



50 SPACE MISSIONS THAT CHANGED **THE** WORLD

John A. Read





SPACE HISTORY IS UNFOLDING RIGHT BEFORE OUR EYES!

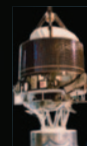
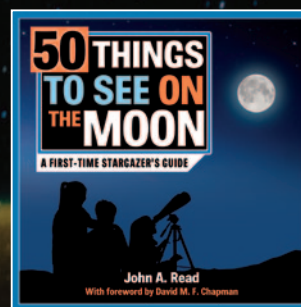
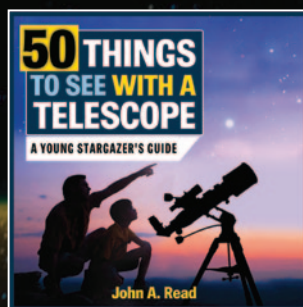
Since the first spacecraft launched in 1957, there have been many incredible missions that have changed the world. The 50 featured in this collection include Voyager's Grand Tour, Apollo 8 (the first crewed mission to the Moon), the first woman in space and the first communication satellite that brought live television to the world. In the early days of space exploration, the focus was on military dominance. Today, most missions require the collaboration of several different countries and there is a broader range of research. This is an exciting time we are living in. Space history is unfolding right before our eyes!

JOHN A. READ is a telescope operator at the Burke-Gaffney Observatory, a member of the Halifax Centre of the Royal Astronomical Society of Canada (RASC) and recently graduated with a degree in astrophysics from Saint Mary's University. In 2020 he was presented with an RASC award for Excellence in Science Communication. He lives in Halifax, Nova Scotia.



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50

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A very special thanks to space historians Chris Gainor (past president of the Royal Astronomical Society of Canada and author of Arrows to the Moon) and Randy Attwood (former Executive Director of the The Royal Astronomical Society of Canada, journalist and Canadian Space Agency photographer).

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Changing the World

What lies under the cloudy skies of Venus? What does Pluto look like? Until we sent a spacecraft there, we didn't know. Since the early days of space exploration, there have been hundreds of important space missions that have discovered new and exciting things. Space exploration has resulted in new inventions and new technologies as scientists and engineers have worked to get rockets, satellites and astronauts into space.

How many times do you turn on the TV or check the weather and take those services for granted? It is hard to imagine life without these inventions, but they both rely on satellites in space.

Another invention, Global Positioning System or GPS, transformed how we navigate and even how countries go to war. When an airplane crashes or a ship gets lost at sea, beacons send the position to space, notifying Search and Rescue. This would not be possible without space missions.

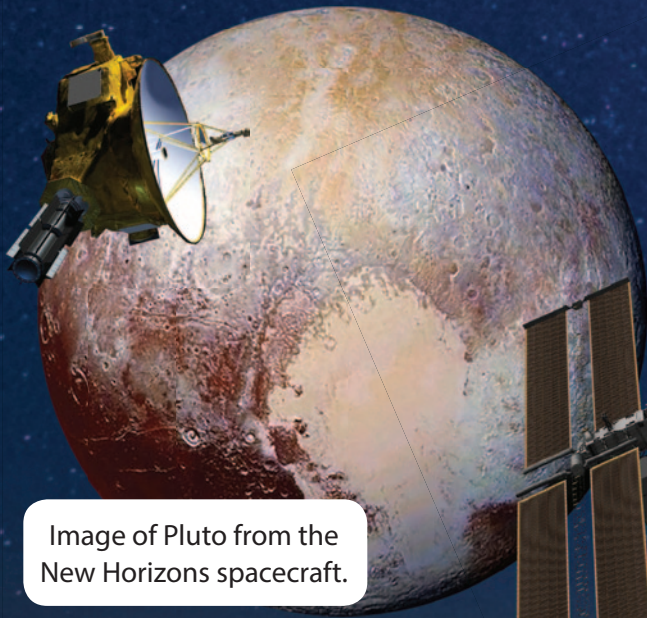
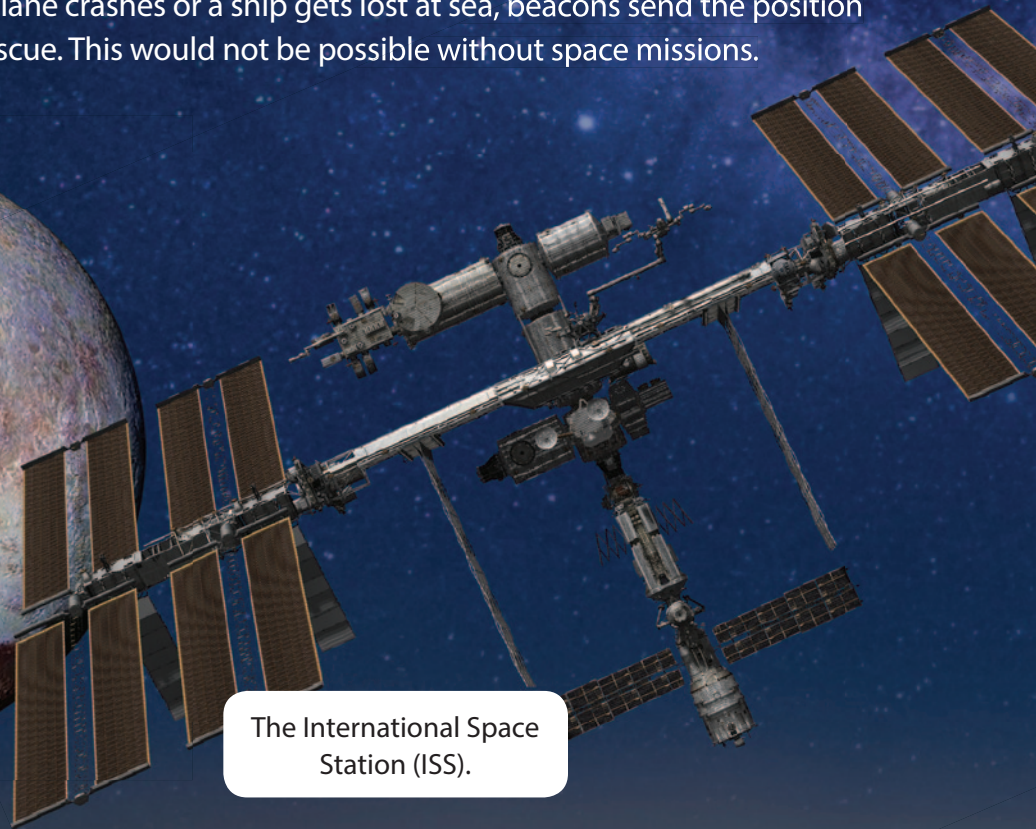


