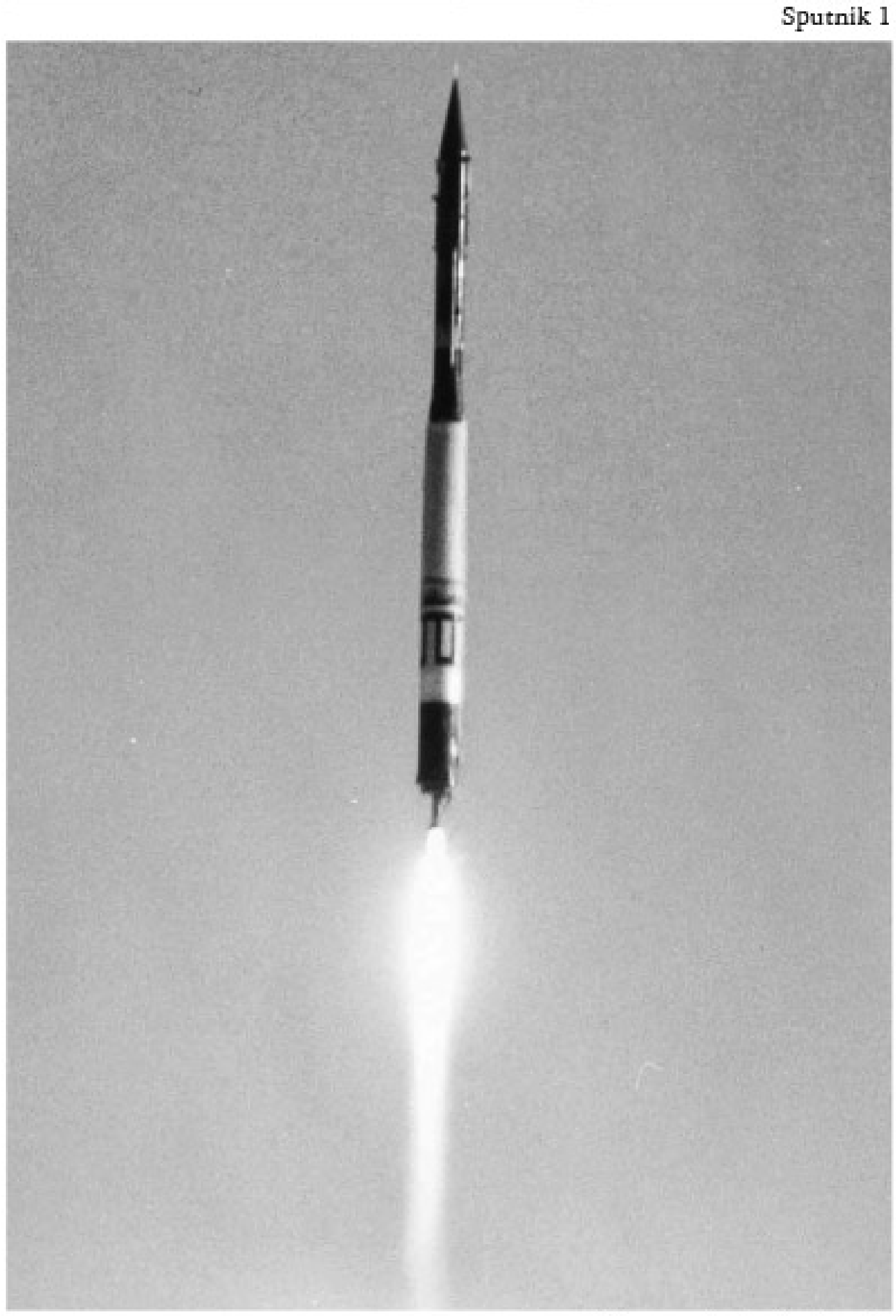
Scientists worldwide celebrate the International Geophysical Year (1957-58), with the purpose of studying our planet in every possible way. Among several proposals, the idea emerges to launch artificial satellites to investigate the Earth in a new way. The Soviet Union and the United States announce they are working on such project. Von Braun has Jupiter C rocket ready, but president Eisenhower does not want a satellite devoted to scientific studies to be carried into space by a military missile, so he chooses the Vanguard vector. In the meantime, Korolev has tested the R-7 in an intercontinental launch and, turning down the satellite designed by Tilkhonravov (1.5 tons), chooses a smaller and lighter vector to send it to space before the US.

On October 14 1957, from the Baikonur cosmodrome (Kazakhstan), Sputnik 1 is launched (in Cyrillic, спутник, "Fellow Traveler" or "Satellite"): it is the first artificial satellite to orbit Earth.

Sputnik 1 only features a 58 cm-diameter metal sphere, pressurized with nitrogen and weighing 185 lbs. It contains a series of silver-zinc and



Sputnik 1



Vanguard missile launch

SPUTNIK 1: Mission data

Mass	185 lbs
Launch	Baikonur, October 4 1957 at 19:12 UTC
Vector	Semërka
Destination	Medium Earth Orbit
Orbit	Elliptical (between 150 and 600 miles from ground)
Orbital Period	Around 96 minutes
Duration	57 days

batteries, a thermometer and two radio transmitters tuned at 20.005 and 40.002 MHz respectively, which emitting a characteristic "beep". The main body is equipped with four radio antennae of about 8 feet each.

The instruments aboard the Sputnik work for 21 days. Eventually, the satellite will burn up while re-entering the atmosphere, after about 1,400 orbits and 50,000,000 miles. **The Sputnik carried a banner titled: "Man's Quest for Knowledge".**

After a month, the Soviet Union launches a **second Sputnik rocket**, 6 times heavier then the first Sputnik;

Laika

this time there is a living being on board: a small dog, named **Laika**. She has water and food, but the temperature control system is damaged during the detachment of the satellite from the vector, and the dog dies.

SPECIAL EDITION

YURI GAGARIN

At the end of 1958, Korolev gives up the idea of suborbital launches and focuses on a different project, an orbital spacecraft capable of carrying a human crew. He accomplishes this by reconverting a project initially designed as a spy satellite. This project is called Vostok (East) and is launched on April 12 1961, with the cosmonaut Yuri Gagarin aboard. The flight lasts an hour and 48 minutes, during which a single orbit of Earth is completed. All flight phases are completely automated, including the reentry, which concludes with a

Yuri Gagarin

A MAN IN ORBIT

landing in the south of the Soviet Union. Gagarin parachutes to the ground separately from his capsule after ejecting at 4.5 miles altitude.

Valentina Tereshkova

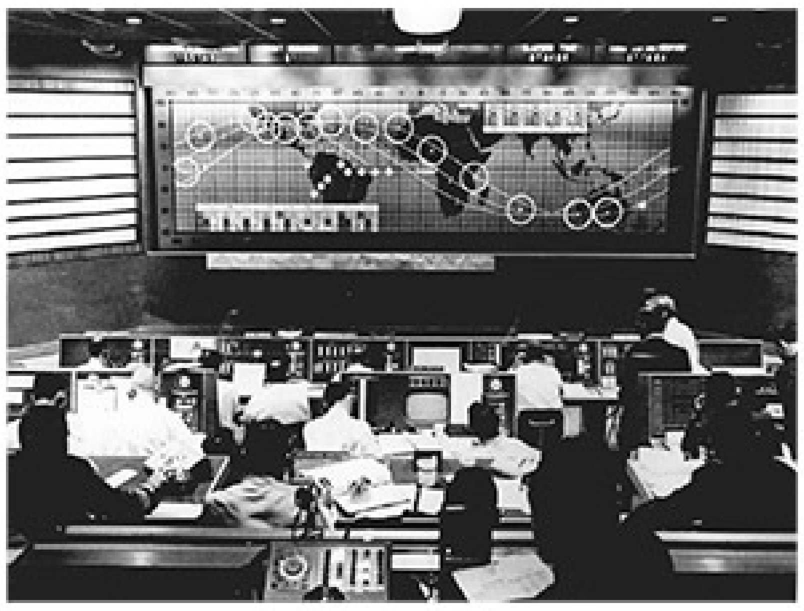
After Gagarin, the Soviet space program continues and Vostok 2 is launched (August 1961). Gherman Titov orbits the Earth for a whole day onboard this satellite. In 1963, Vostok 6 carries to orbit Valentina Tereshkova, the first woman in space.


L'ECO DI BERGAMO
LA NOTIZIA SENSAZIONALE
Lanciato nello spazio il russo ha girato la terra in 89 minuti
In tutto il mondo enorme impressione


The Huntsville Times
Man Enters Space
'So Close, Yet So Far,' Sighs Cape
Soviet Officer Orbits Globe In 5-Ton Ship
Praise Is Heaped On Major Gagarin


НАРОД ЛИКУЕТ!
ЮРИЙ ГАГАРИН В МОСКВЕ!
ИЗВЕСТИЯ

May 5, 1961



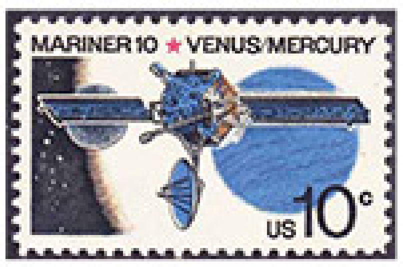
THE U.S. RESPONDS

In October 1958, the NACA (National Aeronautic Committee Advisory) has decided to start a U.S. space program. The objective is to launch a capsule carrying a human crew capable of orbiting Earth. They chose a 60 cubic feet capsule to be launched by the short-range ballistic missile Redstone. A month later, the project took the name Project Mercury.

On May 5, 1961 Alan Shepard became the first American to travel to space in a sub-orbital flight, second only to Gagarin. A second Mercury mission took place and where the ship flew sub-orbitally for 15 minutes. The next step is to achieve Earth orbit. Redstone rockets do not provide enough thrust, so the ballistic missile Atlas was used instead. On May 20, 1962, John Glenn orbited the Earth, the first American to do so, completing three orbits and remaining in space for five hours. After three more flights, Project Mercury will conclude on May 1963 with Leroy Gordon Cooper's flight to space, which lasts 34 hours. These missions prove that it is possible to send humans to space and return them safely to Earth.

The project will be officially terminated when NASA decides to develop a program to land a man on the Moon.

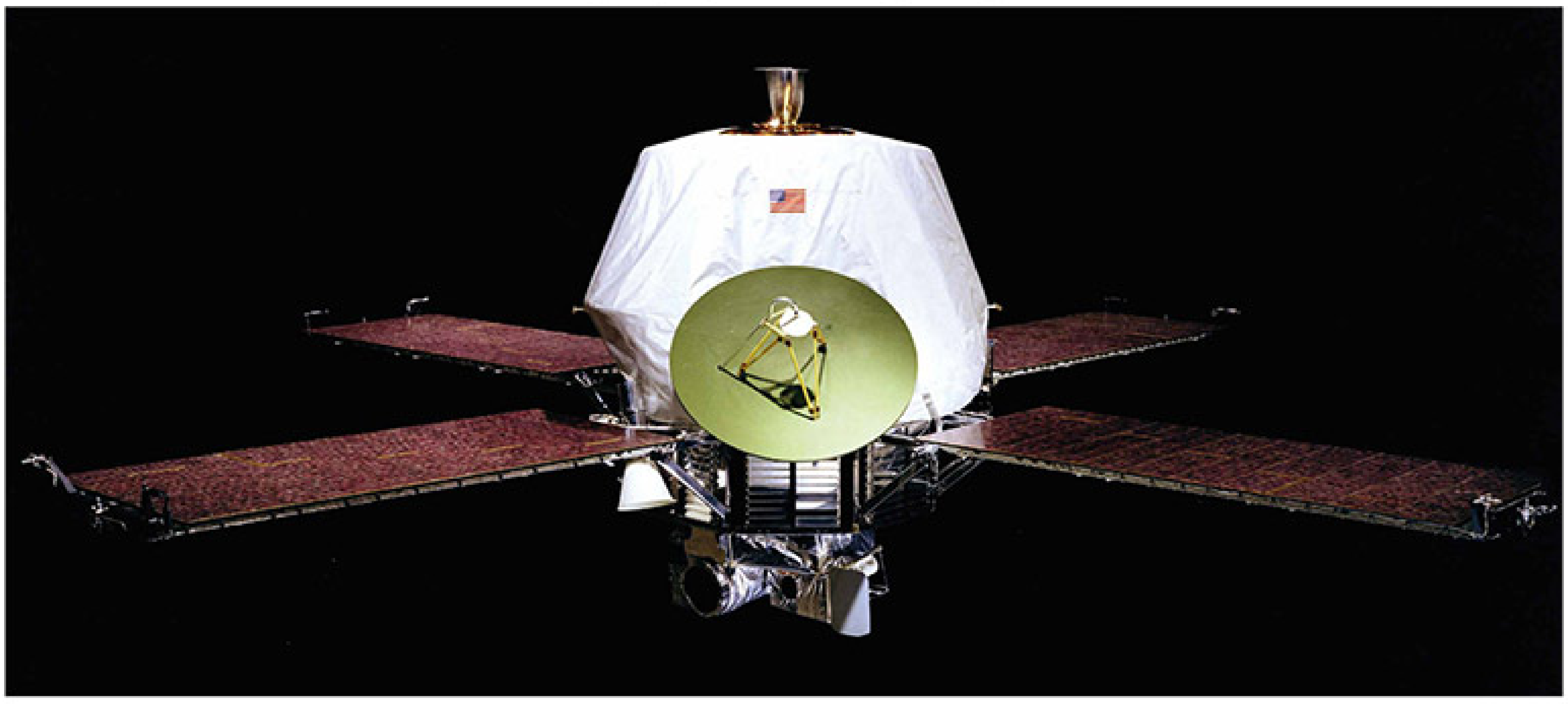
President John Kennedy presents medal to Alan Shepard



GRAVITY

"ASSISTS" MARINER

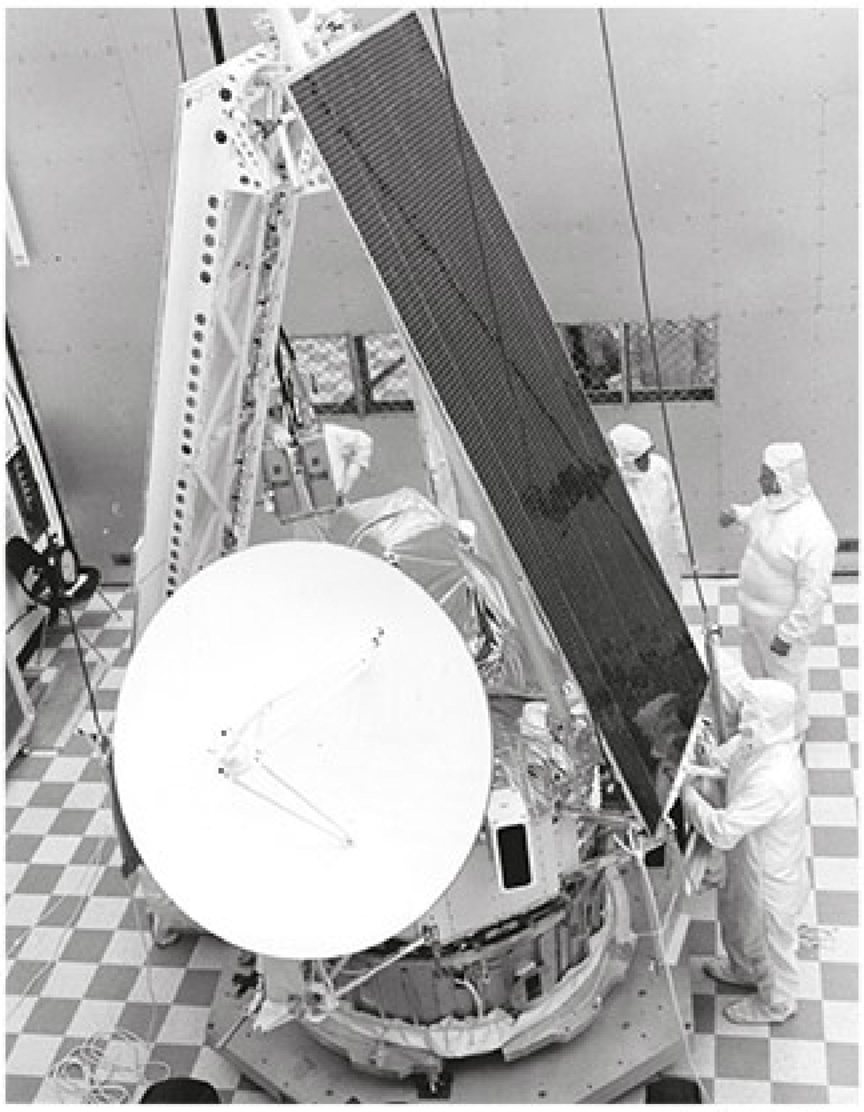
1963 - 1973



Mariner is a project by NASA (1963-1973) designed to investigate Mars, Venus and Mercury. Seven missions are successfully launched, out of ten planned. The last such mission, Mariner 10, is the first U.S. probe to use a "gravity assisted" maneuver. This is achieved thanks to the calculations (performed without computers) of Giuseppe (Bepi) Colombo, who had anticipated the possibility of performing multiple Mercury flybys by taking advantage of Venus's gravitational pull.
The scientific objective of Mariner 10 is to measure Mercury's environment, atmosphere, surface, and mass.

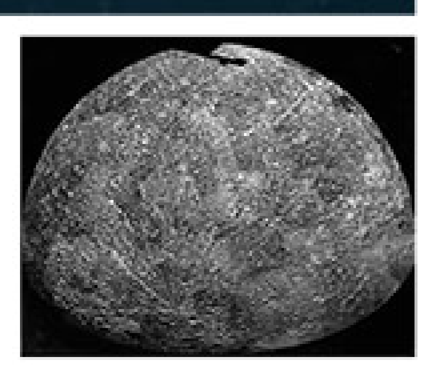
Some of its discoveries are:

- the mapping of 45% of Mercury's surface, taking pictures with a resolution up to 150 feet;
- the analysis of the thermal emission of the planet;
- the ultraviolet analysis of its atmosphere, which reveals traces of H, O, C, Ar, Ne, Xe;
- the observation of craters caused by impacting bodies, analogously to the Moon;
- the evidence that Mercury's core might be made of iron;
- an accurate measurement of its mass.



Assembly of a Mariner

Mariner 10



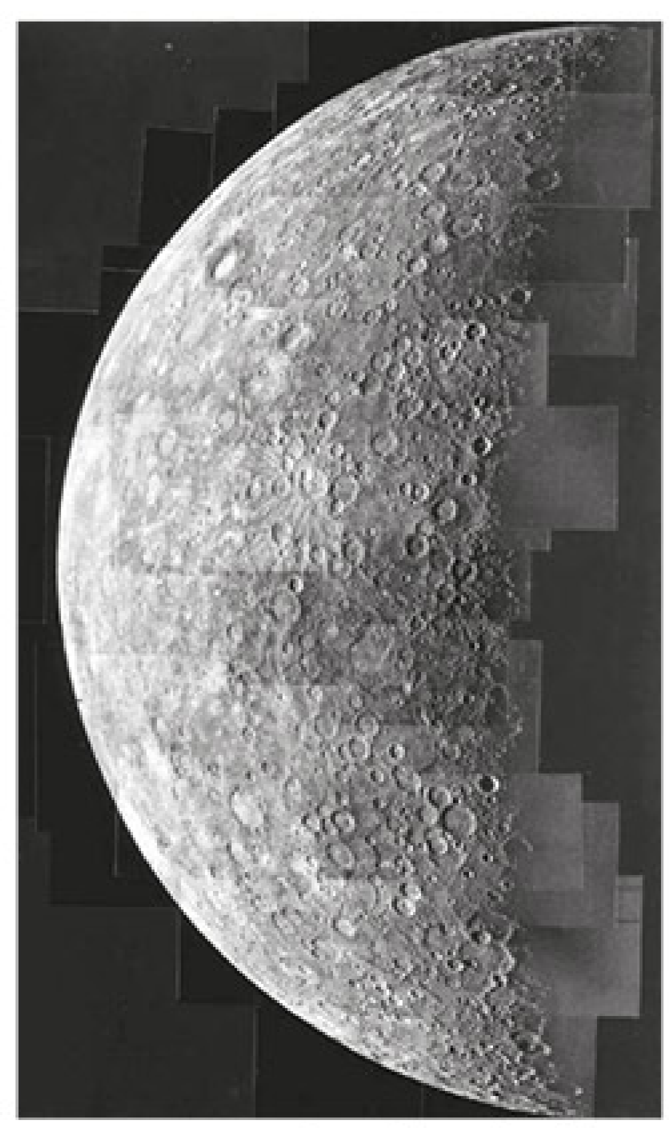
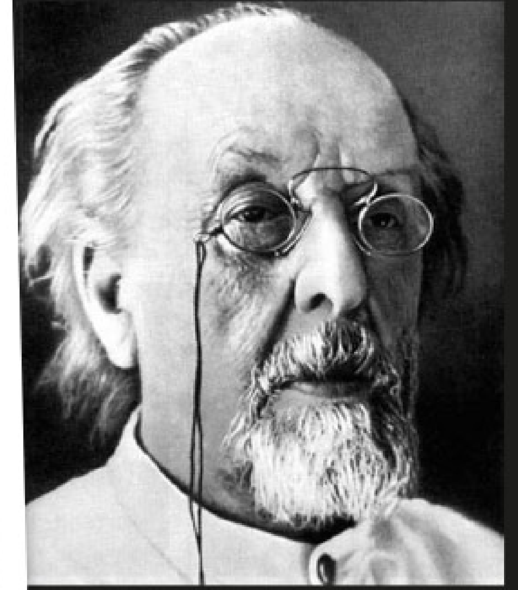


Image of the surface of Mercury

SPACE PIONEERS

"Earth is the cradle of humanity, but one cannot remain in the cradle forever"

Konstantin Tsiolkovsky
(1857 - 1935)
Russian physicist and aeronautical engineer



Completely self-educated, he became a Mathematics and Physics teacher despite his deafness. He laid the theoretical foundations for the new aerospace science. In his "The Exploration of Cosmic Space by Means of Reaction Devices" of 1903, he explained the use of rockets, their performance, the sources of resistance to their movement, and proposed his rocket equation, called "The Tsiolkovsky Formula". This formula is still at the basis of missile engineering. His studies went as far as multistage rockets, liquid propellant, space stations and interplanetary connections.

Gaetano Arturo Crocco
(1877 – 1968)
Italian physicist, mathematician and engineer

He was an Italian public official, scientist and professor, pioneer of aeronautics and rocket propulsion. After World War II, he resumed his rocketry and aeronautics studies, founding the Italian Rocket Society in 1951. In 1956, at the Aeronautical Congress IAF in Rome, Crocco, by then over 80 years old, presented a memoir called "Year long Exploration of Earth-Mars-Venus-Earth". His idea was based on exploiting the gravitational fields of Mars and Venus as propelling forces to reduce the travel time. The importance of his intuition, now a scientific theory known as 'gravitational slingshot' or 'gravity assist' or 'swing-by', was such that, in the following years, NASA recommended to ground the study of interplanetary voyages on the "Crocco Mission". Asteroid 10606 Crocco and Crocco Crater on the Moon are named after him.