Image of Pluto from the New Horizons spacecraft.



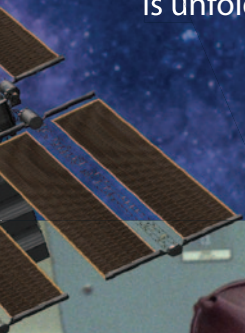
The International Space Station (ISS).

The most famous missions were part of the **Space Race** between the former **Soviet Union** and the United States of America. The Space Race was a battle of the superpowers, and both countries wanted to prove they had the best technology. The race to land a human on the Moon was a very big deal, inspiring kids around the world to become scientists and engineers.

This book is an introduction to the vastness of space exploration. By sharing the details of 50 space missions that changed the world, we hope to inspire you to pay attention to future missions. Space history is unfolding right before your eyes!



GPS satellite.



Canadian astronaut Julie Payette gets suited up to launch on the space shuttle for a 10-day mission to the International Space Station.

Rocket Science

Getting into space is really hard! To get to space, and stay there, almost the entire mass of the spacecraft must be fuel. That's why Moon rockets were so huge. They needed to be large to carry all that fuel!

When a spacecraft fires its engines in the vacuum of space there is no air to slow it down. As long as there is fuel, the spacecraft can keep speeding up! After the engines shut off, the spacecraft coasts, following a path determined by gravity. This path is called a **trajectory**. If that trajectory sends the spacecraft around a planet, moon or star, we say the spacecraft is in **orbit**.

Newton's Third Law

Rockets work by shooting hot gases away from the spacecraft. Isaac Newton's Third Law states that "Every action has an equal and opposite reaction." A rocket pushes against the hot gases and the gases push back! This moves the rocket forward.

Spacecraft that go into space but have speeds of less than 28,000 kilometres per hour (km/hr) fall right back to Earth. Rockets that fly to space but fall right back down are called sub-orbital rockets.



Action! A rocket pushes on the gas.

Reaction! The rocket moves forward.

Rocket fuel

Most rockets are powered by liquids like kerosene and liquid oxygen. Some rockets, like the side boosters on the space shuttle, use a solid fuel.

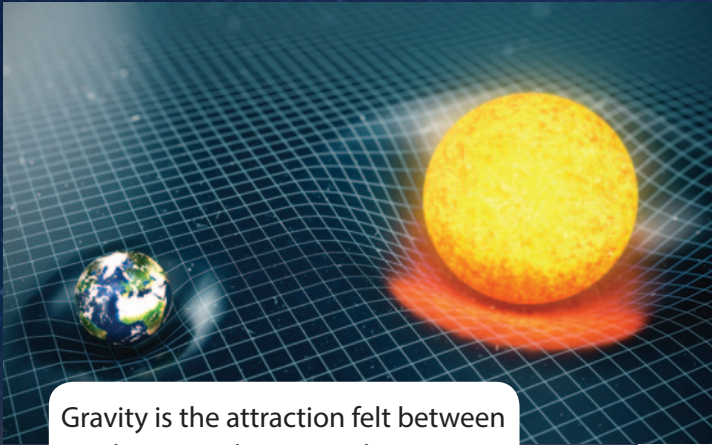
It's all about gravity!