"It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow"

Robert Goddard
(1882 - 1945)
American physicist and aeronautical engineer

He began by developing at his own expense systematic studies on the propulsion provided by various types of gunpowder. In 1919 he published "A Method of Reaching Extreme Altitudes", where he laid the foundations for building a rocket, which he actually did. On March 16 1926 in Auburn, Massachusetts, he successfully flew the first liquid-propellant rocket (kerosene and oxygen); this first flight would be as important in history as the first flight by the Wright Brothers in Kitty Hawk. Throughout his life he obtained more than 200 patents in space technology. In 1959, NASA established their main space flight center in Greenbelt, Maryland, in his memory.

"To make available for life every place where life is possible. To make inhabitable all worlds as yet uninhabitable, and all life purposeful"

Hermann Oberth
(1894 - 1945) Romanian-born German physicist and mathematician

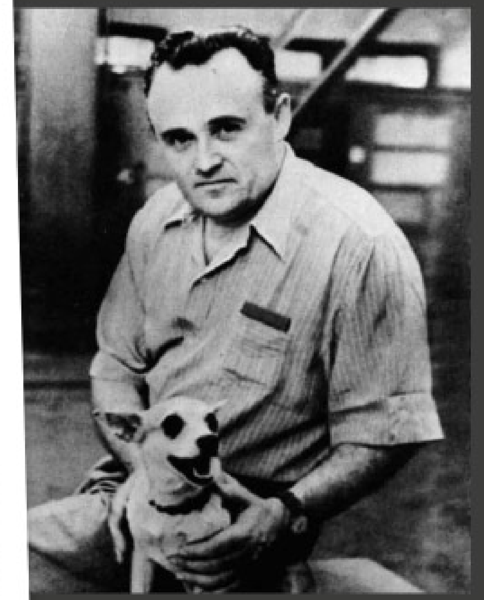
At a very young age, he became intrigued with space travel and concluded that liquid-fueled rockets could be developed. His main contribution to rocketry was developing the concept of multistage rockets. The first rocket based on his design, for which he had registered a patent, was launched in 1931 near Berlin.

Mikhail Tikhonravov
(1900 – 1974)
Russian engineer

After his graduation in 1925, he became an expert in the field of aircraft design. In 1932 he started working with Sergei Pavlovich Korolev and participated in designing the first liquid-fueled Russian rocket, launched in 1933. In 1935 he became the head of one of the departments of OKB-1, Korolev's Experimental Design Bureau, and played a central role in the design of the Sputnik satellites, of the Vostok spacecraft and of the first Moon space probes. He became professor at the Moscow Aviation Institute in 1962 and received several Russian awards.

"The road to the stars is open"

Sergej Korolev
(1907 – 1966)
Russian engineer



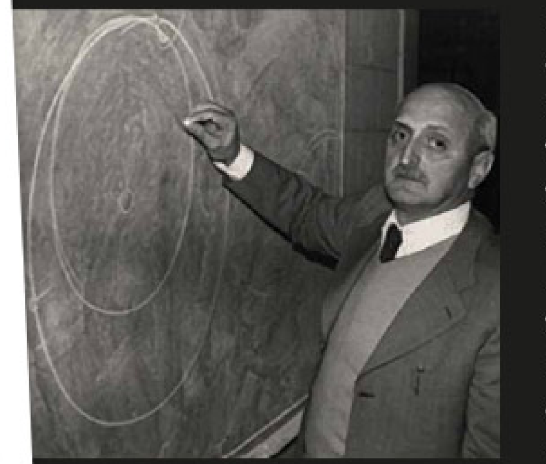
He was born in Ukraine. At 17 he designed a glider. Fascinated by Tsiolkovsky's writings, he was the creator of the first Russian liquid-fueled rocket. Unjustly suspected during the first Great Purge of Stalin, he was arrested on June 1938 and sentenced to ten years in a Gulag labor camp. In 1944 he visited the German production sites of the V2 rockets. He later designed the intercontinental rocket R-7 Semyorka, the Sputnik propeller (which carried the first satellite into space), and achieved several more records.

"It (the rocket) will free man from his remaining chains of gravity which still tie him to this planet. It will open to him the gates of heaven"

Wernher von Braun
(1912 - 1977)
German-born American physicist and engineer

As a child, he was introduced to the study of space by his mother, an engaged astronomer who gave him a telescope as a gift. But inspiration came when he read Oberth's book, "A Rocket to the Interplanetary Space." Von Braun was the man who reached space, combining the help of the army and his innate pragmatism for experimentation, in the only road to prove a mathematical theory. He designed and constructed the V-2, the precursor of all rockets that would later allow the conquest of space. Would mankind have reached the Moon without him? If so, in what era?

Giuseppe (Bepi) Colombo
(1920 – 1984)
Italian physicist, mathematician and engineer



Born in Padua, he completed his studies in Pisa. In 1970 he was invited by NASA to join JPL (Jet Propulsion Laboratory) where the Mariner 10 Project was being developed. Mariner 10 was built for the exploration of Venus, which it reached 3 months after its launch. After traveling for two more months, it reached Mercury. Colombo calculated that after the flyby of Mercury, the period of the probe's orbit would amount to twice the period of revolution of the planet itself, and suggested taking advantage of such resonance to plan for multiple flybys of Mercury. In the following months, the physicists and engineers of JPL implemented his calculation in the mission plan. It allowed three flybys of Mercury at the cost of one, before the probe ran out of propellant.

John Glenn
(1921 –)
American astronaut

One of the "Mercury Seven" astronauts, he was the first American to orbit Earth on February 20 1962. After leaving NASA in 1964, he served as US Senator from Ohio from 1974 to 1999. In 1998, at age 77, he participated in the Space Shuttle STS-95 mission. He thus became the only astronaut to fly in both the Mercury and Space Shuttle programs. In April 2003, John and his wife celebrated their seventieth wedding anniversary.

Edward White
(1930 – 1967)
American astronaut

A navy pilot, he was selected for the astronaut program in 1962. On June 3 1965, he became the first man to "walk" in space on board the Gemini 4 mission. Extremely trustworthy and capable, fellow astronaut and friend Frank Borman defined him "A true West Point man. To him, Country, Honor and Duty were not just words; they were his own person." White died along with his fellow astronaut Virgil"Gus" Grissom and Roger B. Chaffee during prelaunch testing for the first manned Apollo mission at Cape Canaveral. He was awarded the NASA Distinguished Service Medal for his flight in Gemini 4 and then awarded the Congressional Space Medal of Honor posthumously.

"That's one small step for [a] man, one giant leap for mankind"

Neil Armstrong
(1930 – 2012)
American astronaut

A participant in the U.S. Air Force's Man in Space Soonest and X-20 Dyna-Soar human spaceflight programs, Armstrong joined the NASA Astronaut Corps in 1962. He made his first space flight as command pilot of Gemini 8 in March 1966, becoming NASA's first civilian astronaut to fly in space. He entered history as the first man to walk on the Moon's surface on July 20 1969, as commander of Apollo 11. He left NASA in 1972 but continued working in the aerospace industry until his death on August 25.

"The earth is blue. How wonderful. It is amazing"

Yuri Gagarin
(1934 – 1968)
Russian astronaut

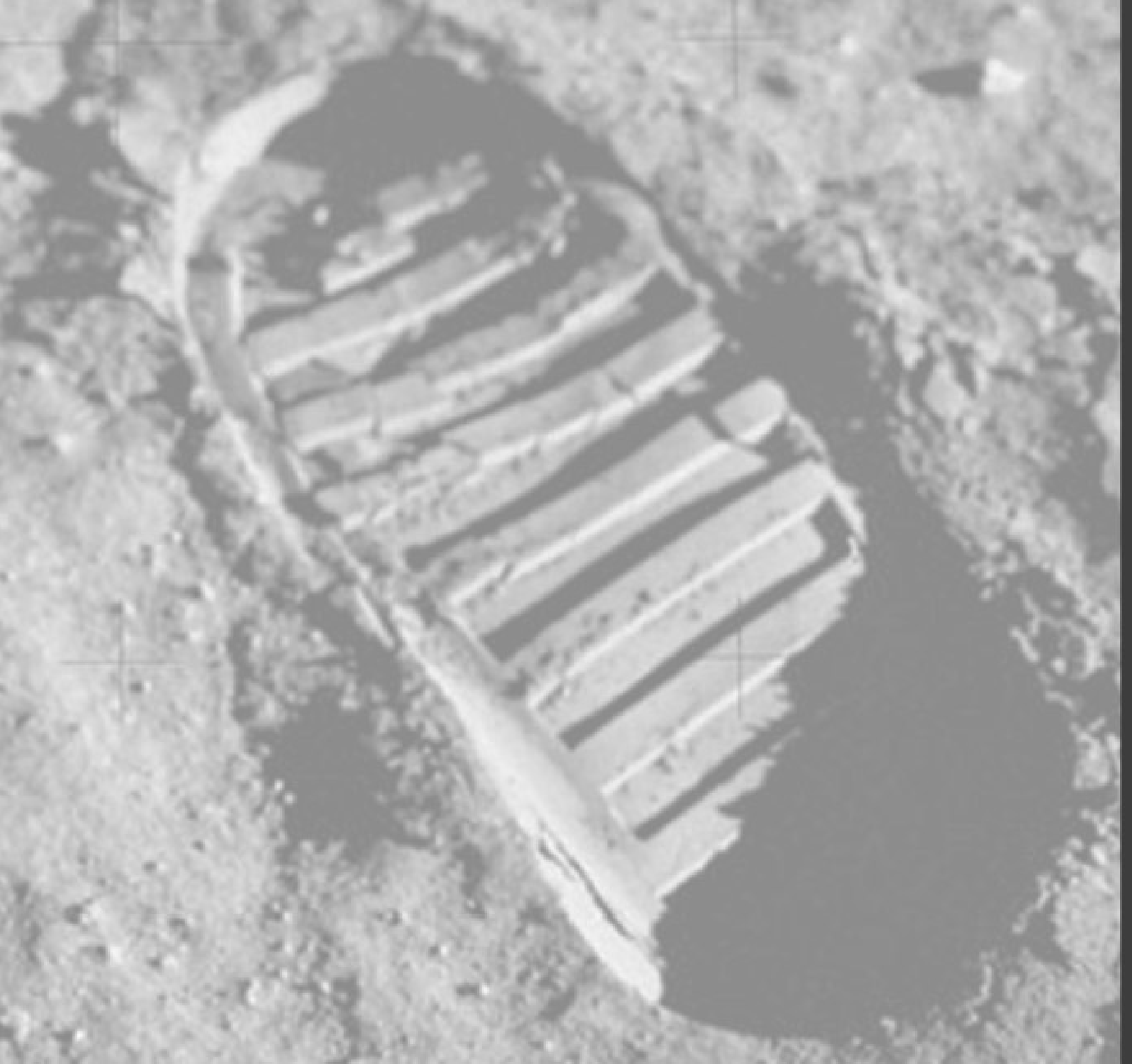
He was the first man to journey to space on April 12 1961. Gagarin worked as a test pilot from 1957 to 1959, when he was selected to the Vostok cosmonaut program. During his first, historic flight, he was the first man to see Earth from space. He reported to Moscow and to the whole world: "The earth is blue. [...] How wonderful. It is amazing." Celebrated as a national hero in the Soviet Union, he died on March 27 1968, when the MiG-15 training jet he was piloting crashed.

"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard"

John Fitzgerald Kennedy,
25 settembre 1961

THAT'S ONE SMALL STEP...

Apollo is the third U.S. manned spaceflight program. It is a continuation of the Gemini Program and is designed to land humans on the Moon by 1969, according to president Kennedy's wishes.
The Apollo capsule consists of a command module and a service module and can host 3 astronauts. After Apollo 8, the LEM (Lunar Excursion Module), is introduced.



The Apollo capsule is launched on a Saturn V rocket, the most powerful rocket ever built, designed by Von Braun's genius. On the Apollo mission, the three astronauts have different jobs: a commander, a command module pilot and a service module pilot.
The program starts off tragically when a flash fire occurs on the launch pad during a preflight test for Apollo 1, resulting in the death of the crew. The program resumes in October 1968, with several launches in rapid succession. July 20 1969 sees the first historic walk on the surface of the moon by Neil Armstrong and Buzz Aldrin, members of the Apollo 11 mission.

"That's one small step for a man, one giant leap for mankind", said Armstrong, the first man to set foot on the moon. This phrase would achieve a symbolic status in the Apollo program.
After Armstrong, thirteen more men would walk on the Moon for a total of seven successful missions and six moon landings.

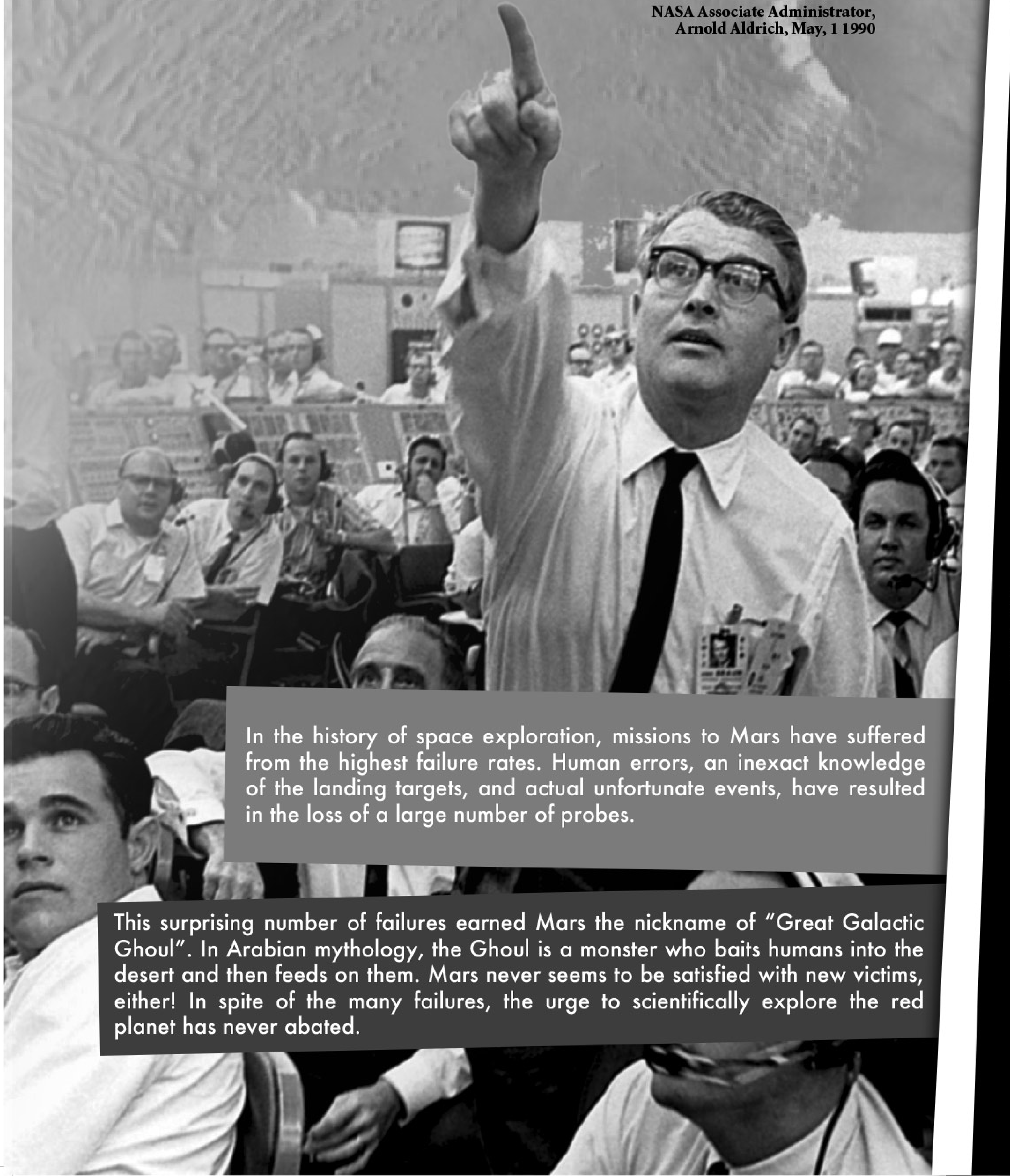
"That's one small step for a man, one giant leap for mankind"

Neil Armstrong

THE GREAT GALACTIC GHOUL

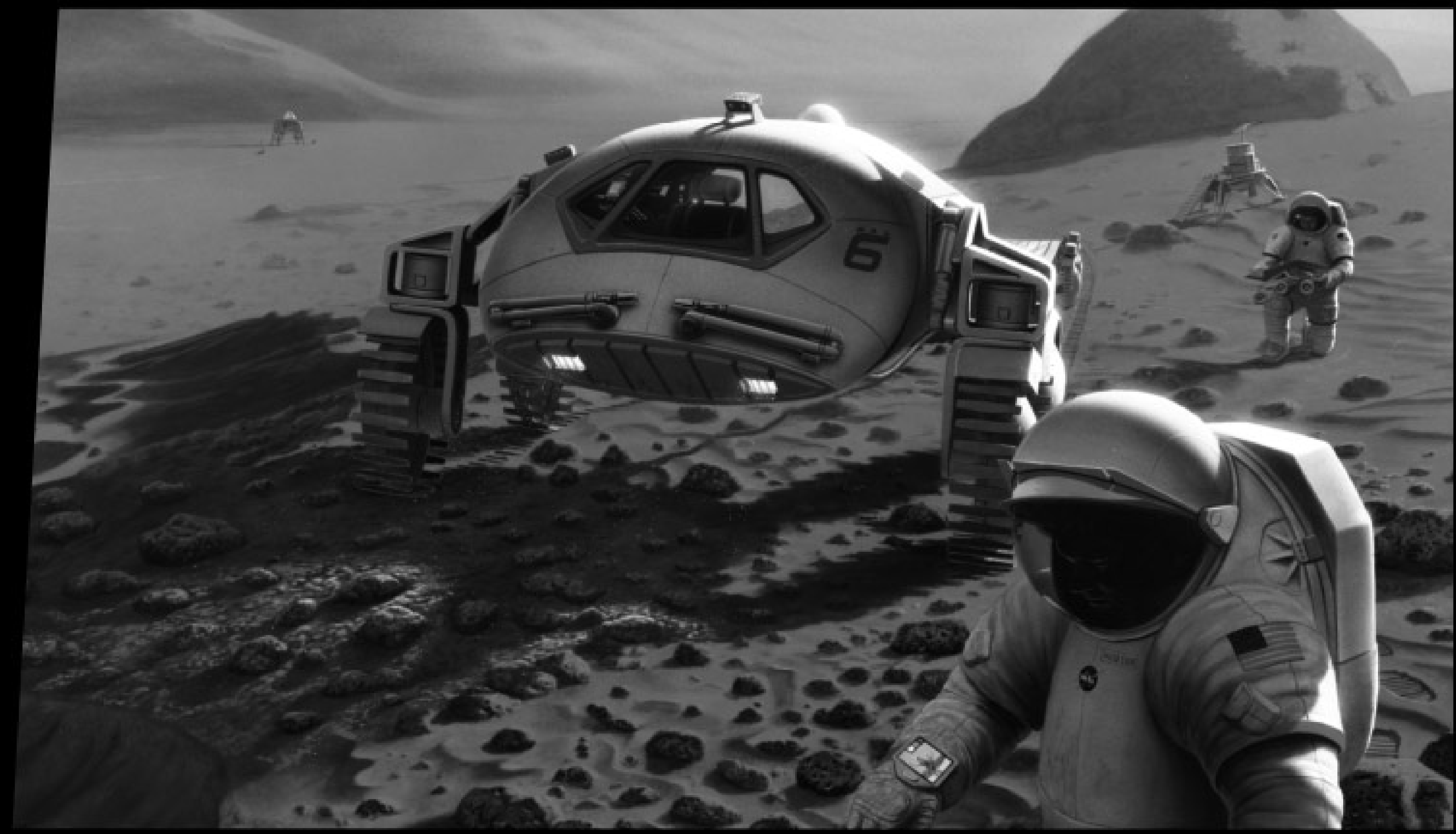
> "Mars responds to a fundamental need in all of us. There is a human imperative to explore. People must explore because they are human beings with a desire to expand the scope of human experience. Exploration adds to our knowledge, satisfies our curiosity, and responds to our sense of adventure. We are going to Mars because we are alive, and because it reflects something very special inside each and every one of us"

NASA Associate Administrator,
Arnold Aldrich, May, 1 1990



In the history of space exploration, missions to Mars have suffered from the highest failure rates. Human errors, an inexact knowledge of the landing targets, and actual unfortunate events, have resulted in the loss of a large number of probes.

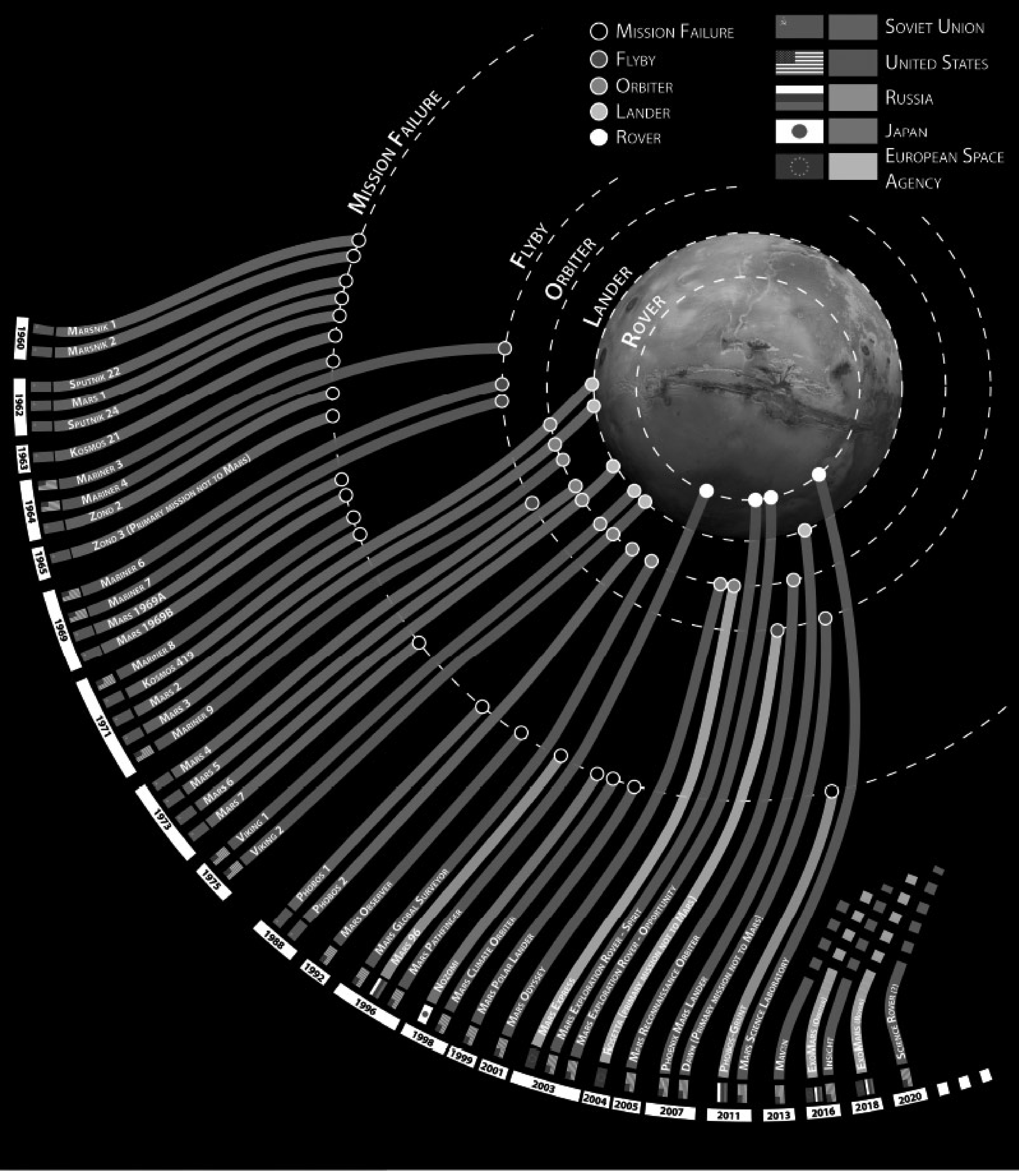
This surprising number of failures earned Mars the nickname of "Great Galactic Ghoul". In Arabian mythology, the Ghoul is a monster who baits humans into the desert and then feeds on them. Mars never seems to be satisfied with new victims, either! In spite of the many failures, the urge to scientifically explore the red planet has never abated.

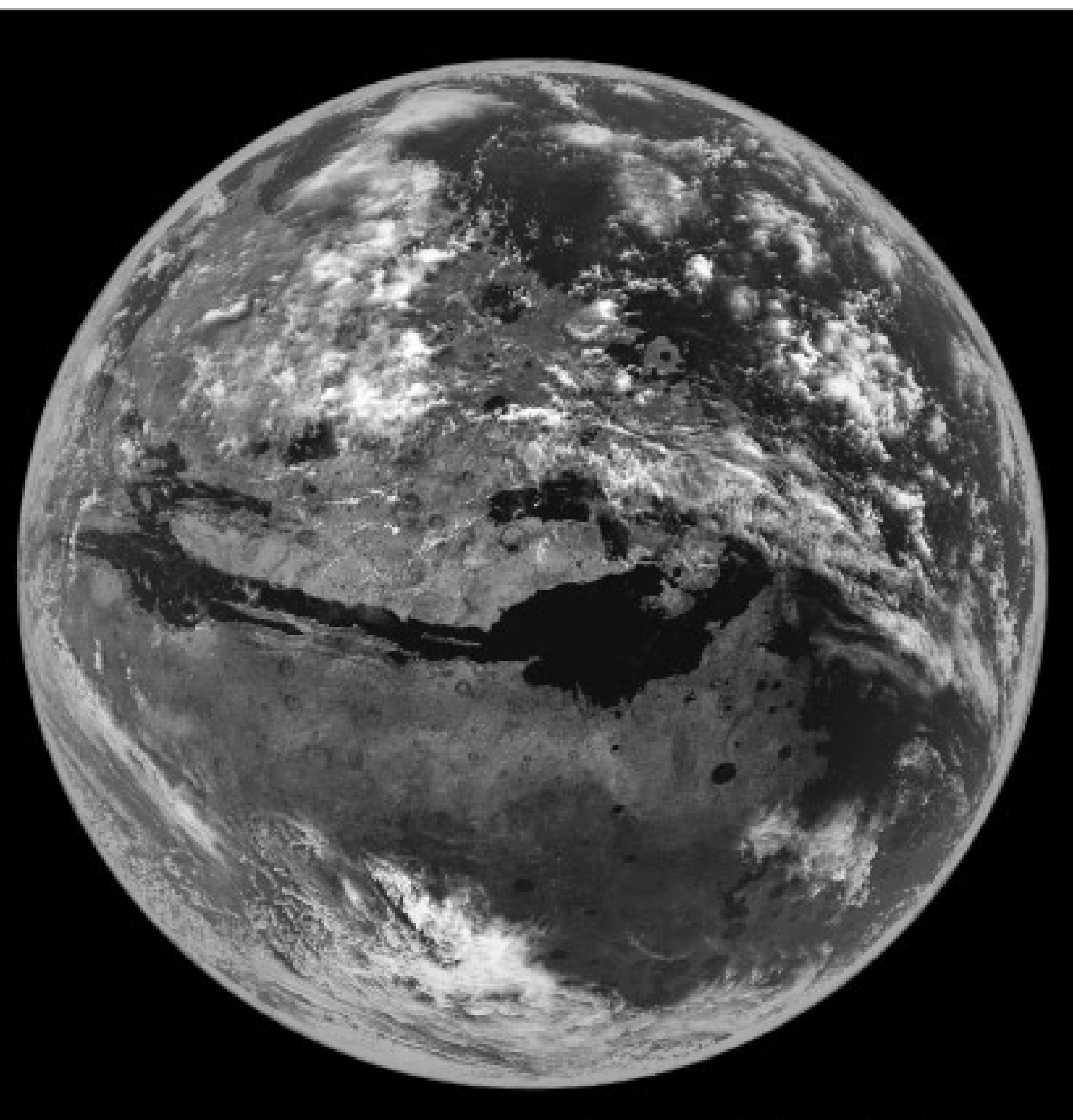


Drawing from NASA, depicting the colonization on Mars (1990s).

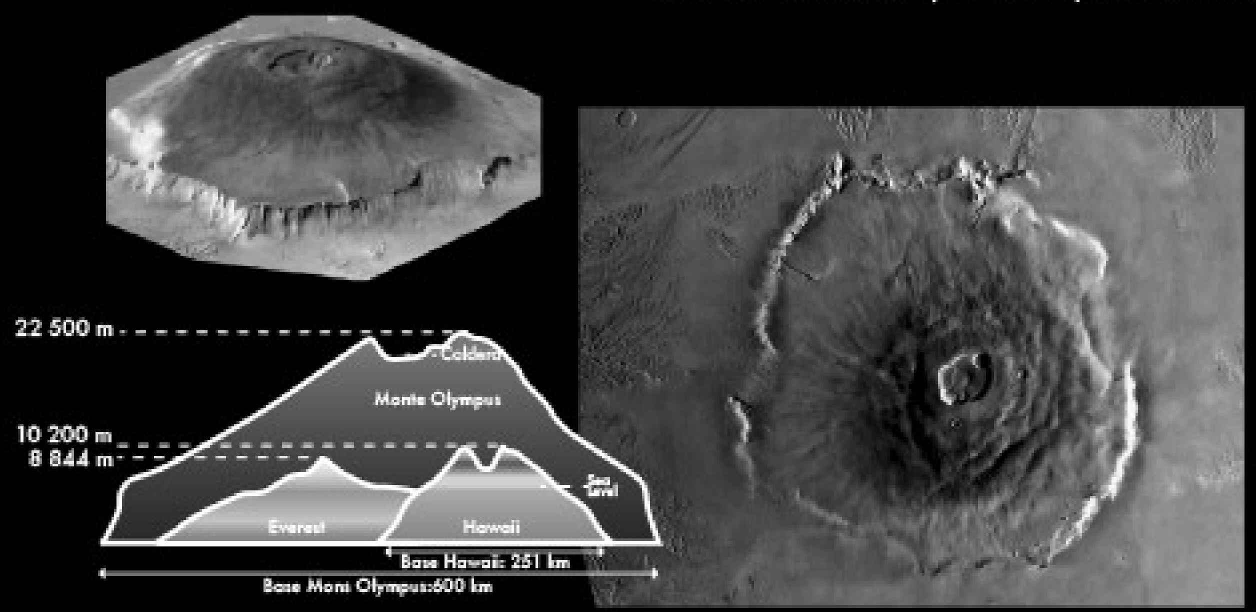
PEOPLE ON MARS?

Mass media often showcase the idea that colonizing Mars is the next natural step after successfully visiting the moon. However, several reasons make the human journey to Mars unlikely. First of all, current propulsion systems do not support a spaceship capable of carrying people to Mars and return them to Earth. Moreover, the experience of space stations shows that the human body cannot live for long stretches of time without gravity: muscles waste away, bones suffer from osteoporosis, alterations happen to the cardiovascular system, to the nervous system and to the balance system. Moreover, solar radiations are more intense outside the Earth magnetic field and can lead to alterations in the immune and reproductive systems and facilitate the onset of cancer. What would happen to a man forced to travel in interplanetary space for over a year?
In spite of all these problems, though, von Braun's dream to colonize Mars has been getting the support of thousands of people, willing to forsake their life on Earth for an unknown Martian life. Several private companies are developing Mars colonization projects, including SpaceX, the Mars Foundation and Mars-One. But what are we looking for in such an inhospitable destination? Can we reasonably think that Mars offers more possibilities than Earth?

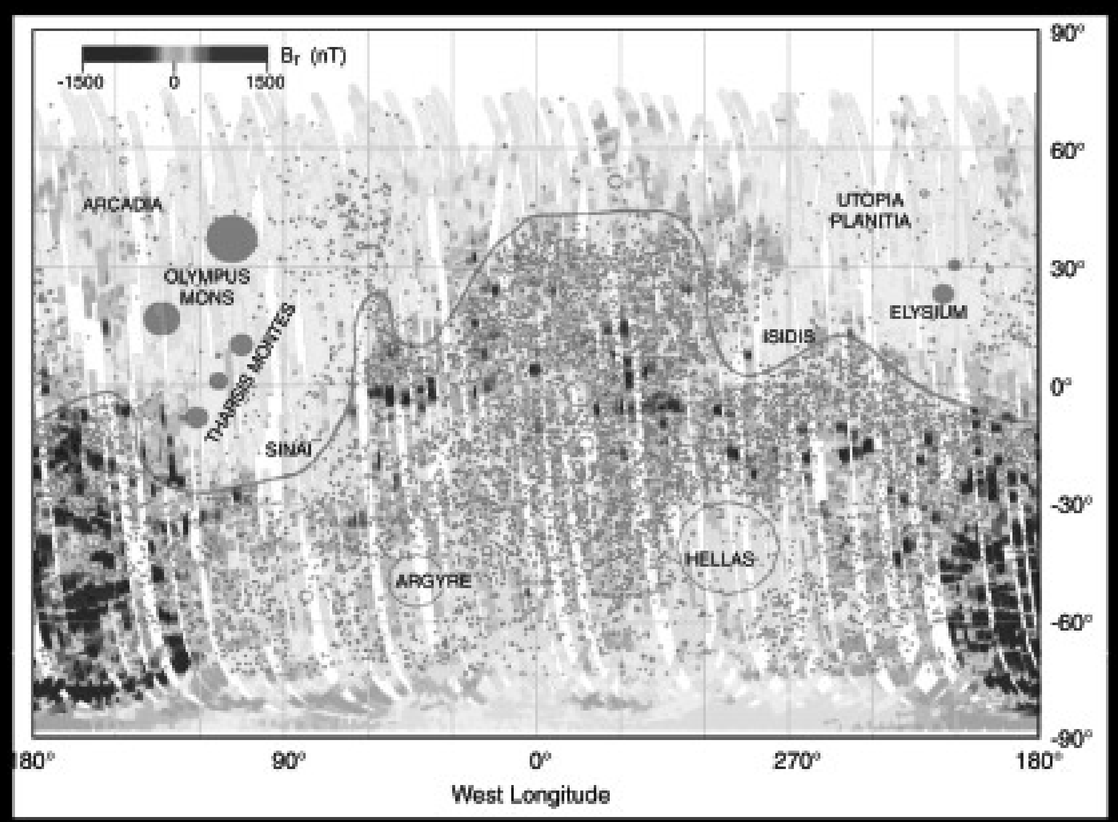




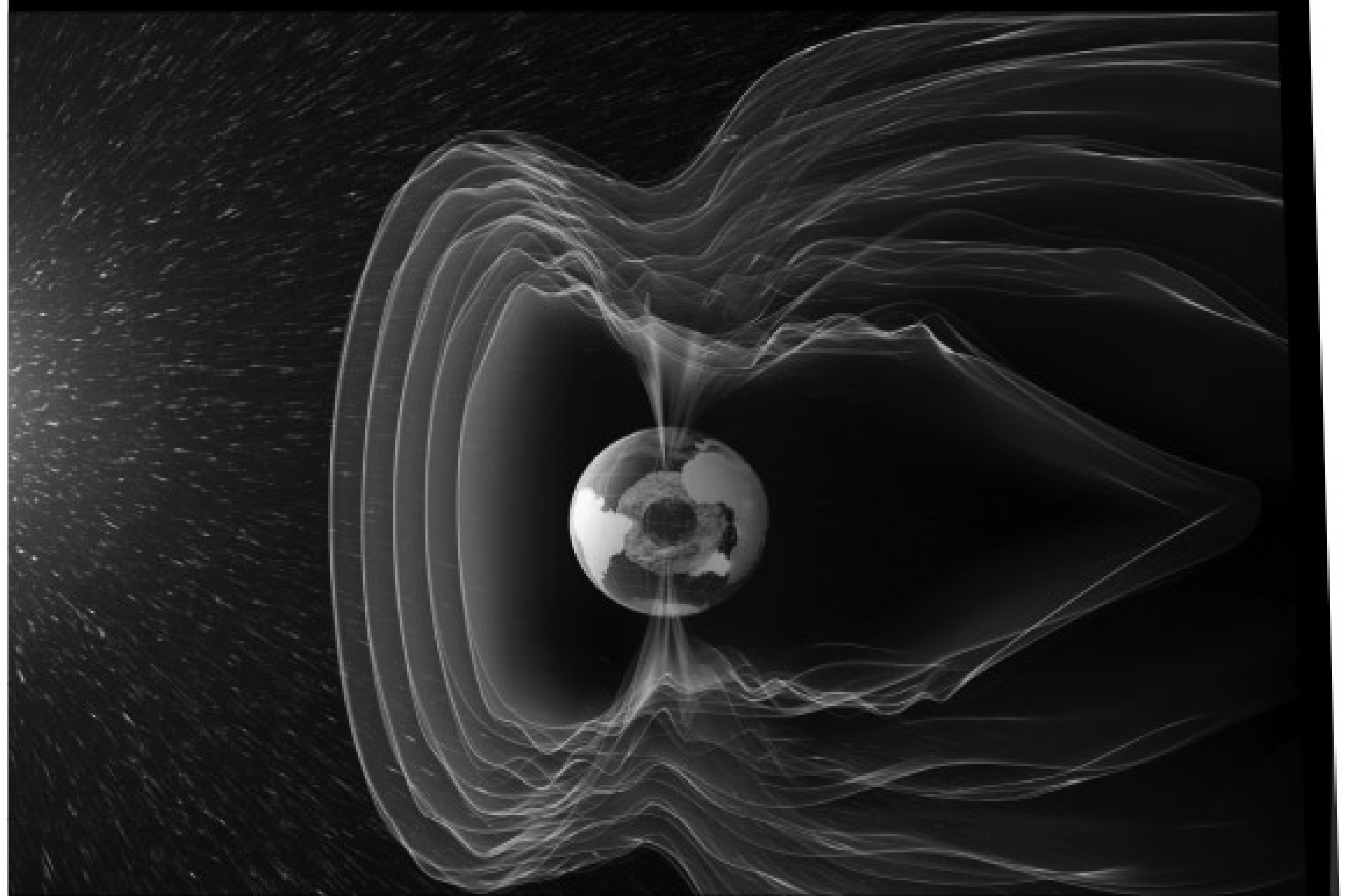
What Mars would look like if liquid water were present on its surface.



Mons Olympus: 17 miles high, it is the tallest mountain in the solar system. Its size is likely due to the lack of plate tectonics: the crust does not move and therefore the hot spot underneath has been producing lava for millions of years, always in the same spot.



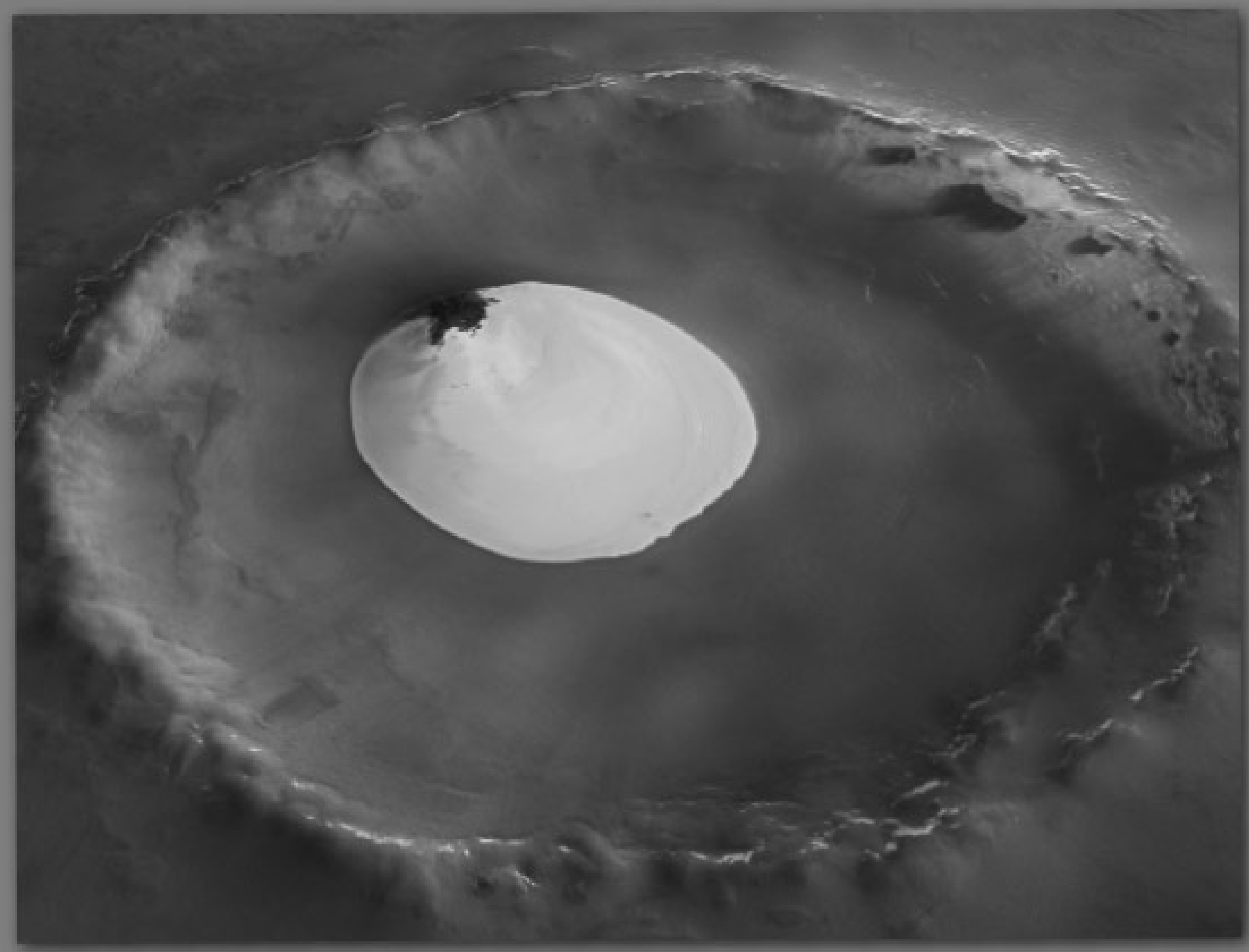
The Martian Magnetic Field, as measured by the Mars Global Surveyor probe. Anomalies can be observed in the distribution of magnetic filed lines, which don't reach the poles.



The Terrestrial Magnetic Field, in a reconstruction by ESA.

WATER AND METHANE

The search for life is tightly connected to the search for liquid water and methane. The amount of methane measured on Mars is not sufficient to guarantee the existence of any form of life. At the same time, the low temperature and low atmospheric pressure do not allow for liquid water on the planet's surface. However, evident signs of erosion in channels and rocks and the presence of calcium carbonate indicate that water must have been present on Mars in the past.



LOOKING FOR LIFE ON MARS

PROS AND CONS OF MARTIAN GEOLOGY

The intensity of the magnetic field on Mars is much lower than on Earth. This lack of magnetic protection from the solar wind could be among the factors causing the rarefaction of the Martian atmosphere. This effect is connected to the planet's geology. Contrary to what happens on Earth, we think that on Mars there are no currents of molten rock moving in the planet's core. This would cause the observed suppression in magnetic field.

> **"Mars is at a primitive stage of plate tectonics. It gives us a glimpse of how the early Earth may have looked and may help us understand how plate tectonics began on Earth"**
>
> An Yin, Earth, Planetary and Space Sciences, University of California, Los Angeles.

"The environmental conditions on the Earth today are not the same as when life first arose on this planet. For life to survive, the nutrients need to be renewed and this can only be done by active geological processes [...]. A major problem on Earth is that plate tectonics have eliminated all of the first 500 million years of rock history and severely altered the next 500 million years [...], when life arose and took a foothold. This gap in our knowledge can be filled by studying other planets that did not develop plate tectonics and still have a record of the early environmental conditions. Mars is an ideal goal. [...] Mars had an early history that was similar to that of the early Earth and conditions that were suitable for the appearance of life".