In space travel, gravity is by far the ruling force. Gravity weakens as you go away from a planet or star, but never goes away entirely. In fact, the gravity on astronauts floating in the space station is almost the same as on Earth!

So why do astronauts float? On Earth, we are pulled towards the ground, and in turn, the ground pushes back on us. When a spacecraft is in orbit, it is falling. It just happens to be falling around the Earth. Because astronauts fall along with the spacecraft, the floor of the spacecraft isn't pushing up on the astronauts, and that's why they float!

How high is space?

Space is considered to be anywhere above 100 km. However, if a spacecraft wants to stay in space, it would need to be almost twice that high. Any lower, and there's enough air to slow it down, causing it to fall back to Earth.



Gravity is the attraction felt between objects as they warp the space around them.

It is never correct to say, "there is no gravity in space." For this reason, we use the word **microgravity** for the weightless environment aboard a spacecraft.



Space Jobs

Space exploration provides jobs to millions of people all around the world! Government space agencies, like NASA, are only a small part of this huge industry.

There's a lot to learn if you want to work with rockets and spaceships. You may think the most important subjects are physics, chemistry and math. You'd be right, these subjects are important. But so is working as a team as well as good communication skills.

After high school, more training is required before you can get to work. While a degree in engineering, physics or math is required for many space jobs, other skills are also needed. Tradespeople such as welders and metalworkers construct rockets, spacecraft and robots.



Constructing the Boeing CST-100 Starliner spacecraft.

Internships

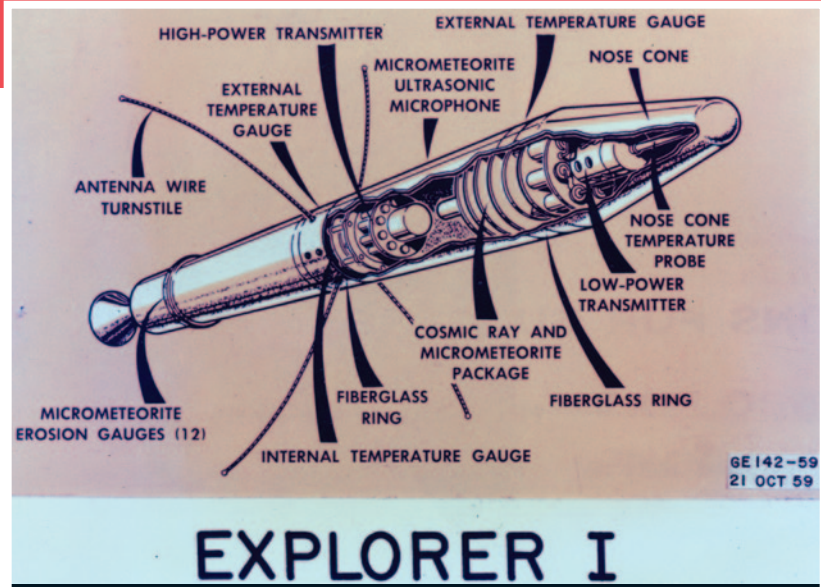
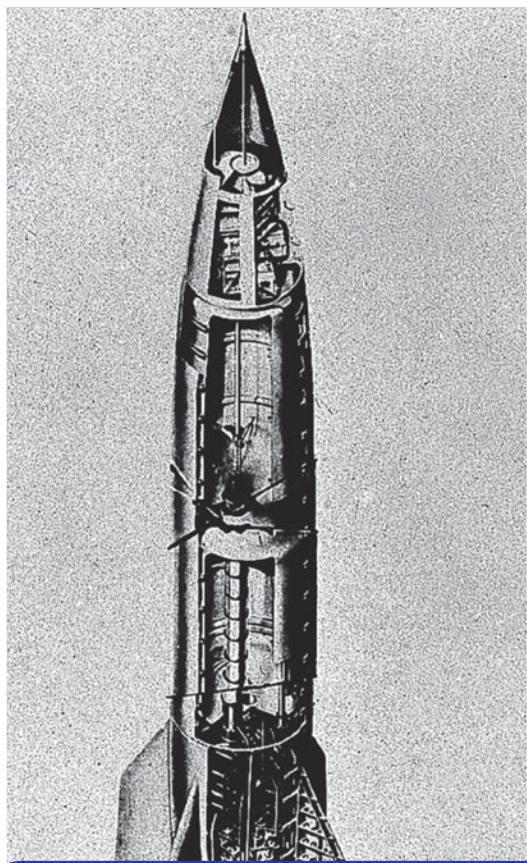
University physics and engineering programs often offer paid internships where students work on important real-world problems. These internships are often the ticket to the most exciting jobs after graduation.