(Cosmic Visions, ESA space exploration roadmap, 2015-2025)

AT THE EDGE OF THE SOLAR SYSTEM

"When the Voyagers launched in 1977, the space age was all of 20 years old. Many of us on the team dreamed of reaching interstellar space, but we really had no way of knowing how long a journey it would be — or if these two vehicles that we invested so much time and energy in would operate long enough to reach it"

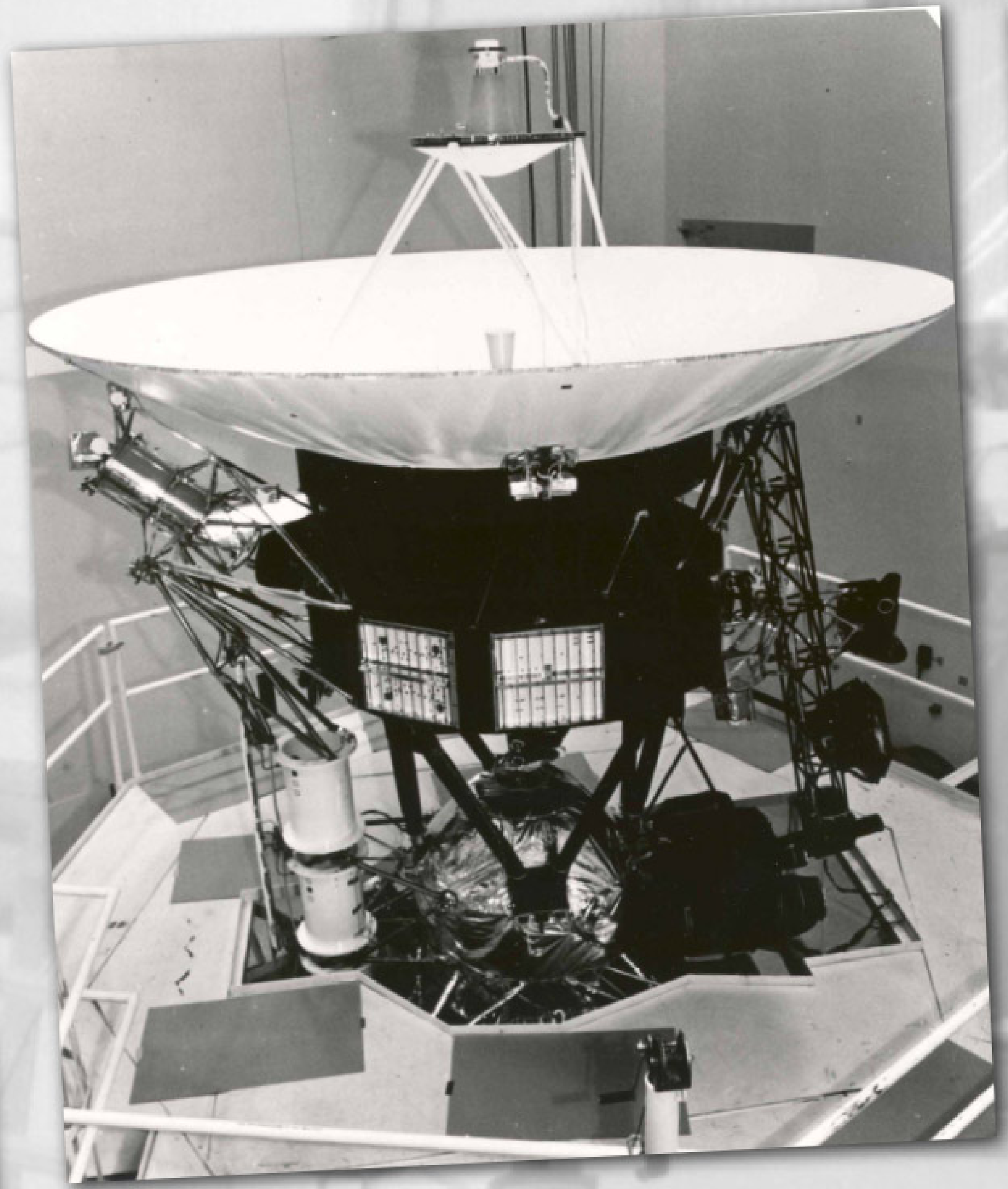
Edward Stone,
Voyager Project Scientist
JPL Director 1991-2001

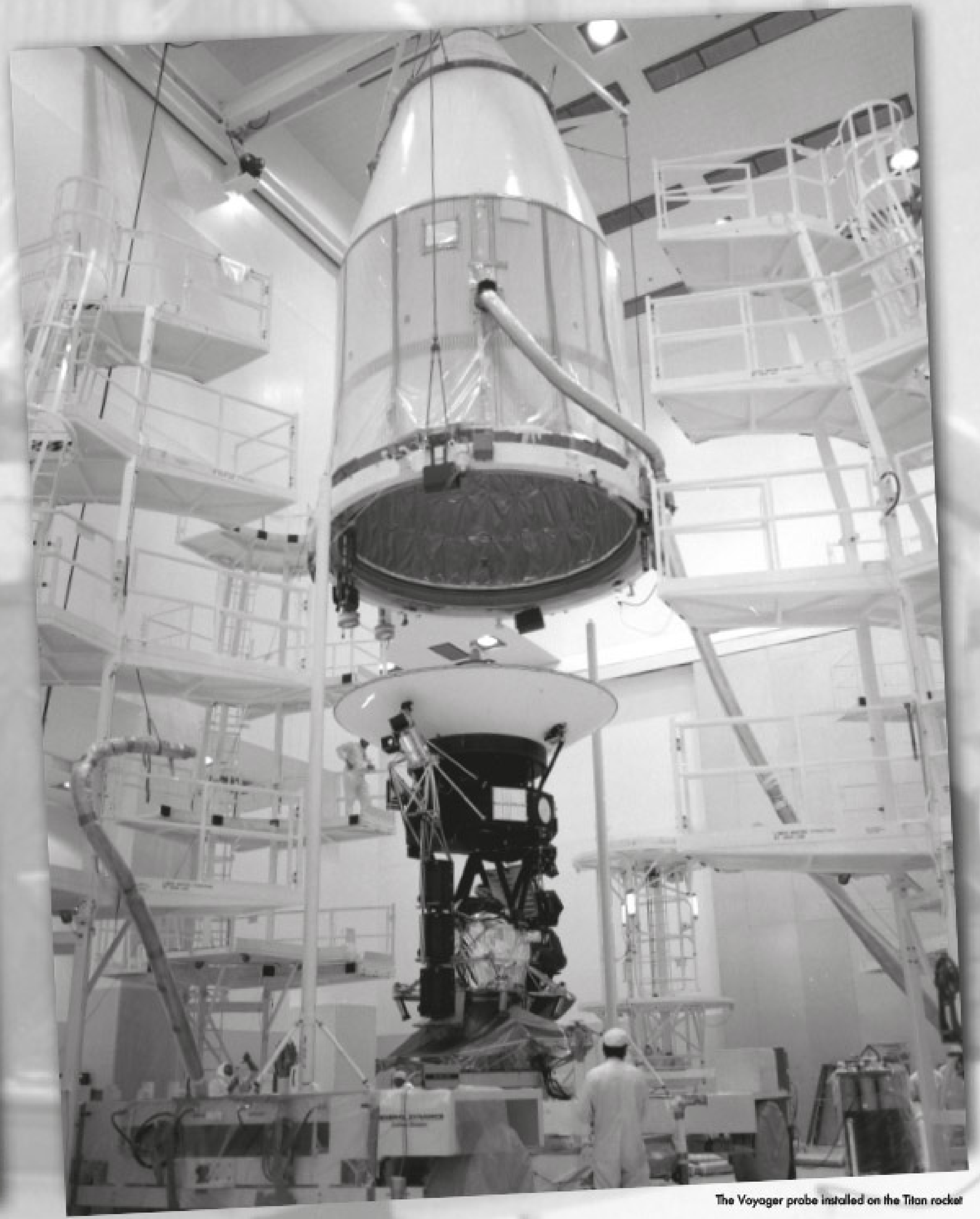
Edward Stone

"Man needs the unfathomable and the infinite just as much as he does the small planet which he inhabits"

Fëdor Dostoevskij

The Voyager Program followed in the footsteps of the successful space programs that started in the late 1950s and landed a man on the moon in just a little more than ten years.
The original idea of the mission was to complete a Grand Tour of the outer planets (Pluto included), using multiple pairs of probes and taking advantage of a favorable planetary alignment. The program was downsized due to budget cuts, and at first it was to be included in the Mariner Program (the two probes were to be named Mariner 11 and 12). Later, the program would be renamed Voyager, to underline the tremendous amount of progress achieved since the Mariner days.





The Voyager probe installed on the Titan rocket

The final design consisted of two probes weighing about 1800 pounds each, with 55 feet aperture. Each probe carried 11 instruments, some of which implemented cutting-edge technologies. The mission was budgeted to over 900 million dollars, including operational costs. Edward Stone was appointed supervisor of the program in 1972, and has continued in this role to this day. The mission was scheduled to last 20 years, but was extended after a successful tour of the outer planets.

Primary Mission

"The primary mission was the exploration of Jupiter and Saturn. After making a string of discoveries there – such as active volcanoes on Jupiter's moon Io and intricacies of Saturn's rings – the mission was extended. Voyager 2 went on to explore Uranus and Neptune, and is still the only spacecraft to have visited those outer planets. The adventurers' current mission, the Voyager Interstellar Mission (VIM), will explore the outermost edge of the Sun's domain. And beyond."

Interstellar Mission

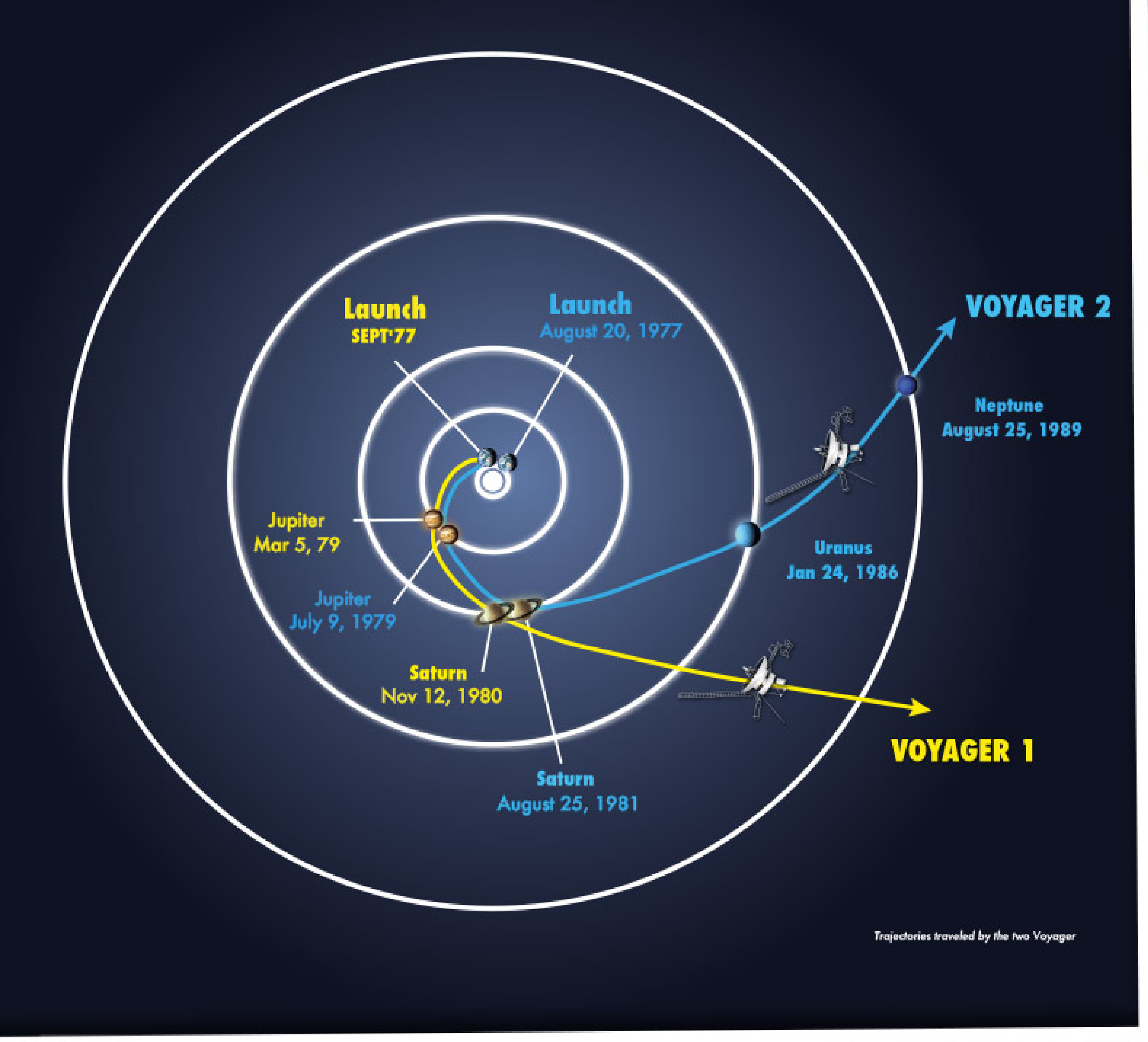
"The mission objective of the Voyager Interstellar Mission (VIM) is to extend the NASA exploration of the solar system beyond the neighborhood of the outer planets to the outer limits of the Sun's sphere of influence, and possibly beyond. This extended mission is continuing to characterize the outer solar system environment and search for the heliopause boundary, the outer limits of the Sun's magnetic field and outward flow of the solar wind. Penetration of the heliopause boundary between the solar wind and the interstellar medium will allow measurements to be made of the interstellar fields, particles and waves unaffected by the solar wind." (from the Voyager Website,

(From the Voyager; http://voyager.jpl.nasa.gov/)

Reconstruction of the Heliosphere

Outer region of the LL-Ora star, in the Orion Nebula. We can observe how the interstellar medium is deflected by the star's sphere of influence, just as it happens at the outer limits of the Heliosphere.

PLANETARY HIGHWAYS

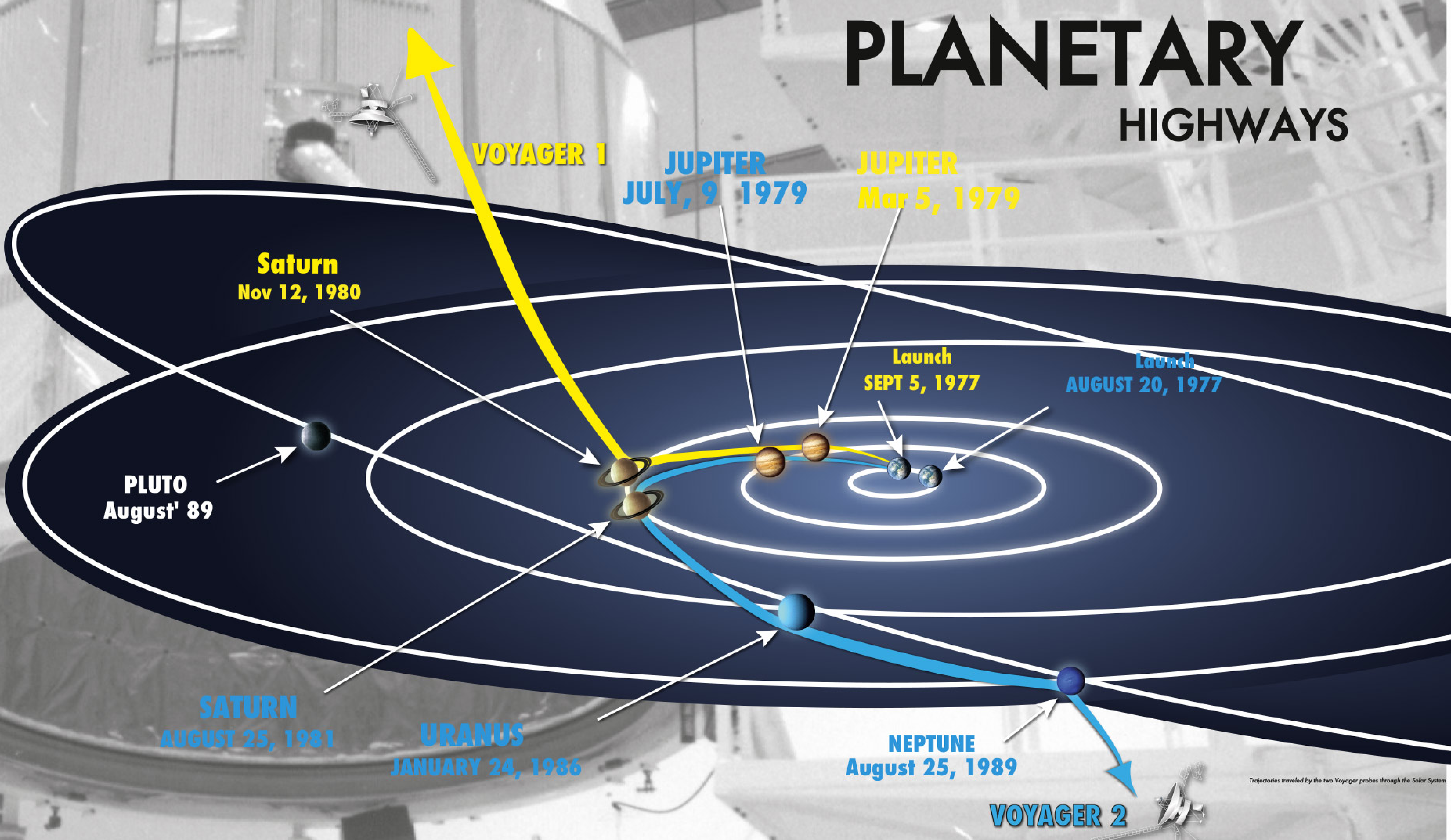


Since the early days of rocket science, it was understood that covering the huge distances to the outer planets and beyond the edge of the Solar System would be impossible with on-board propellers, because of the main gravitational source in our Planetary System: the Sun. In order to overcome such gravitational "brake", a special expedient is used, called Gravity Assist (or"gravitational slingshot"). After the probe leaves the Earth orbit, it reaches the other planets and is pushed forward by their motion, increasing its speed to the point of overcoming the escape velocity of the Solar System, which is around 26 miles/s.

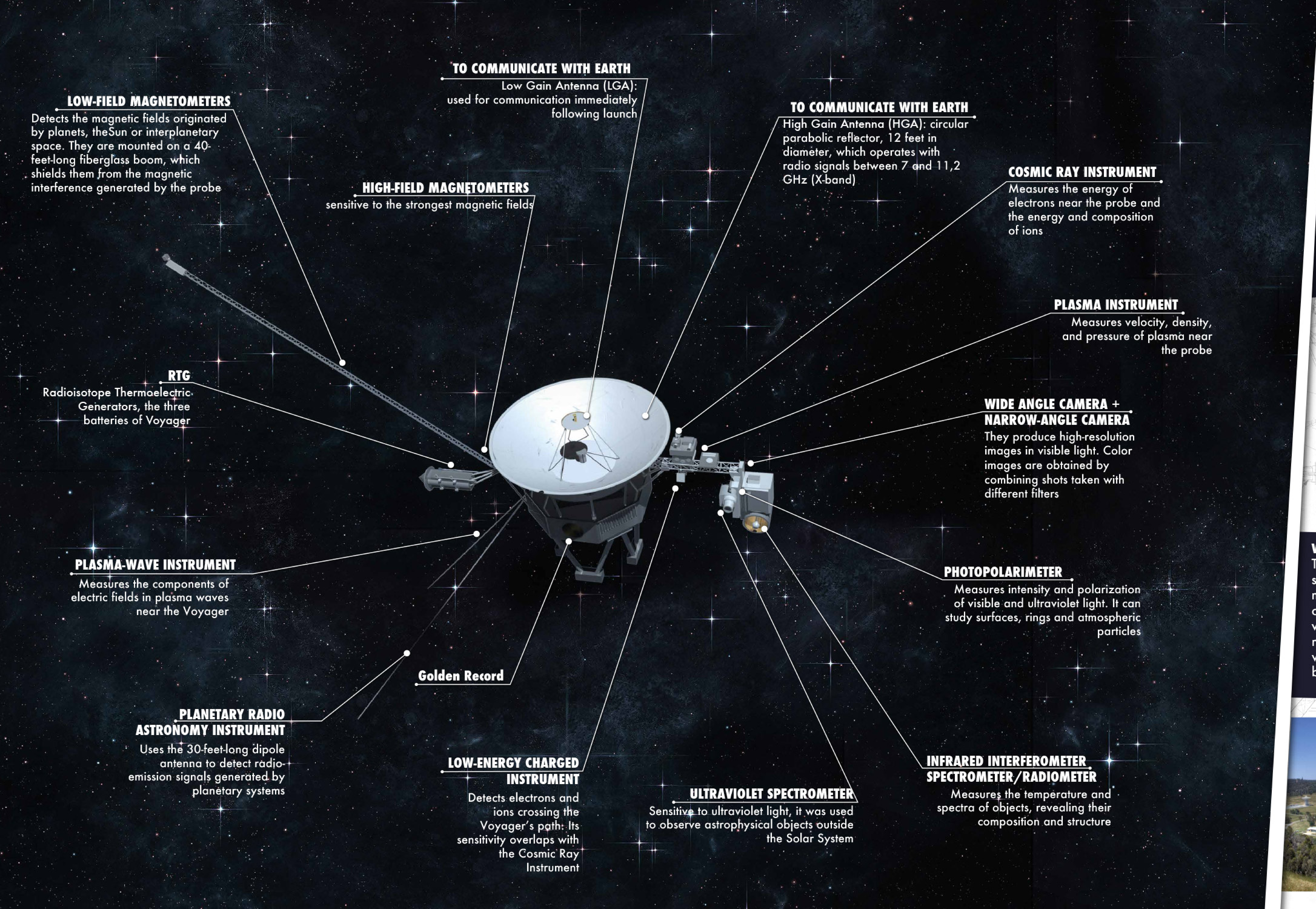
If we know the planetary configuration at a given date, we can show up in the right place at the right time, by using favorable paths, which take advantage of multiple gravitational slingshots. Thus, we can travel on real "highways" that become available for limited periods of time in the Solar System.
The time window that the Voyager mission used in 1977 lasted only a few months. Thanks to a special arrangement of the planets, the Voyager probes traveled to the outer edge of the Solar System. A similar arrangement of planets will happen again only in 2152 (175 years after launch)!
In order to allow for small corrections, the probe was equipped with small engines, which also helped with the orientation of the onboard instruments, especially the main antenna.

"Our burning question as to the whence and whither — all we can ourselves observe about it is the present environment. That is why we are eager to find out about it as much as we can. That is science, learning, knowledge; it is the true source of every spiritual endeavour of man"

(Erwin Schrödinger, Science and Humanism, 1951)



- **1977** — Mariner Jupiter/Saturn 1977 is renamed Voyager
- **1977 AUGUST 20** — Voyager 2 launched from Kennedy Space Flight Center
- **SEPTEMBER 5 1977** — Voyager 1 launched from Kennedy Space Flight Center
- Voyager 1 returns first spacecraft photo of Earth and Moon
- **1979 MARCH 5** — Voyager 1 makes its closest approach to Jupiter
- **JULY 9 1979** — Voyager 2 makes its closest approach to Jupiter
- **1980 NOVEMBER 12** — Voyager 1 performs a Gravity Assist around Saturn and begins its trip to the edge of the Solar System
- **AUGUST 25 1981** — Voyager 2 performs a Gravity Assist around Saturn
- **1982** — Deep Space Network upgrades two 85-feet antennas to 110-feet
- **JANUARY 24 1986** — Voyager 2 has the first-ever encounter with Uranus
- Deep Space Network begins expansion of 210-feet antennas to 230-feet
- **1987** — Voyager 2 observes Supernova 1987A
- **1988** — Voyager 2 returns the first color images of Neptune
- Voyager 2 is the first spacecraft to observe Neptune
- **1989 AUGUST 25** — Voyager 2 begins its trip out of the Solar System, below the ecliptic plane
- **JANUARY 1 1990** — The Voyager Interstellar Mission begins
- **1990 FEBRUARY 14** — Last Voyager Images – Optical Instruments are turned off
- **FEBRUARY 17 1998** — Voyager 1 overcomes Pioneer 10 to become the most distant human-made object
- **2004 DECEMBER 15** — Voyager 1crosses the Termination Shock
- **SEPTEMBER 5 2007** — Voyager 2 crosses the Termination Shock, providing evidence of the asymmetry of the Solar System
- **2009 AUGUST** — Voyager 1 enters the region between Termination Shock and Heliopause (Heliosheath)
- **DECEMBER 2010** — Voyager 1 observes the speed of the solar wind drop to zero, but hasn't reached Interstellar Space yet
- **2012 AUGUST 25** — Voyager 1 enters Interstellar Space (as announced by NASA on September 2013)



The power source

The Voyager probes launched in 1977. How can we power their instruments for the whole lifespan of the mission? Solar panels cannot be used because the Sun is too far away and, even from the closest outer planets (Jupiter and Saturn), its light is too weak. Thus, the necessary energy must be generated from a special onboard battery. The Voyager probes use three power generators called RTG ("Radioisotope Thermoelectric Generators"), which take advantage of radioactive decays to generate energy. The generators are placed outside the main body of each probe, mounted on a deployable boom, to avoid thermal disturbance to the instruments. The energy provided by the three batteries will be available until at least 2020, 40 years after the launch.

One of the 3 batteries which power each Voyager probe

BORN TO EXPLORE

Voyager speaking...

The Voyager probes use a high gain antenna to transmit to the ground their position, speed and direction, and of course all their scientific data. The bigger the dish, the more powerful is the transmitted signal. However, intercepting this signal is a great challenge in itself. We must be able to align the probe's antenna, which travels at a very high speed (Voyager 1 is moving away from the Sun at approximately 48,000 mph), with the antennas of communication facilities on Earth (which in turn rotate with the Earth), with an error of some fractions of a degree, over a distance of billions miles.

Deep Space Network

In order to communicate with the probes, NASA uses a combination of giant antennas, located in three specific positions on Earth: at Goldstone Observatory, in the Mojave Desert, California; near Madrid, Spain; and near Canberra, Australia. In each facility, there is an array with at least four space receivers. Each receiver is equipped with ultra-sensitive reception systems and giant parabolic antennae, between 85 and 230 feet in diameter.