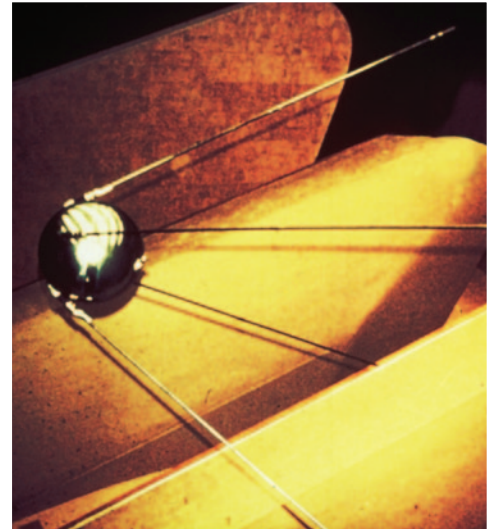
Engineers prepare to do some welding as they construct a spacecraft at the Michoud Assembly Facility in New Orleans.

CHAPTER 1

Enter the Space Age



So many rockets! Text: We tend to only hear about the most famous spaceflights, but in the early days of rocketry, there were thousands of small rockets launched to space (But **not** orbit) from many countries as researchers and engineers tried to learn about the new frontier of space. This even included countries like Norway, Sweden, Greece, and Canada!

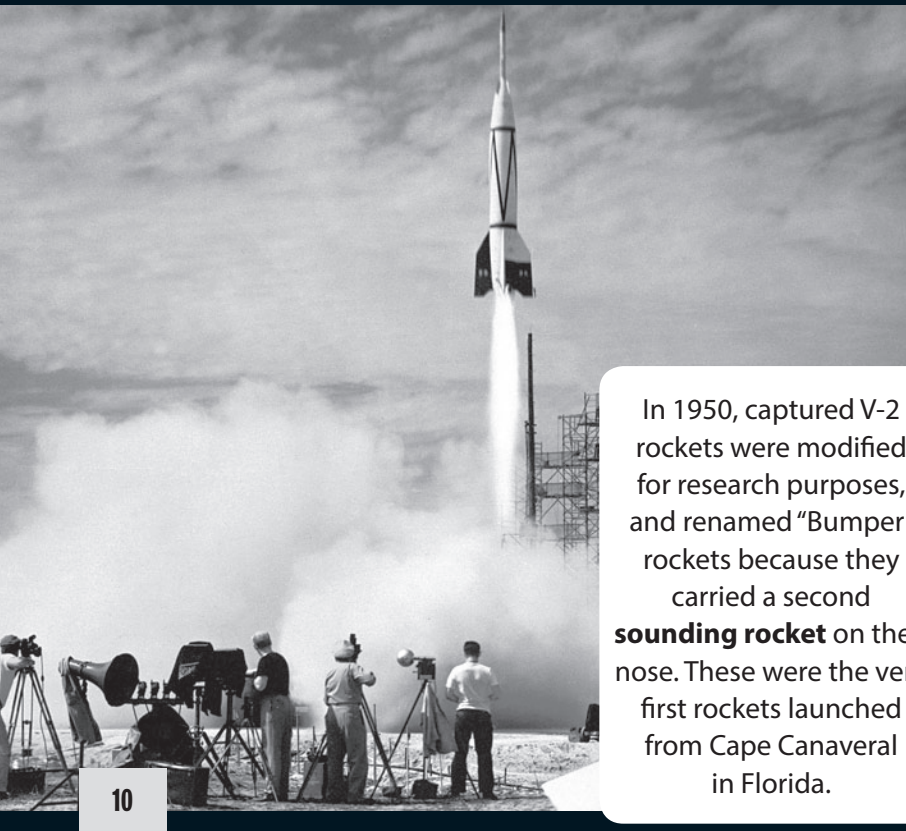


1 The First Spacecraft

First V-2 flight October 3, 1942

After its defeat in the First World War, Germany wanted to regain its military power by making new and improved weapons. Near the end of the Second World War, Germany created a weapon system called the V-2 rocket. The “V” stands for “Vengeance Weapon.” This rocket was the first machine to operate above the Earth’s atmosphere. The Space Age had begun!

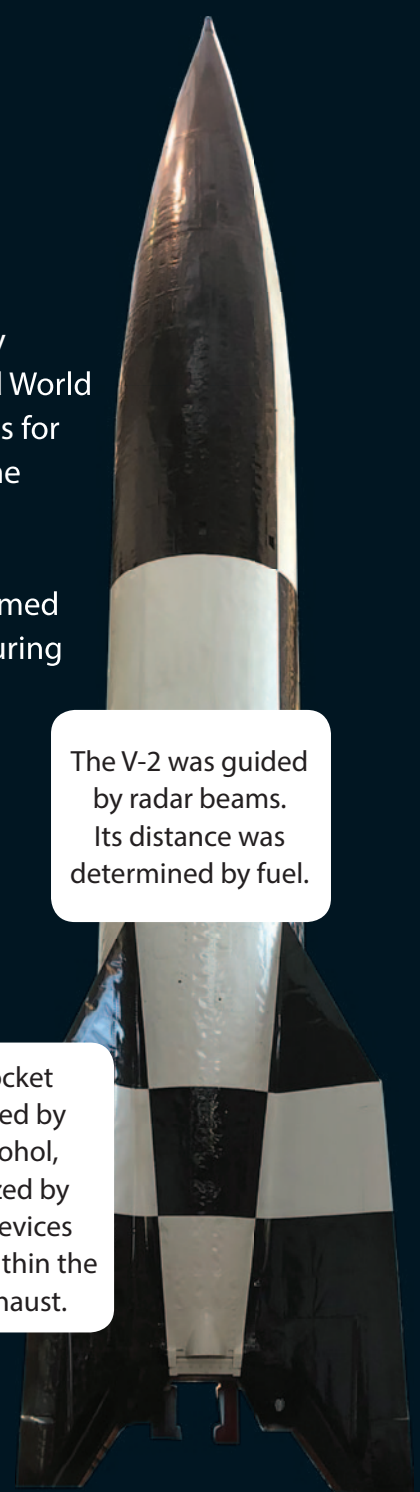
The V-2 rocket was created by a team headed by an aerospace engineer named Wernher von Braun. It was used to bomb London, England, and Belgium during the Second World War. The V-2 could reach altitudes of over 160 km. It was the first time humans had sent an object into space.



In 1950, captured V-2 rockets were modified for research purposes, and renamed “Bumper” rockets because they carried a second **sounding rocket** on their nose. These were the very first rockets launched from Cape Canaveral in Florida.

The V-2 rocket was powered by potato alcohol, and stabilized by jet vanes, devices positioned within the rocket’s exhaust.

The V-2 was guided by radar beams. Its distance was determined by fuel.

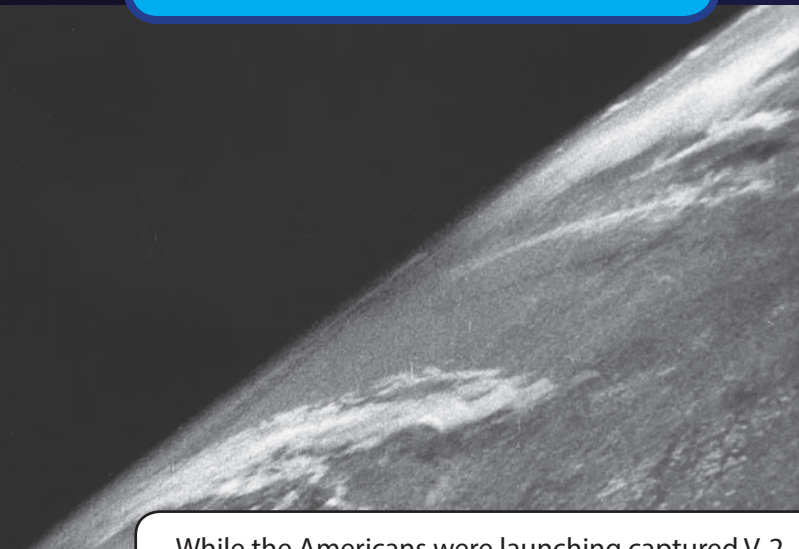


Spaceflight in the 1940s

Near the end of the Second World War, many German rocket scientists surrendered and moved to the United States of America. There they designed rockets for the United States Army and, eventually, **NASA**. Other German scientists surrendered to the Soviet Union. Many continued to work on V-2 rockets and on Soviet rocket programs.

First photos from space

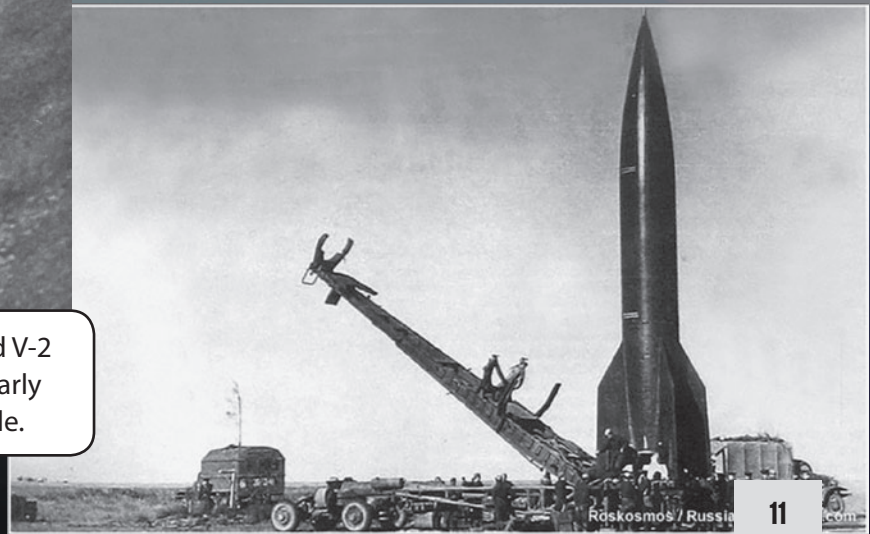
This image was taken using a 35-mm video camera mounted atop a captured V-2 rocket.