THE VOYAGER GOLDEN RECORD

The plan to place a "cosmic postcard" aboard a probe traveling to outer space to be found by extraterrestrial intelligence, was first suggested by an English journalist, Eric Burgess (1920-2005), who had been writing about the Pioneer program since its first tests in 1957. Burgess approached Carl Sagan (1924-1996) with this idea , who endorsed it enthusiastically, becoming one of its main promoter, this became a reality in 1972 when, aboard th Pioneer 10 and 11 probes, gold-plated aluminum plaque was installed. The plaque displayed a selection of engraved images, devised by Carl Sagan, Linda Salzman and Frank Drake.

HOW TO PLAY THE RECORD

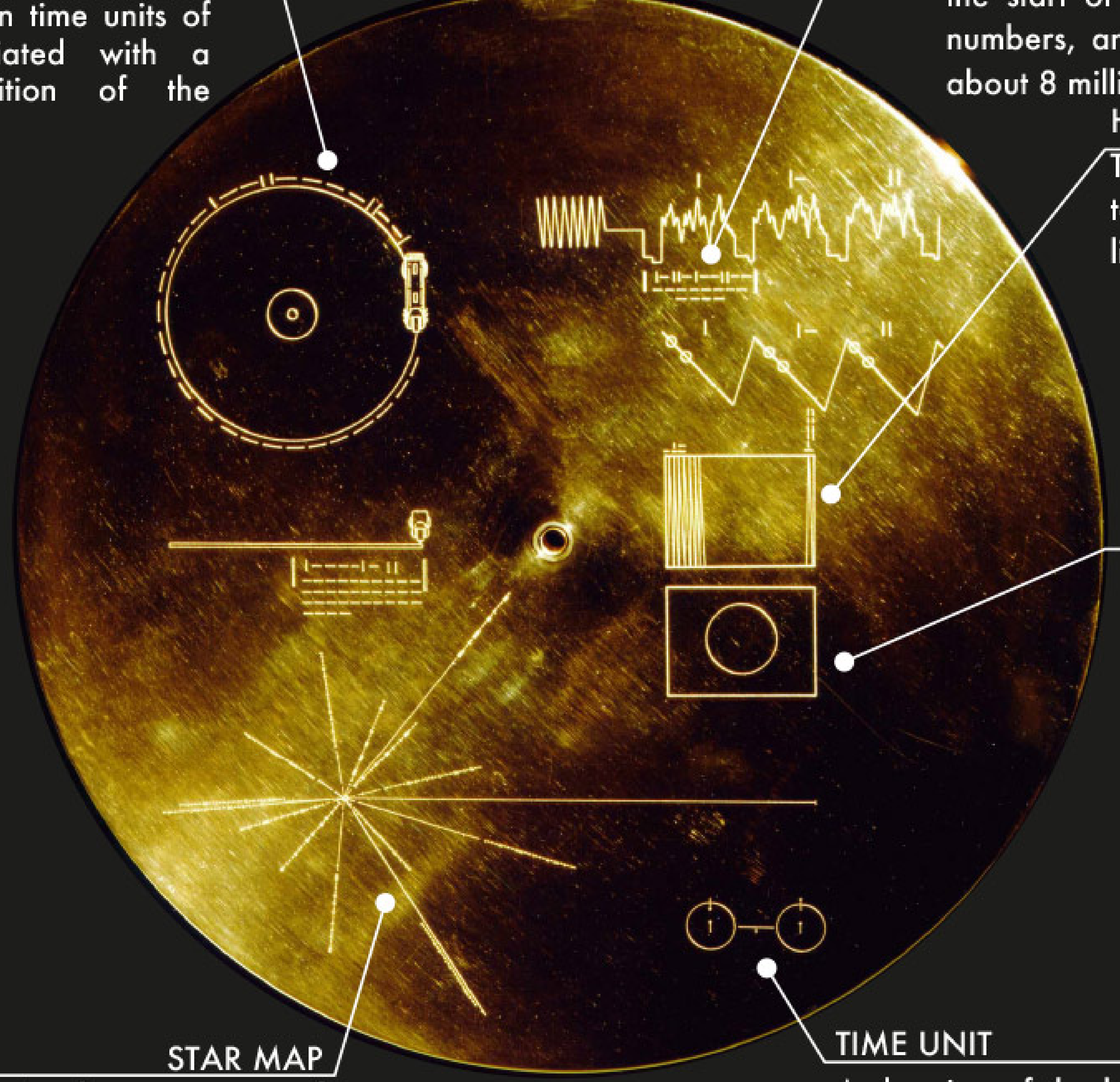
An easily recognized drawing of the phonograph record and the stylus carried with it. The stylus is in the correct position to play the record from the beginning. Written around it in binary arithmetic is the correct time of one rotation of the record, expressed in time units of the period associated with a fundamental transition of the hydrogen atom.

HOW TO RECONSTRUCT IMAGES/1

The top drawing shows the typical signal that occurs at the start of a picture. Picture lines are noted in binary numbers, and the duration of one of the "picture lines," about 8 milliseconds, is noted.

HOW TO RECONSTRUCT IMAGES/2

These lines are to be drawn vertically, similar to ordinary television. There are 512 vertical lines in a complete picture.



HOW TO RECONSTRUCT IMAGES/3

A replica of the first picture on the record, to permit the recipients to verify that they are decoding the signals correctly.

STAR MAP

The pulsar map previously sent as part of the plaques on Pioneers 10 and 11. It shows the location of the solar system with respect to 14 pulsars, whose precise periods are given in binary code along the lines connecting the Sun to each star.

TIME UNIT

A drawing of the hydrogen atom in its two lowest states, with a connecting line and digit 1 to indicate that the time interval associated with the transition from one state to the other is to be used as the fundamental time scale, both for the time given on the cover and in the decoded pictures.

The Golden Record's case with instructions on how to play the record

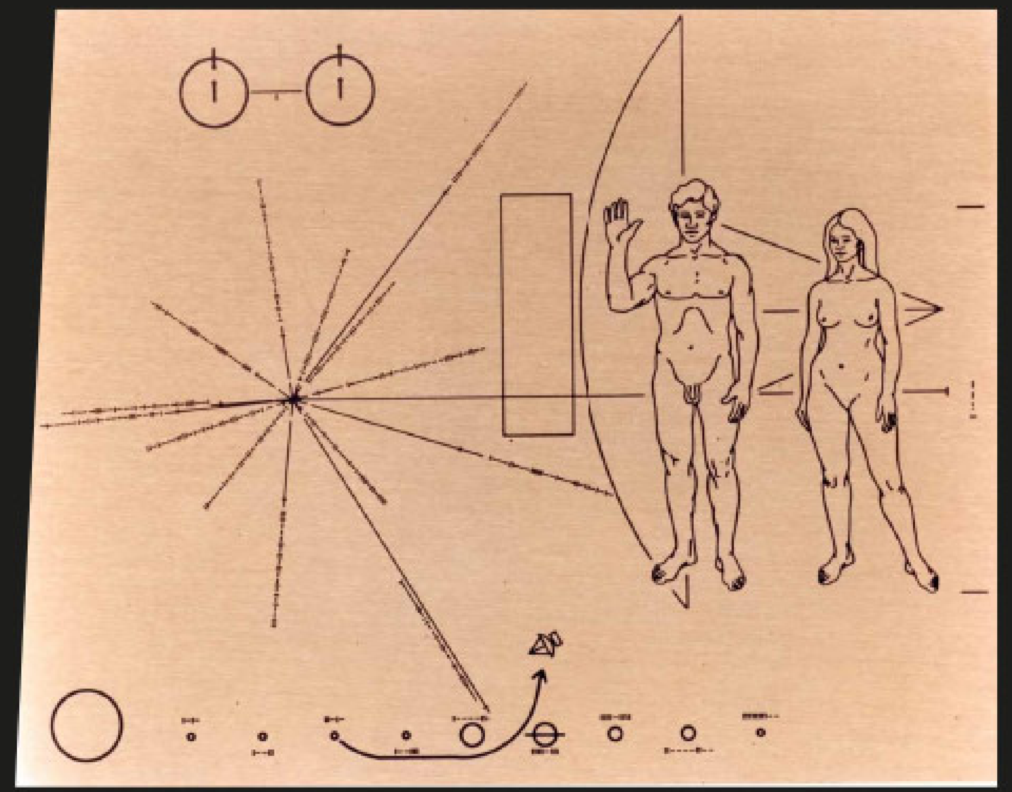
The Pioneer experience was expanded for the Voyager mission, by creating a message engraved on a golden record, aiming to introduce humankind to a possible alien civilization: many famous scientists were involved in its design, but also science fiction writers such as Isaac Asimov, Robert Heinlein and Arthur C. Clarke. Obviously the record contents were discussed thoroughly. Eventually a selection of Earth images and musical pieces was assembled, with the hope to communicate through them something about our inner life.

Beyond the specific choices, the Voyager message is chiefly a testimony to the fact that through exploration, mankind tries to better know the world, but the same time harbors a desire not only to find "something", but also "someone".

The problem of introducing ourselves to someone we don't know anything about is an encouragement to reflect on what really defines us as humans: whether or not we will ever find someone out there in deep space, this is a provocation for us to look at ourselves with more truth and awareness, as Carl Sagan states: "We are a way for the cosmos to know itself."

"A billion years from now, when everything on Earth we've ever made has crumble into dust, when the continents have changed beyond recognition and our species is unimaginably altered or extinct, the Voyager record will speak for us."

Carl Sagan



The golden plaque aboard 10 and 11

The Golden Record

TARGETING JUPITER

"It's often thought that once these projects are launched, everything is routine. It's anything but routine. You have to solve very interesting technology problems under tight schedule pressures. We do some of the greatest Sherlock Holmes work you can image."

William J. O'Neil,
Galileo Project Manager
(1990-1997)

The Galileo Mission was marked by many setbacks and unexpected events. The most dramatic setback happened when the high-gain antenna on the spacecraft failed to fully deploy: only the talent and the creativity of the Galileo team made it possible to overcome a problem that would have otherwise undermined the success of the whole mission. The spacecraft didn't lose the expected precision: when it reached Jupiter, it "missed" the expected target by just 108 km (this is equivalent to shooting an arrow from New York to San Francisco and "missing" an orange by 6 inches).

Also unexpected was the observation of the impact of the Shoemaker-Levi comet with the Jovian atmosphere. The images transmitted by Galileo were the only witnesses to this event, which would be otherwise unobservable from Earth.

Galileo was the first spacecraft to orbit Jupiter, returning the most accurate data ever collected on its atmosphere and moons. Upon its arrival to the Gas Giant, Galileo dropped a probe into Jupiter's atmosphere, investigating its composition, returning real time data for the first time. This allowed us to better understand the origin and evolution of Jupiter and the Solar System.

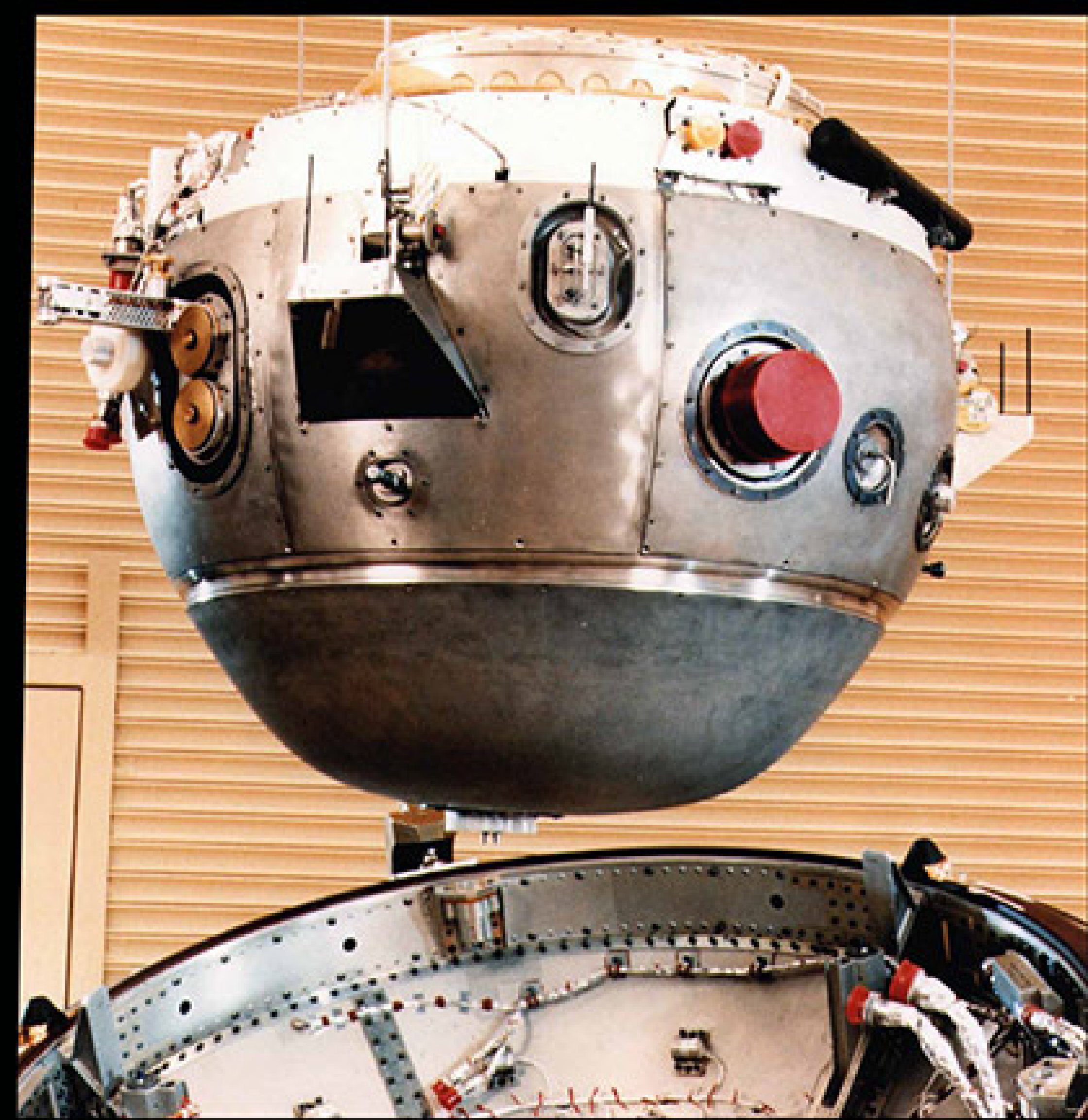
The close flybys of Jupiter's moon Europa gave final evidence of an underground saltwater ocean. This makes the Jovian satellite one of the few contenders to host life, even if in elementary forms, in the Solar System. Given its success, the Galileo Mission was extended twice, from the initially planned two years, eventually to eight years.

The Galileo probe in the lab

Shoemaker-Levi fragments crashing into Jupiter and observed by Galileo

Volcanic activity on the surface of Io

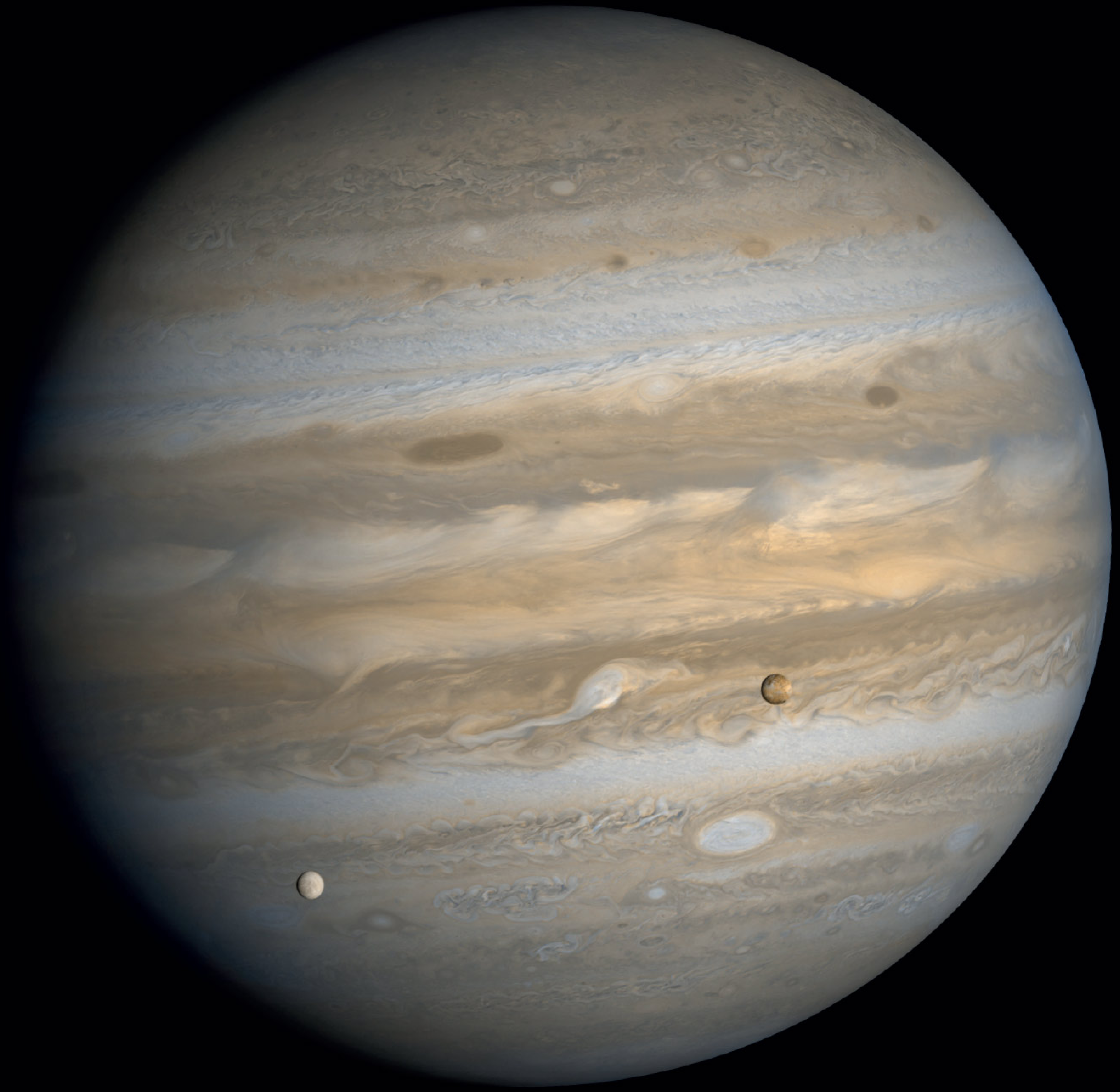
Europa's surface photographed by Galileo



The descent module

GALILEO FACTS AND FIGURES

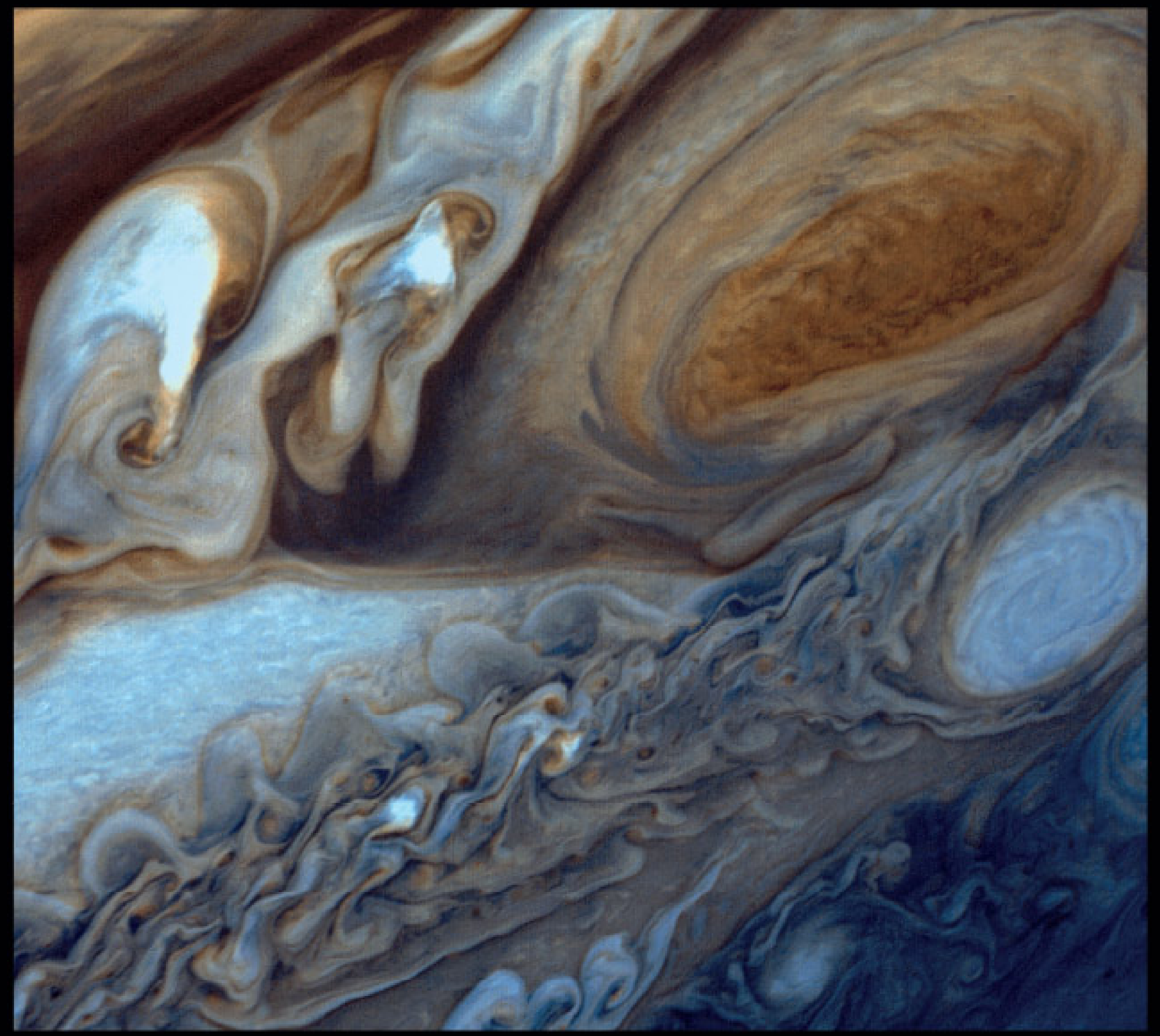
TOTAL WEIGHT	2500 kg
TRAJECTORY	Three gravitational assists (Venus-Earth-Earth)
DISTANCE COVERED TO JUPITER	2,4 billions km
AVERAGE SPEED TO JUPITER	70800 km/h
ATMOSPHERIC PROBE WEIGHT	340 kg
TEMPERATURES WITHSTOOD IN JUPITER'S ATMOSPHERE	14000 K
TOTAL COST	1,4 billions $



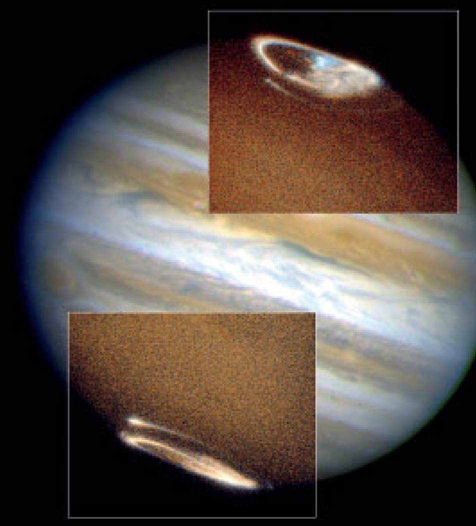
> "It was when I was happiest that I longed most. And because it was so beautiful, it set me longing, always longing. Somewhere else there must be more of it. Everything seemed to be saying- come!"
>
> C. S. Lewis

THE STORMY GIANT

Jupiter is the largest planet in the Solar System. It's called "the gas giant", because of its size and chemical composition, which can hint to a "failed star". The missions Pioneer, Voyager 1 and 2, Galileo, Cassini, Ulysses, and New Horizon targeted Jupiter and used its gravitational pull. Other missions, such as Juno, will be studying it in the near future.