While the Americans were launching captured V-2 rockets, the Soviet Union was launching a nearly identical rocket called the R-1 ballistic missile.



Wernher von Braun with a model of the V-2 rocket. Although employed by the German army to build rockets, Wernher von Braun was obsessed with spaceflight.



2 Sputnik and the Space Race


October 4, 1957

After the Second World War, a new type of war brewed between the world's superpowers, the United States of America and the Soviet Union. Although the two countries did not engage in direct combat, they were both determined to build the best weapons. This was the **Cold War** and it lasted until 1991.


In war, the army on the highest ground has the advantage, and nothing is higher than space. The United States of America and the Soviet Union raced to control this new frontier, and the Space Race was born.

On October 4, 1957, the Soviet Union became the first nation to send a spacecraft into orbit around the Earth. Its name was Sputnik, and at 58 cm wide, it wasn't much larger than a beach ball. But this was a huge win for the Soviets.

Humans could now send things up to space, and keep them there!



In October 1957, Sputnik became the first spacecraft to orbit the Earth.



Sputnik launched in the very tip of the nose of an R-7 Semyorka rocket.

What was the Soviet Union?

The Soviet Union (USSR) was a group of communist nations joined into a single large country. The largest of these nations was Russia. The USSR broke up in 1991.

Second place in space

With the Soviet Union now able to send a spacecraft into orbit, this meant that at any moment, a nuclear missile could be directed anywhere on Earth. The launch of Sputnik and other large satellites by the Soviets showed that the United States was behind in space exploration! This led the American government to form NASA on July 29, 1958.

America's first satellite was called Explorer 1. It was developed by Jet Propulsion Laboratory (JPL) in California. Explorer 1 launched just four months after Sputnik. Like Sputnik, the spacecraft was tiny, at about 2 metres long and 16 cm wide. Unlike Sputnik, Explorer 1 carried scientific instruments to detect **meteoroids** and **radiation**.

Explorer 1
launched on January 31, 1958.

Canada was the third country to put an artificial satellite into orbit. The spacecraft, named Alouette 1, was launched from California on an American rocket.

Launch of
Explorer 1 on a
Jupiter rocket.

Alouette 1, Canada's first satellite,
launched on September 29, 1962.

3 First Animals in Space

Sputnik II launched on November 3, 1957

One month after Sputnik, Sputnik II launched into orbit around the Earth. A tiny chamber in the nose of the rocket carried Laika, a stray dog from the streets of Moscow. Laika became the first living thing to orbit the Earth.

Many people think that Laika was the first animal in space, but this isn't technically true. Many other animals, including other dogs, travelled to space before Laika without going into orbit.

Although Laika died shortly after entering orbit, the mission proved that it was possible for living creatures to orbit the Earth. This was another win for the Soviet Union in the Cold War with the United States of America.



Albert II was the first primate in space, but his V-2 rocket did not reach orbit.

Animal firsts

The first animals in space were fruit flies launched aboard a V-2 rocket. The first mammal in space was a monkey named Albert II. The first dogs in space were named Tsygan and Deszik.



Laika preparing for flight.

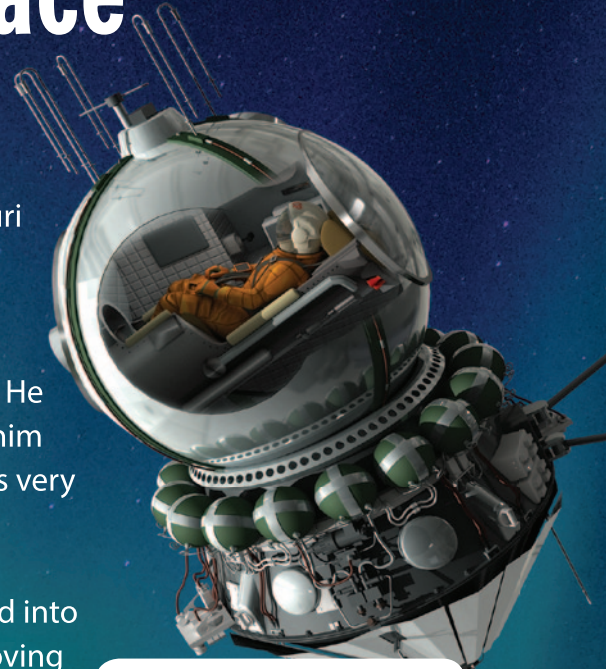
4 First Human in Space

April 12, 1961

Growing up on a farm outside of Moscow, and living under German occupation during the Second World War, the young Yuri Gagarin could never have imagined that someday he would be the first person to voyage into space.

Yuri was a talented pilot, very smart and well-liked by everyone. He was also very short, at just under 5 feet 2 inches tall. This made him the ideal person to crew the Soviet Vostok spacecraft, which was very small.

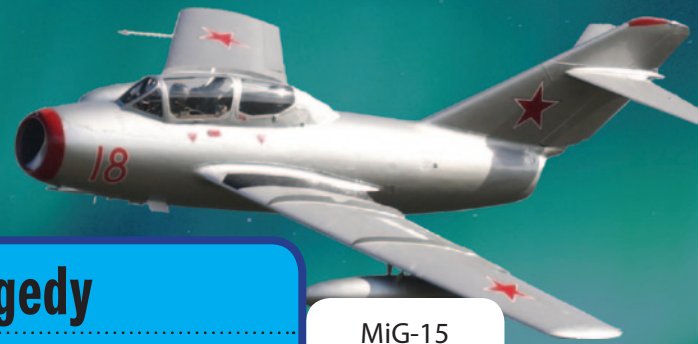
The spacecraft Yuri flew to orbit was named Vostok 1. It launched into space on April 12, 1961. During the flight Yuri ate and drank, proving that the human body could work in space. After one orbit around the Earth, **retro rockets** fired, sending the spacecraft back into the atmosphere. As the capsule fell towards Earth, Yuri ejected and parachuted safely to the ground.



Vostok 1, the spaceship that carried Yuri into space.



Yuri Gagarin, first human in space.



MiG-15

Tragedy

The Soviet government tried to keep Yuri safe, banning him from future spaceflights. However, seven years after his record-breaking spaceflight, Yuri died after his MiG-15 fighter jet crashed while on a training flight.

5

The First Astronaut

Freedom 7 launched on May 5, 1961

Three weeks after Yuri Gagarin's flight, the United States of America launched its first astronaut, Alan Bartlett Shepard Jr., into space on May 5, 1961.

Unlike Gagarin, Shepard didn't go into orbit. The rocket that carried Shepard's Mercury spacecraft was made from a US Army missile. These rockets went to space and fell right back down.

Shepard's spacecraft was named Freedom 7. Despite his flight lasting only 15 minutes, Shepard had a lot to do. During the flight, he changed between manual and automatic control, testing his ability to steer the spacecraft.

Ten years later, Alan Shepard became the fifth person to walk on the Moon.



Astronaut Alan Shepard awaits lift-off in the Mercury capsule named Freedom 7.



The Mercury-Redstone Rocket (MR-3) carrying the Freedom 7 spacecraft.



The previous Mercury flight carried Ham the chimpanzee.



Alan Shepard on the Moon.

6 An American Orbits the Earth

Friendship 7 launched on February 20, 1962

On February 20, 1962, the United States of America finally placed a human into Earth's orbit. During the flight, John Herschel Glenn Jr. spent almost five hours in space, circling Earth three times. It was a good thing Glenn was a talented pilot, because the spacecraft's automatic control system failed, and he had to fly the spacecraft manually.

When the craft re-entered Earth's atmosphere it began to rock back and forth. The parachute deployed about 2,000 metres too early and the spacecraft strayed from its course. Fortunately, the spacecraft splashed

down safely in the Atlantic Ocean and Glenn was rescued by a navy warship. With Glenn safely back on Earth, the United States of America was finally catching up to the Soviet Union.

John Glenn's spacecraft, named Friendship 7, launched atop an Atlas rocket. This same rocket design would later be used to send robotic spacecraft to the Moon, Mars and Venus.



John Glenn



Friendship 7 capsule

Atlas rocket

Mercury 7

Alan Shepard and John Glenn were members of NASA's Mercury 7 — a group of 7 test pilots chosen to be America's first astronauts.



7 The First Spacewalk

Vostok 2 spacewalk, March 18, 1965

Proving that humans could survive in spacesuits outside their spacecraft was an important step in the race to the Moon. However, the first spacewalk by Soviet **cosmonaut** Alexei Leonov almost ended in disaster.