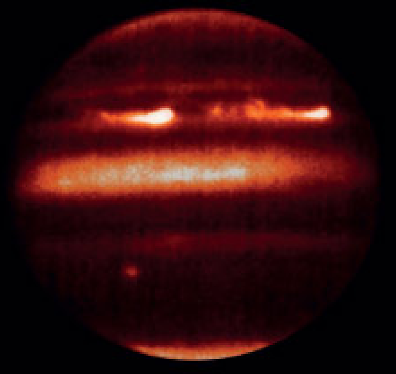
The Great Red Spot on Jupiter imaged by the Voyager 1 probe.
It is a giant storm that has been active for several centuries. Three times larger than Earth, the GRS ("Great Red Spot") is located in the Southern hemisphere and is a persistent anticyclonic storm: its rotation is therefore counterclockwise; the eye of the storm remains still, while the outer layers rotate around it.



Aurorae on Jupiter.
The spectacular Aurorae on Jupiter (which are especially visible in X-rays), were discovered by the Voyager satellites. These aurora are due to particles trapped in the planet's magnetic field and interacting with its atmosphere.

6-22 July 1994: the comet Shoemaker-Levy is swallowed by Jupiter's atmosphere.
Thanks to its mass, Jupiter attracts several asteroids and comets. In this image from the Hubble Space Telescope, a dark spot can be seen, pointing to the impact location of one of the comet's fragments.

Jupiter's rings observed by the Galileo probe
The rings are not observable from Earth, because they are made of particles reflecting the Sun's light towards the exterior of Jupiter's orbit. They were discovered by Voyager 2 after its flyby of Jupiter. According to Galileo's observations, the ring was formed by the impact of Jupiter and its satellites with meteorites and other bodies.



Lightning strikes on Jupiter
The thermal emissions on Jupiter observed by NASA's Infrared Telescope Facility (Mauna Kea Observatory): lightning strikes can be seen in the northern hemisphere, which are up to 1,000 times larger than those observed on Earth.

Jupiter's atmosphere, projected on a cylindrical section
The most evident feature of Jupiter's atmosphere is the presence of horizontal bands, caused by the fast rotation of the planet (1 revolution every 10 hours). The different colors correspond to various chemical elements (mostly ammonia compounds), and to the transition between different wind speeds, which approach 130 m/s on the surface. The large stationary storms have internal dynamics which are still under investigation.

	Jupiter	Comparison with Earth
Maximum distance from the Sun	816 001 807 km	5.365 times the maximum distance Earth-Sun
Minimum distance to the Sun	740 679 835 km	5.035 times the minimum distance Earth-Sun
Average orbital speed around the Sun	47 002 km/h	0.348 times the Earth's
Axial tilt	3.13 degrees	23.4 degrees
Orbital period	11.8618 years	1 year
Mean radius	69,911 km	10.97 times the Earth's
Volume	$1.4313 \times 1015\ km^3$	1,321.3 Earths
Mass	1.891×1027 kg	317.8 Earths
Density	$1.326\ g/cm^3$	0,241 times the Earth's
Surface gravity	$24{,}79\ m/s^2$	2,53 times the Earth's
Surface Temperature	-148° C	+14°C
Number of satellites	50	1
Core	Rocky, surrounded by metallic hydrogen	Liquid Iron and Nickel
Sidereal rotation period (day's duration)	9.925 hours	24 hours
Atmosphere	Hydrogen, Helium	Nitrogen, Oxygen

Image of Titan in false colors: the vast oceans of the satellite (such as Kraken and Ligeia) are visible. These oceans are entirely made of hydrocarbons.

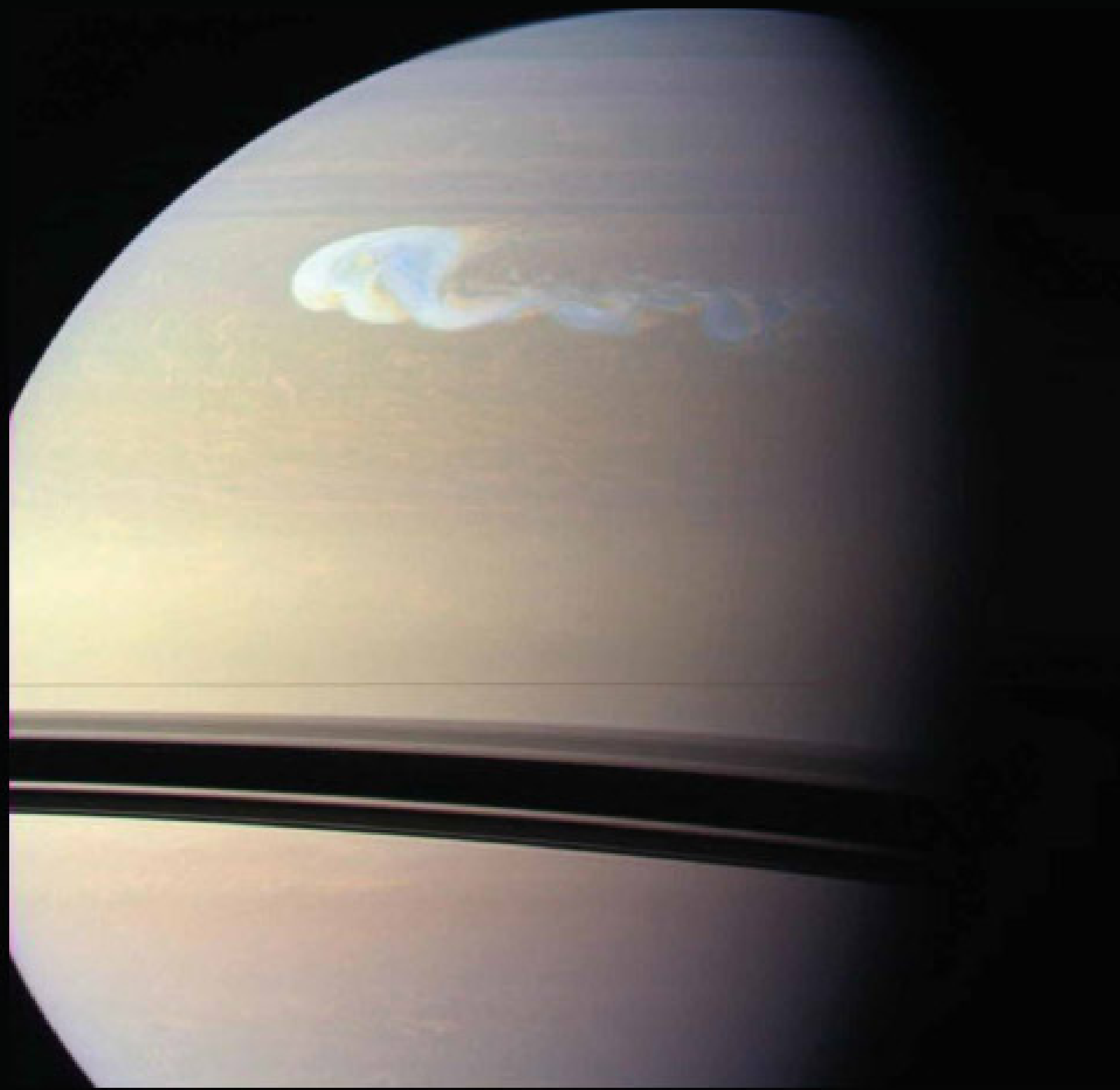
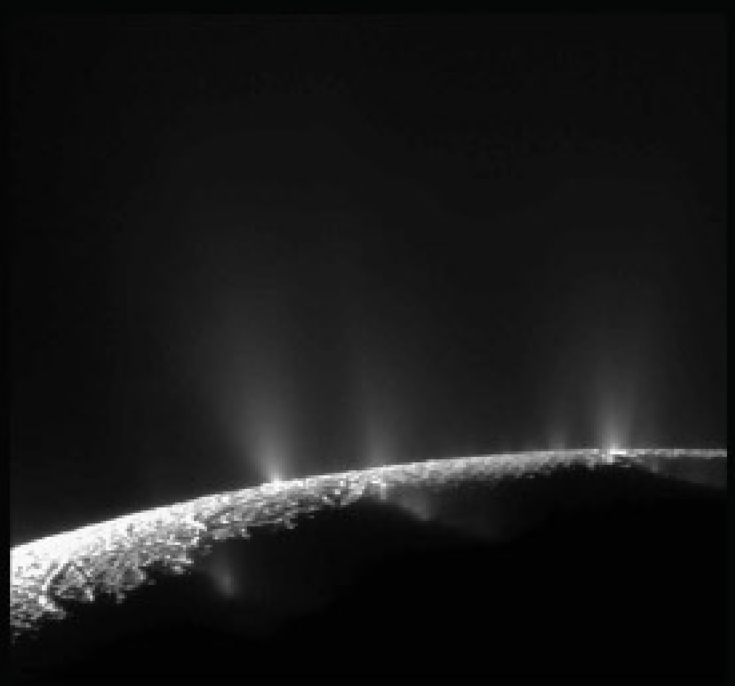


Image of a storm on Saturn: a massive storm at latitude of approximately 35 degrees North on Saturn's surface.



The geysers on Enceladu's surface

The first photograph of Titan's surface, captured by the Huygens spacecraft.

CASSINI-HUYGENS FACTS & FIGURES

TOTAL WEIGHT	2,125 kg
DIMENSIONS	6.7 X 4 meters
TRAJECTORY	4 gravitational assists (Venus-Venus - Earth - Jupiter)
DISTANCE COVERED TO REACH SATURN	2.2 billion km
AVERAGE SPEED TO SATURN	54,200 km/h
DISTANCE COVERED SINCE REACHING SATURN	3.21 billion km
HUYGENS PROBE WEIGHT	320 kg
TOTAL COST	about 3.27 billion $

DISCOVERING SATURN AND ITS COMPANIONS

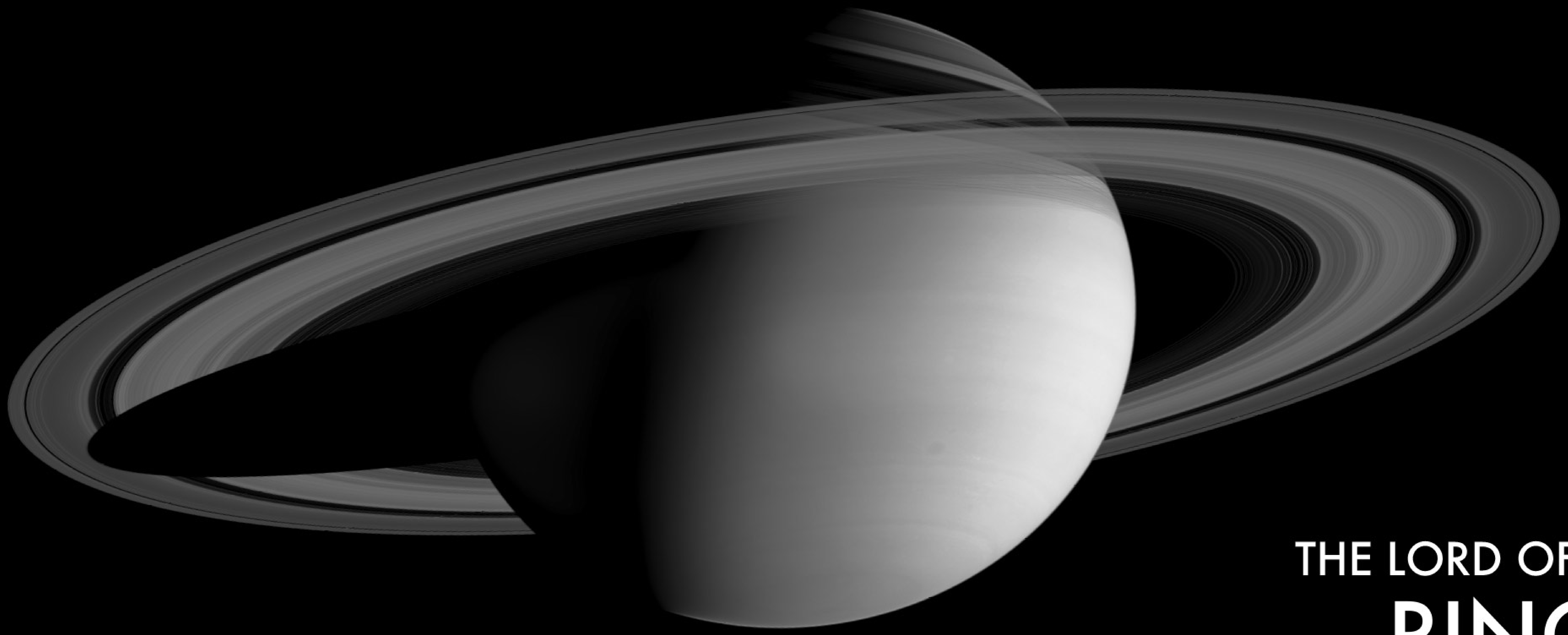
The assembly of the probe Cassini-Huygens

After "conquering" Jupiter, NASA's efforts were addressed to the study of the second gas giant of the Solar System: Saturn. Soon enough, though, NASA realized that facing such costly and scientifically complex project on its own was impossible. Thus, the Mission, renamed Cassini-Huygens, became one of the first collaborations among different Space Agencies: NASA, the European Space Agency (ESA) and the Italian Space Agency (ASI).

The launch of the spacecraft, which was one of the largest ever sent to space, took place in 1997, to enter Saturn's orbit in 2004, after four gravitational assist maneuvers: two by Venus, one by Earth and one by Jupiter.
The mission objectives are manifold: the study of Saturn, its composition and the dynamic of its atmosphere, the origin and nature of its rings, its magnetosphere, and the satellites of this gas giant, particularly one of its moons: Titan. The Huygens probe was released on Titan: after penetrating the moon's thick atmosphere, it spent a few hours on its surface, capturing incredible images. Later, Cassini's repeated flybys of Titan revealed the presence of rivers and lakes of liquid hydrocarbons on its surface, providing a glimpse into what Earth might have looked like before life began: methane and ethane are actually compounds associated with biological activity on Earth.

The Cassini Mission, designed to conclude in 2008, was extended twice. The end of the program is currently planned for 2017. Cassini has orbited Saturn more than 200 times: close encounters that allowed us to study some strange phenomena involving the planet, such as the hexagonal-shaped storm surrounding its north pole, first discovered by Voyager. Another mystery that Cassini was able to solve was the so-called "moonlet waves", actual "waves" observed within Saturn's rings. The probe observations confirmed the original intuition that such waves were generated by many smaller moons, "nestled" into the rings system.

Thanks to Cassini's observations, the amount of data and images of Saturn have drastically increased, bringing the number of known moons from 63 to more than 90. Lately, much attention has been paid to Enceladus. It is considered one of the brightest objects in our solar system (its surface is covered in water ice causing a strong albedo), and is believed to be geologically active, as evidenced by the powerful water and gas geyser-like sprays, combined with internal hot sprays.



"Awe is the amazement of the mind at seeing, hearing, or in some other way perceiving, great and marvelous things. Inasmuch as they appear great, they inspire reverence in those who perceive them; inasmuch as they appear marvelous,they create a yearning for know for knowledge of them. "

Dante - Convivio;
IV, XXV, 5

THE LORD OF THE RINGS

The surface of Saturn features strong winds and currents that can reach a speed up to 500m/s, almost 4 times the speed of the fastest winds on Jupiter and 10 times the strength of a hurricane on Earth. The prevailing winds on Saturn blow eastward, in the same direction that the planet rotates, and reach their highest velocities near the equator. Despite its violent storms, Saturn does not present the typical dynamic and colorful stripe structures that Jupiter does. This happens because Saturn is surrounded by a layer of dust that makes its surface look uniform to our eyes (that is, in the range of the visible).Occasionally, very large stormy clouds of ammonia ice, heating up, rise above the outward opaque layer and become visible.

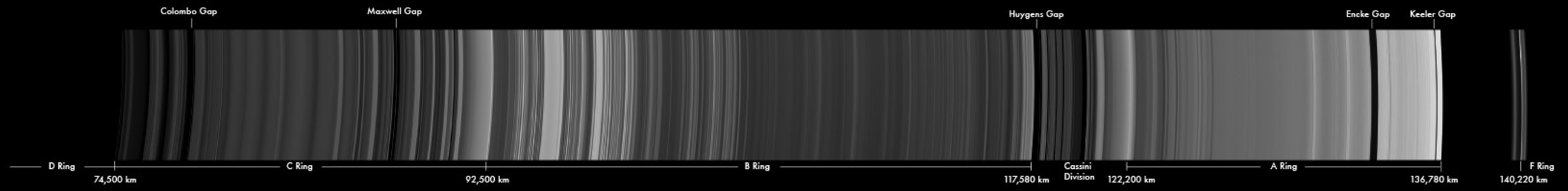


Diagram of Saturn's Rings from a mosaic of images taken by the Cassini probe. The A, B and C rings are composed of water ice crystals, which contain a small component of impurities of organic materials. The chemical composition of the particles causes changes in the colors of the different rings. In general, most Saturn's rings (particularly rings A and B) show a strong component of macroscopic particles (their radius is between one meter and one kilometer). In rings C and D, the particles sizes are of order tens of microns. Lastly rings F and E are made of even smaller particles, that is particles whose size is smaller than millionth of a meter.

Aurora at Saturn's South Pole, combining ultraviolet images with visible- light images, Hubble Space Relescope.

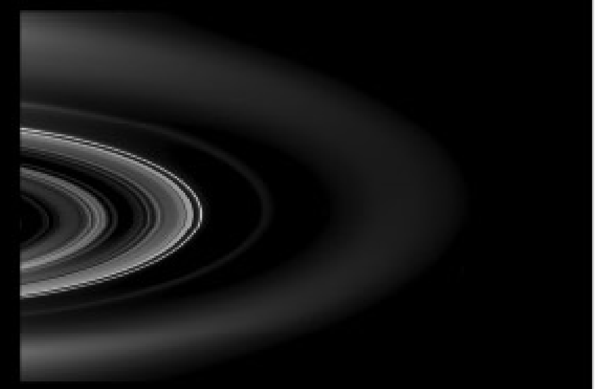
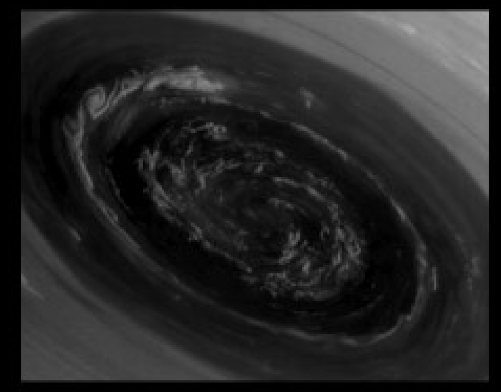
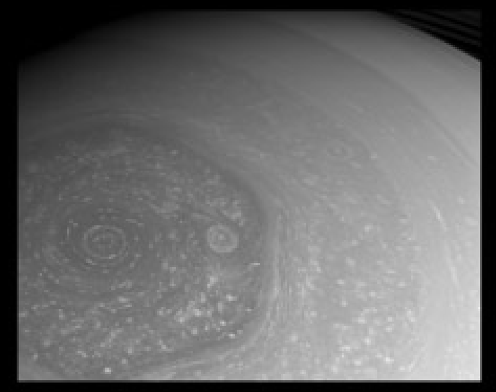


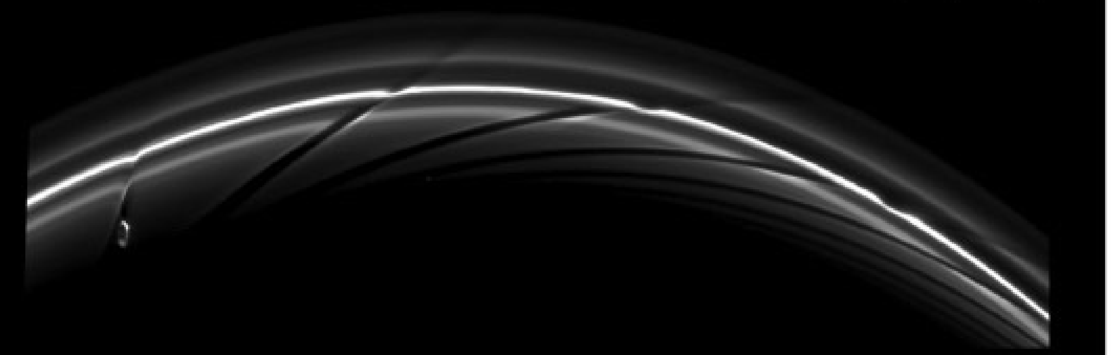
Image of the rings from the Cassini mission. Starting from the center, we can observe: the thickest D, C, B and A rings; the thin and very bright F ring; and the outermost and more rarefied G and E rings.



False-color image of the stormy vortex at Saturn's North Pole. Its size is approximately the same as the Earth's.

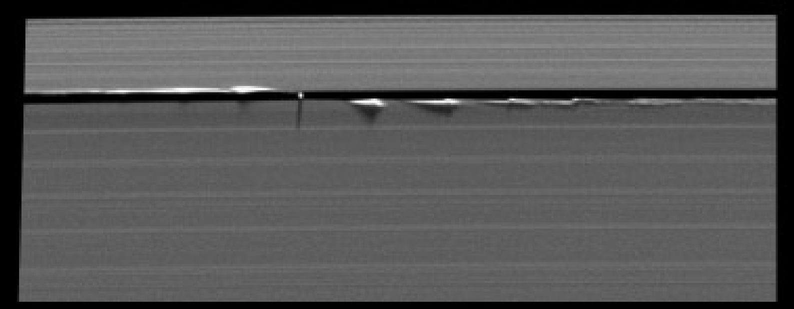


Saturn's hexagonal storm, imaged in visible light by the Cassini probe. The stability in time of the giant North Pole storm and the origin of its perfect hexagonal shape remain a mystery to this day.

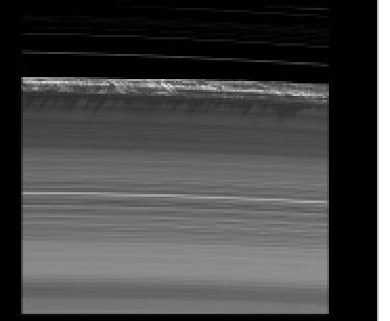


Interaction between the Prometheus moon and the F ring, observed by the Cassini probe.

Density waves in Saturn's ring.
The combined gravitational pull of Saturn and of its closest moons can redistribute the ring particles and thus shape the different structures. These small moons, called "shepherd satellites", exert only a weak gravitational force on the ring particles. However, their contribution becomes important when their orbital period and the orbital period of the particles are exact fractions; in this case, we talk about resonance effects. This particular effect and Saturn's gravitational pull can repel and attract the particles, creating the succession of thin rings of low and high concentration. Density waves are generated, which can propagate radially through the rings. The passage of shepherd satellites through the gaps generate not just density waves but also undulations that are tangential to the movement of the planet and orthogonal to its plane, that is, outside such plane. They look like wakes left by ships moving through water.

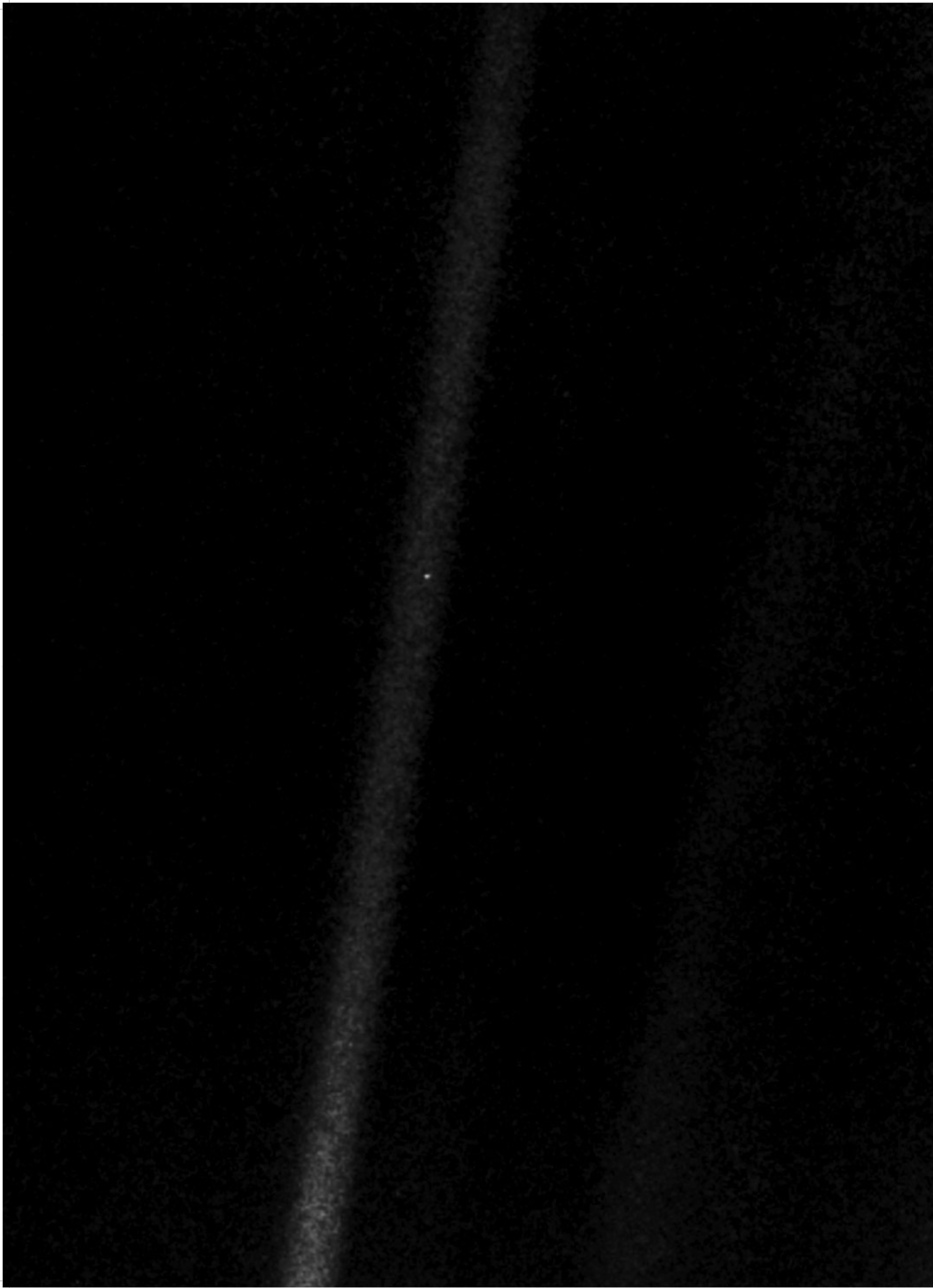


Passage of shepherd satellite Pan in the Encke Gap in the A ring, observed by the Cassini probe.



Vertical structures at the outer edge of the B ring, imaged by the Cassini probe. These structures are among the tallest seen in all of Saturn's rings and rise abruptly, casting the long shadows that can be observed on the ring.

	Saturn	Comparison with Earth
Revolution period	29,5 years	1 year
Average radius	58 232 km	9,14 times the Earth's
Volume	$8.2713 \cdot 10^{14}$ km^3	763,6 times the Earth's
Mass	$5.6846 \cdot 10^{26}$ kg	95,2 times the Earth's
Density	0.687 g/cm^3	0,24 times the Earth's
Surface gravity	10.44 m/s^2	Everything weighs 1,07 times more than on Earth
Surface temperature	-139 °C	14 °C
Number of satellites	62 (plus numerous minor satellites called "moonlets")	1
Core	Iron and Nickel, surrounded by metallic and liquid Hydrogen and liquid Helium	Liquid Iron and Nickel
Length of day	10,57 hours	24 hours
Atmosphere	Hydrogen, Helium	Nitrogen, Oxygen



"From this distant vantage point, the Earth might not seem of particular interest. But for us, it's different. Consider again that dot. That's here, that's home, that's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar", every "supreme leader", every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam. The Earth is a very small stage in a vast cosmic arena."

Carl Sagan

"Robotic exploration is really just humans operating their sensor systems far from home. But in fact, all the learning is done by men and women.
It's not learned by the robots, it's by all of us who send the robots. And so robotic exploration is a human activity."

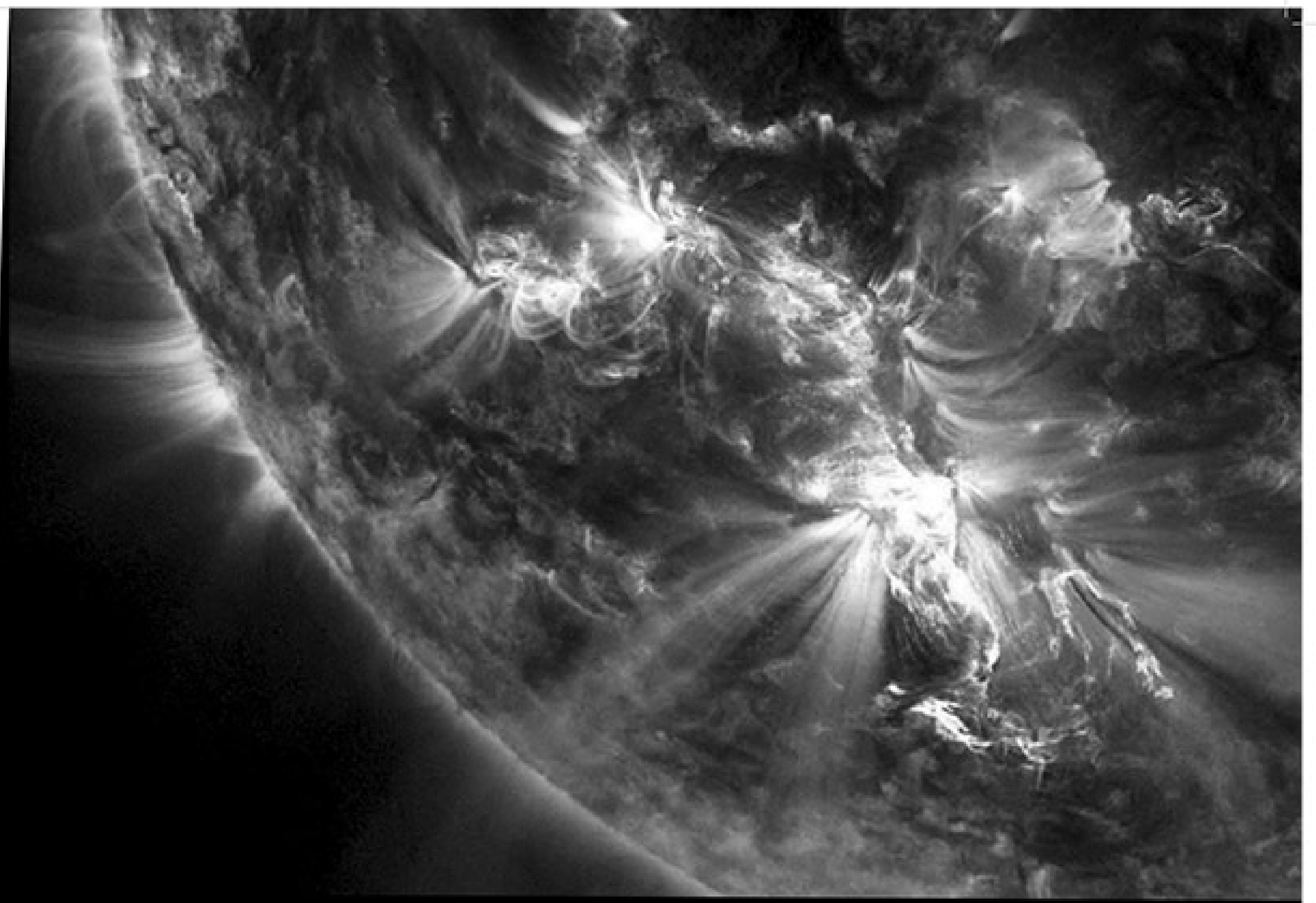
Edward Stone

How do we know that Voyager left the Solar System? What marked this passage? What did Voyager see at the edge of the Solar System?
The Sun's magnetic activity is responsible for the production of the so-called solar wind: a constant stream of particles (also called cosmic rays) and magnetic field - that is, plasma- emanating outward from the center of the Solar System. This solar wind can be observed, for exemple, in the images taken by NASA's SOHO and SDO satellites, designed to study the Sun. Their images clearly show the magnetic field lines guiding the propagation of particles.

MEASURING THE SOLAR WIND

At a large enough distance from the Sun, the wind loses strength and collides with the interstellar wind that comes from outside the Solar System, creating a collision area between the two plasmas. This transition area marks the boundary between the Heliosphere and the interstellar space, where the Solar wind is no longer predominant..

The signal that Voyager traveled past the edge of the Heliosphere was first detected on August 25, 2012, when a decrease in the density of solar cosmic rays (low-energy ions) was measured, along with an increase in the density of electrons, protons and higher energy alpha particles, which originate in other regions of the Galaxy and make up the interstellar plasma. This is exactly what can be observed in the count charts shown to the right.
The instruments that measured these phenomena - particle detectors and plasma wave detectors, plus the magnometer - are the last working instruments onboard the spacecraft, which are still operating to collect information on the outskirts of the Solar System.



The Sun's photosphere: we can observe the magnetic field lines two points of the Sun's surface (Credits: SDO, NASA).

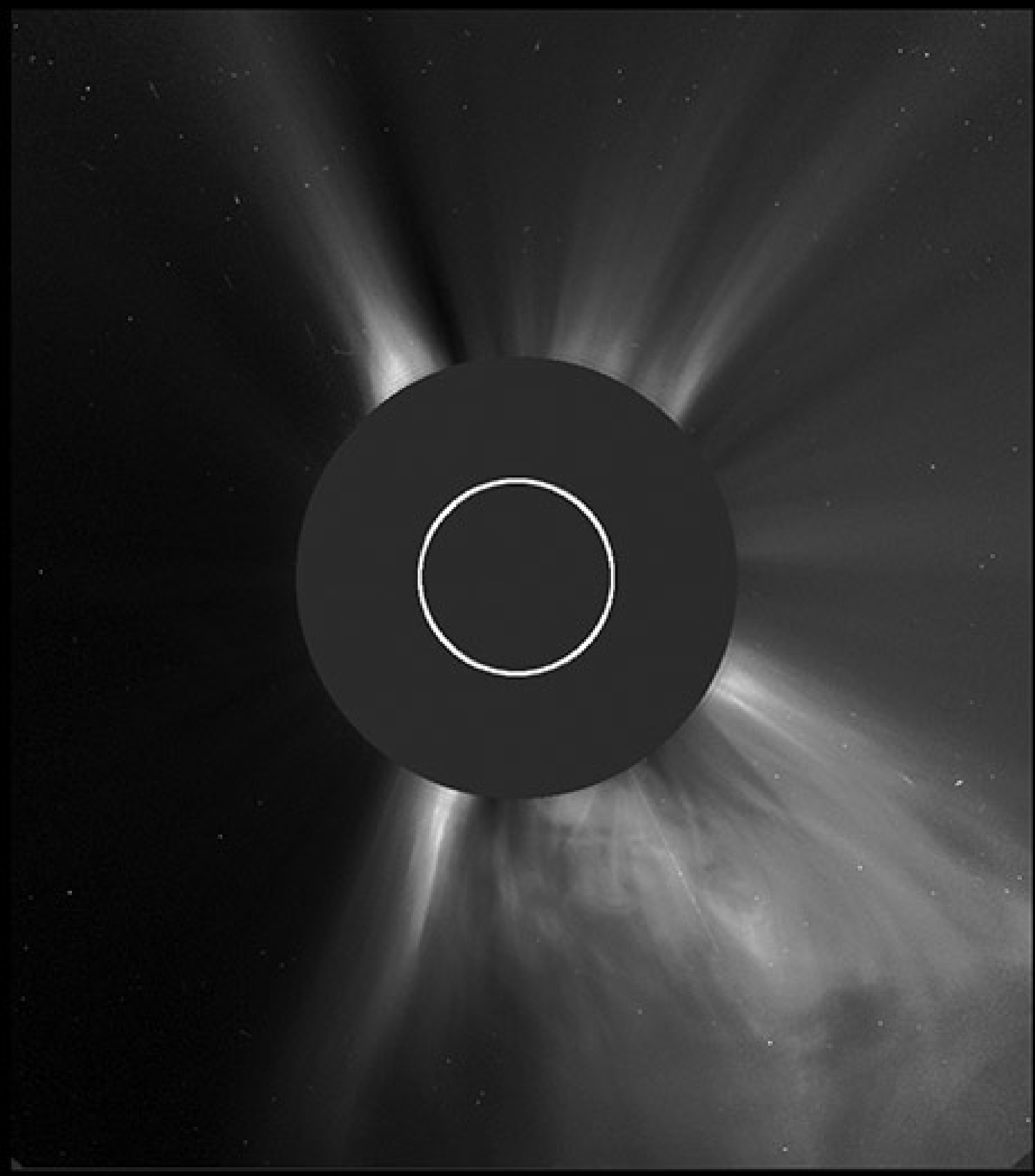
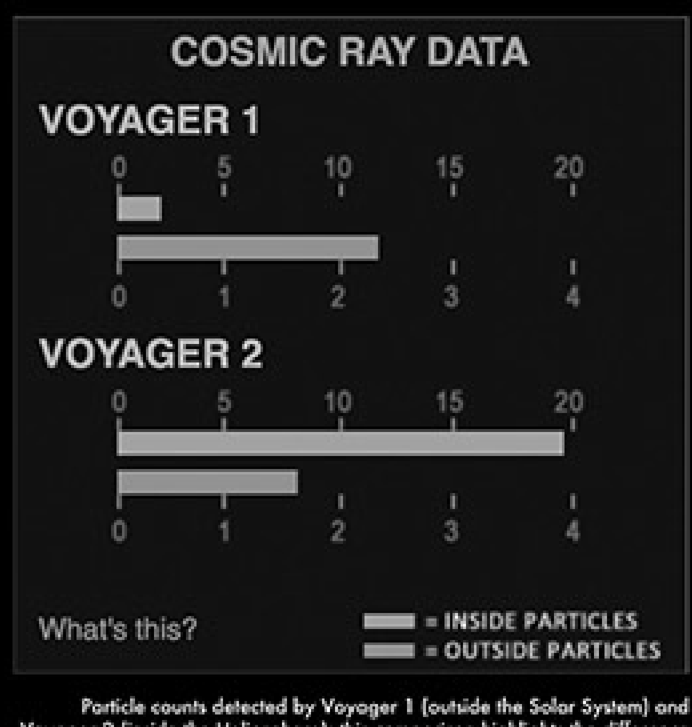
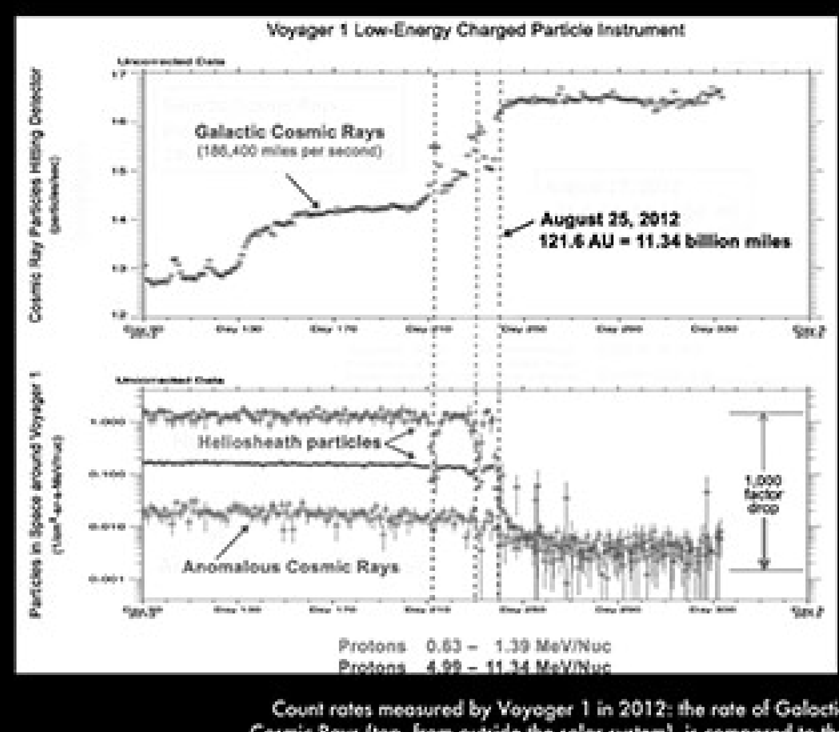


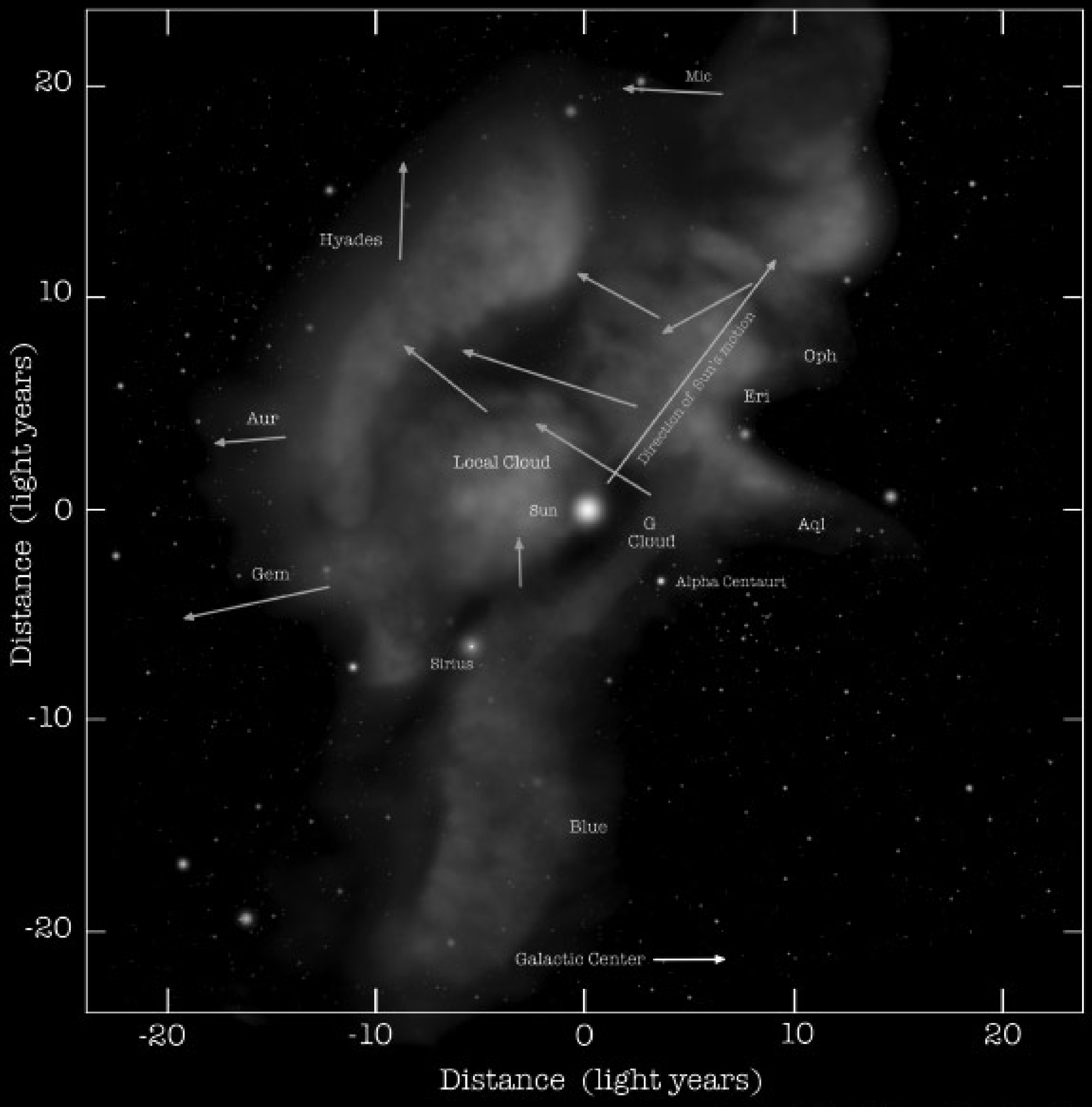
Image of the solar wind with the Sun masked out (Credits: SOHO, NASA, ESA).



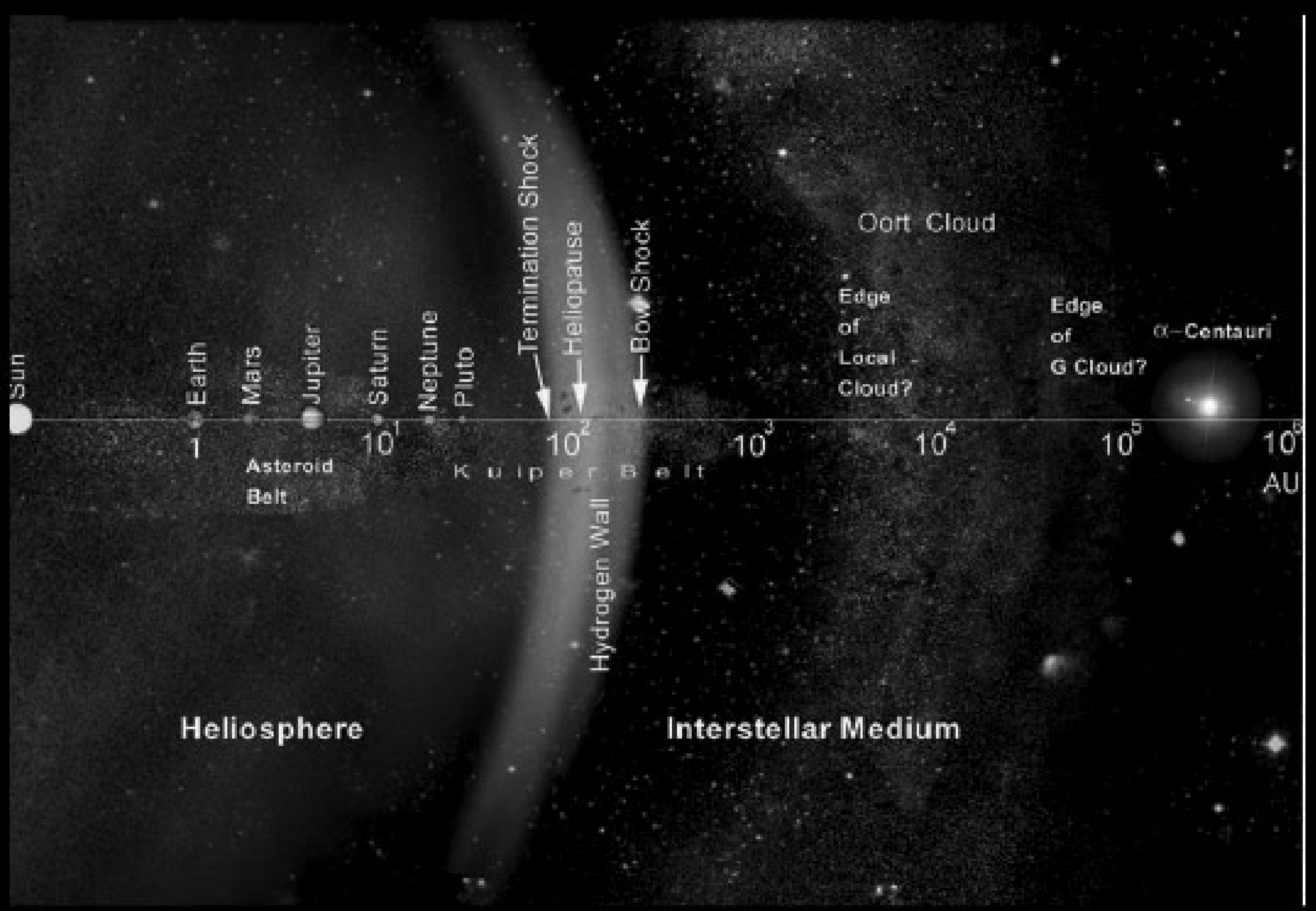
Particle counts detected by Voyager 1 (outside the Solar System) and Voyager 2 (inside the Heliosphere): this comparison highlights the difference between solar and galactic cosmic rays. (Credits: Ed Stone, CALTECH/GSFC).



Count rates measured by Voyager 1 in 2012: the rate of Galactic Cosmic Rays (top, from outside the solar system), is compared to the rate of Heliosphere particles (bottom, from the Sun). (Credits: Ed Stone, CALTECH/GSFC).



1 The path of the Solar System within the local nebula.



The distance between the Sun and the closest star (Credits: Jet Propulsion Laboratories, NASA).)

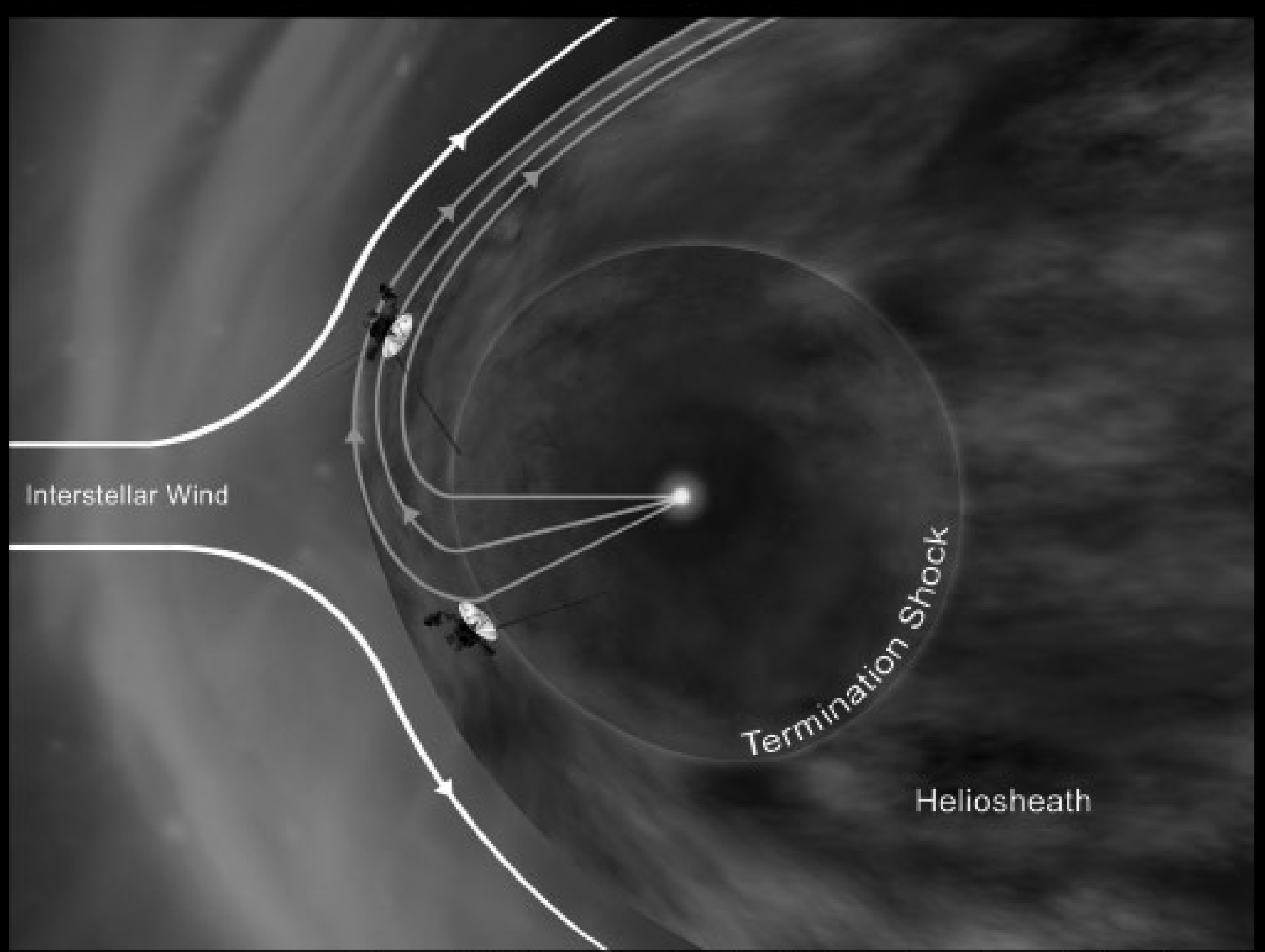


Diagram of the Helioshpere. Trajectories are depicted for the outgoing cosmic rays and for those who come from interstellar space (Credits: Jet Propulsion Laboratories, NASA).

BEYOND THE EDGE OF THE SOLAR SYSTEM

On August 25, 2012 Voyager 1 became the first and only human-made object to leave the Solar System after traveling a distance of more than 12 billion miles (125 astronomical units) at a speed of approximately 40,000 miles per hour.
The edge of the Solar System is far beyond the orbit of the farthest planet from the sun. Neptune is about 29 UA from the Sun, while the Heliosphere, the edge between the Solar System and interstellar space, is 4 times farther than that, which is why Voyager 1 arrived only after traveling for a total of 36 years.

The boundary of the Solar System is the end of the Sun's sphere of influence. The Solar System is swept by the magnetic field and particles (protons and electrons) generated by the Sun, also known as the "solar wind". The solar wind travels towards the space surrounding the Sun, defining the boundaries of the Heliosphere.

The space outside the Heliosphere is full of magnetized plasma as well. The Heliosphere can be pictured as a bubble where the internal pressure is in equilibrium with the external pressure. The Heliopause, which is the contact region between these two "plasma winds", creates a shock zone that defines the boundary between the Solar System and interstellar space. The oblong shape of the Heliosphere is produced by the motion of the Solar System through the Galaxy. In other words, the collision between the two plasmas generates an aerodynamic tail.

"You can simulate the Heliosheath in your kitchen sink," says Stone. "Turn on the faucet so that a thin stream of water pours into the sink. Look down into the basin. Where the stream hits bottom, that's the Sun. From there, water flows outward in a thin, perfectly radial sheet. That's the solar wind. As the water (or solar wind) expands, it gets thinner and thinner, and it can't push as hard. Abruptly, a sluggish, turbulent ring forms. That ring is the Heliosheath." (From an interview to Ed Stone)

13 STEPS IN THE FUTURE OF SPACE EXPLORATION

The main space missions over the next few decades

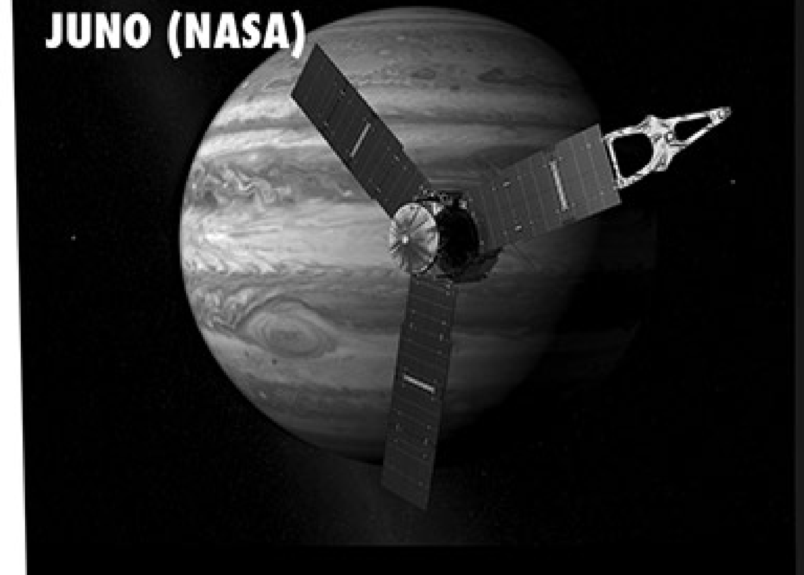
ROSETTA (ESA)

Launched in 2004, the objective of the mission is the study in situ of comet 67P/Churyumov–Gerasimenk. After a long pursuit, it landed on the comet in August 2014 and will collect samples to study its core and establish its chemical composition.

New Horizons encounters Pluto (NASA)

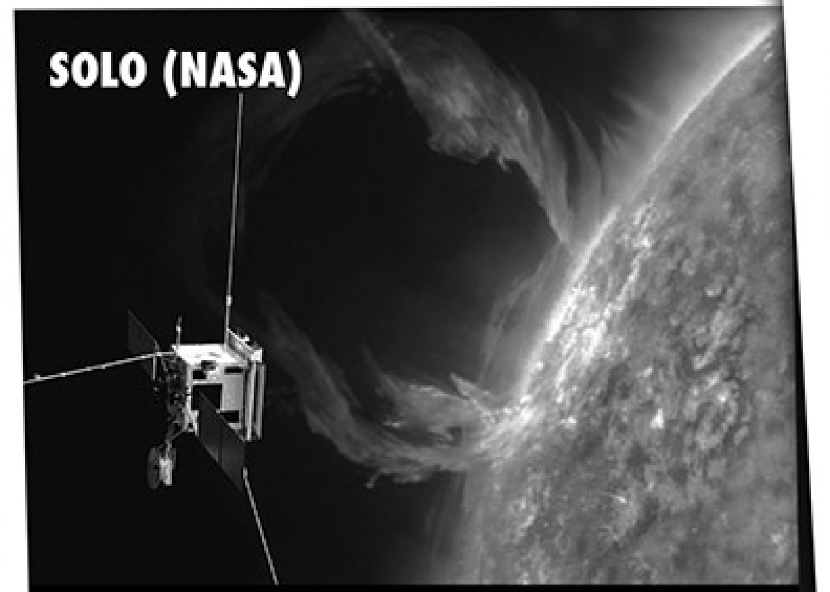
The main goal is to study the geology and morphology of dwarf planet Pluto and its satellite Charon. Launched in January 2006 from Cape Canaveral, the probe performed a flyby of Pluto on July 14, 2015. The probe is now continuing its journey into the Kuiper belt.

JUNO (NASA)



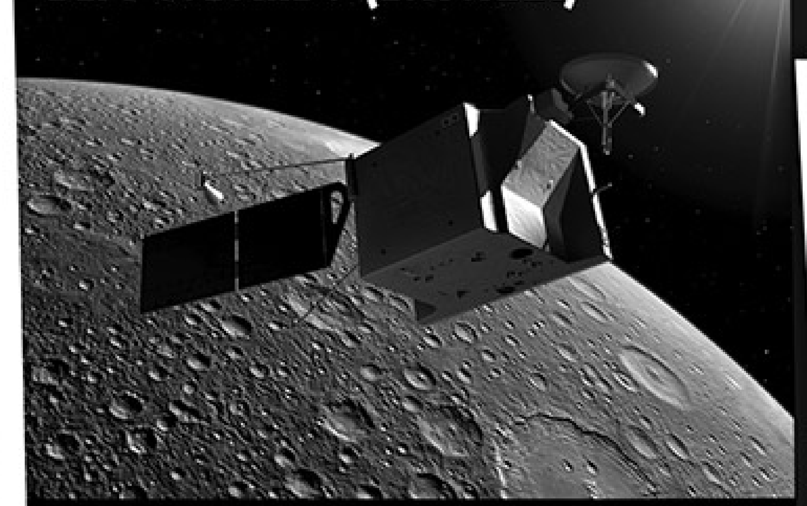
It will study Jupiter's magnetic field by achieving a polar orbit around the planet. Launched on August 5 2001, it will reach its destination in July 2016. The highly elliptical orbit will allow it to approach the poles and to study Jupiter's composition, its magnetic field, and its magnetosphere. .

SOLO (NASA)



SOLas Orbiter will try and answer some of the questions about the formation of the Solar System and also study the physic of solar plasma. The probe will be placed at a distance of a quarter of a UA from the Sun making it the closest mission ever to the Sun. It is scheduled for launch in 2017.

BEPI COLOMBO (ESA-JAXA)

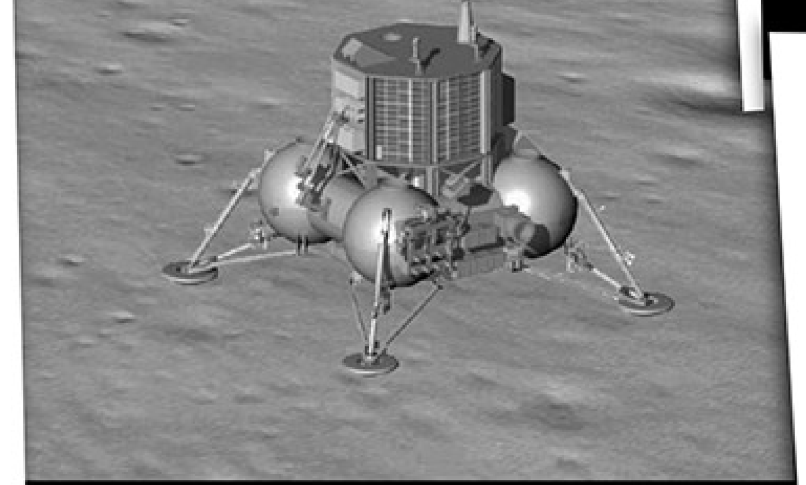


It is one of the first missions designed to study Mercury and carries two probes, Mercury Planetary Orbiter (MPO) and Mercury Magnetospheric Orbiter (MMO). The former will study the composition of the surface of the planet, while the latter will study its magnetosphere. The mission will launch in 2016 and will reach in planet in 2022.

ExoMars Trace Gas Orbiter and EDM lander (ESA-Roscosmos)

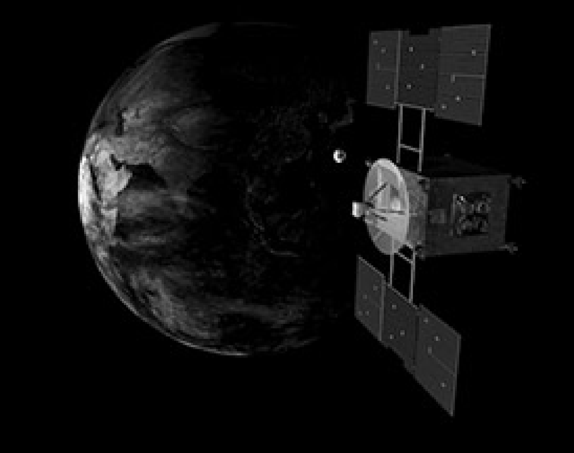
The probe is scheduled for launch in March 2016. Its first task will be to orbit Mars searching for atmospheric methane and other gases that could indicate the presence of life. In 2018, a second module with a weather station and other instruments, will land on Mars to investigate its environment and geophysical features.

Chandrayaan-2 e Aditya (ISRO)



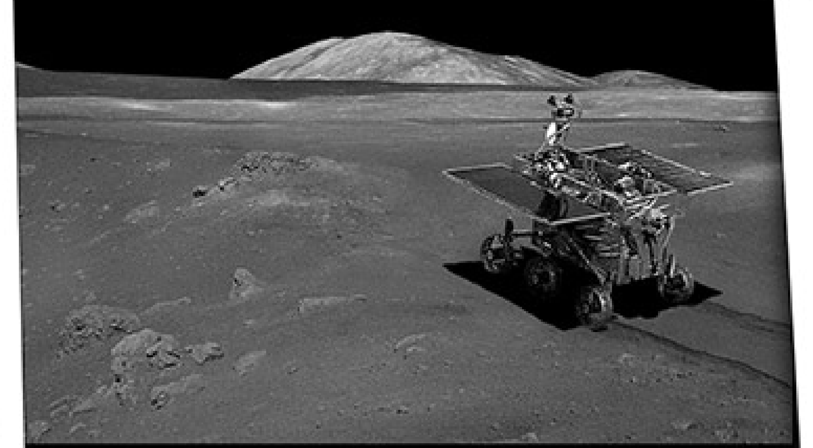
Two Indian missions planned within the Extraterrestrial Explorations program, designed to study the Moon, Mars, Venus and the Sun. The first mission, scheduled for launch in 2017, will study the lunar surface, while the second (2017-2018) will study the Sun.

Hayabusa 2 (JAXA)



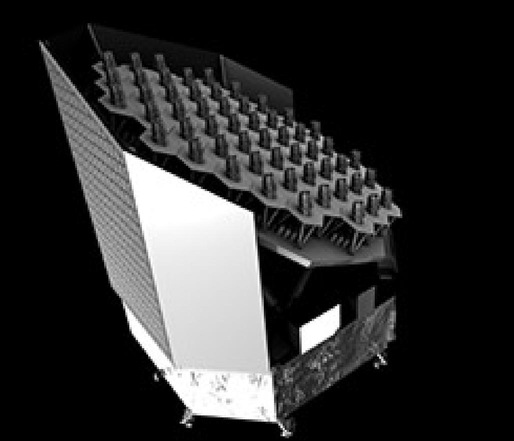
Launched in 2014, it is designed to land on an asteroid in the asteroids belt and to collect samples that will be returned to Earth. The spacecraft will reach the asteroid in July 2018 and return on Earth in 2020.

Change 4, 5 e 6 (CNSA)



Planned for 2015, 2017 and 2019, the Change missions will allow China to study the Moon with the purpose of doing a manned mission in 2020-2030. A manned mission to Mars is planned as well (2040-2060). At the same time, China is planning to build a greenhouse system on Mars or on the Moon.

PLATO - Planetary Transits and Oscillations of stars (ASI-ESA)

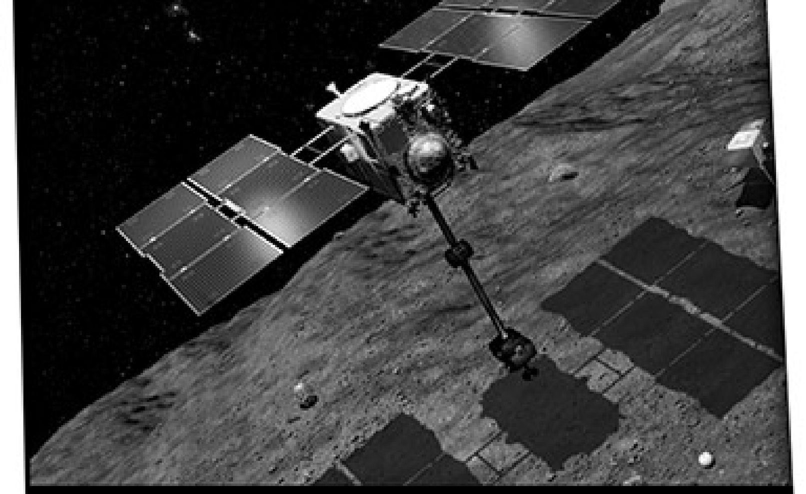


It will address two fundamental issues: "What conditions are necessary for the formation of planets and the appearance of life" and "How does the Solar System work"? PLATO will observe a large sample of bright stars, allowing for the characterization of planets and their host stars. It is scheduled to launch in 2024.

JUICE - Jupiter Icy Moon Explorer (ESA)

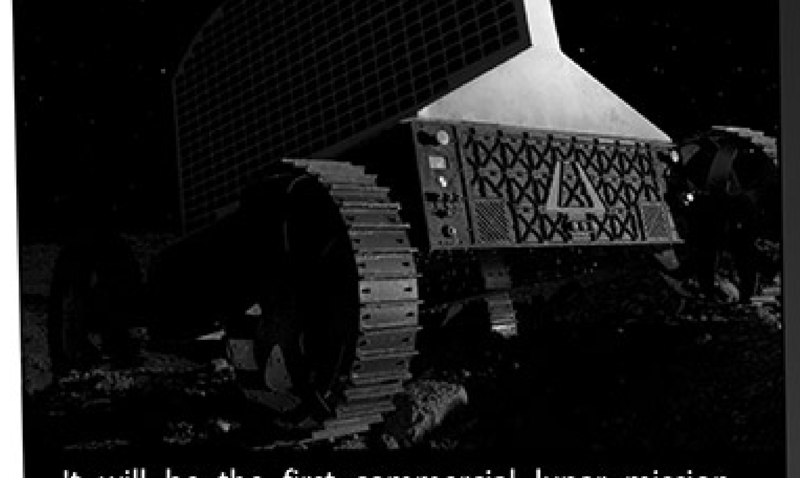
It will study the Jovian system, especially its satellites Ganymede, Callisto, and Europa. Its main scientific goals are to investigate the planet's magnetic field and carry out in-depth observations of the surfaces of its moons. Proposed in 2012, it is scheduled to launch in 2022 and to start scientific operations in 2030.

Marco Polo (ESA-JAXA)



Its target is to collect a sample from a near-Earth asteroid and then to return it to Earth. This should give insight on the origins of the Solar System and its formation, and also on the origins of life on Earth. It is currently scheduled to launch in 2020.

Griffin Lander (Astrobotic Technology, Inc.)



It will be the first commercial lunar mission, developed by Astrobotic Technology. SpaceX plans to provide the launch vehicle in October 2015. The purpose is to land on the Moon and look for frozen water, most likely is to be found at the poles. Astrobiotic is competing for the Google Lunar Lander X-Prize.