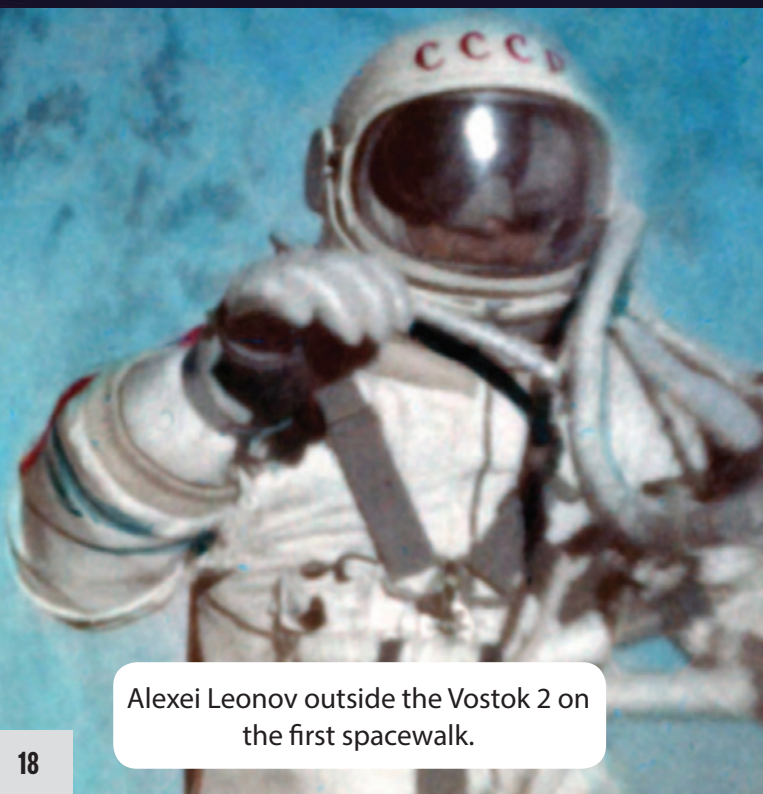
There were two cosmonauts onboard the Vostok 2 spacecraft: Alexei Leonov and Pavel Belyayev. The spacecraft had an airlock that let one person leave the capsule. The mission was simple: conduct the first spacewalk and record it on film.



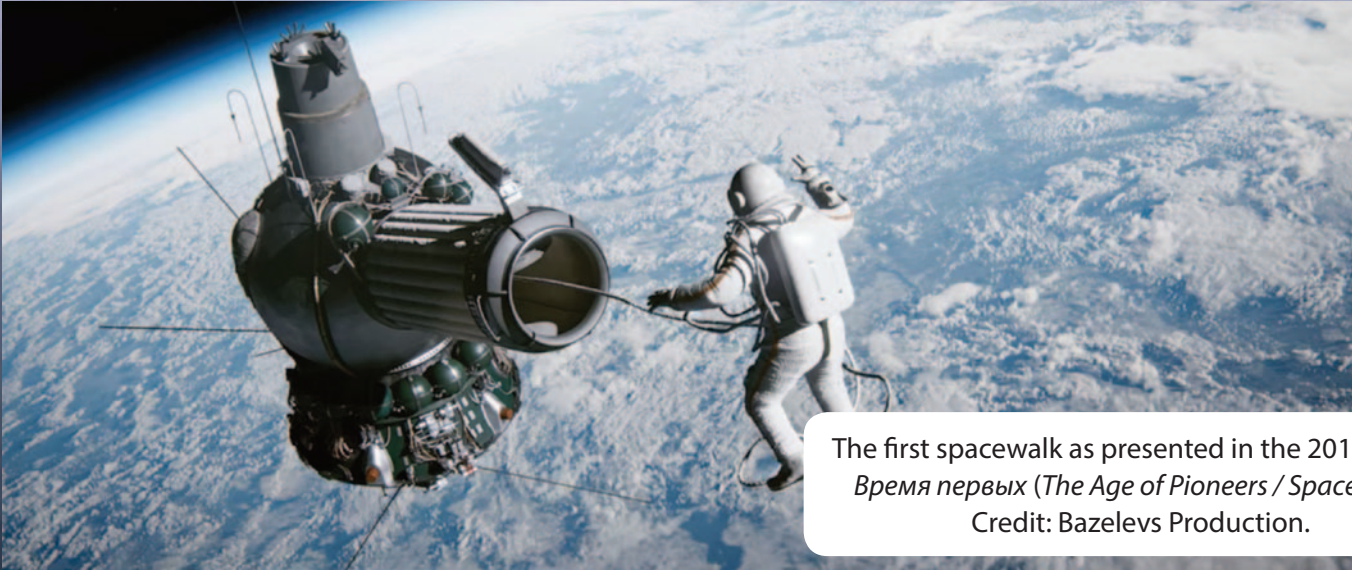
Alexei Leonov

However, after 10 minutes outside the spacecraft, Leonov's spacesuit began to swell. It became difficult to bend his arms and legs and he was unable to fit his body back into the airlock!

Letting some air out of the suit, he entered the airlock headfirst but had trouble turning around to close the hatch. After a struggle, he was finally able to close the airlock hatch and re-enter the spacecraft.



Alexei Leonov outside the Vostok 2 on the first spacewalk.



The first spacewalk as presented in the 2017 movie *Время первых (The Age of Pioneers / Spacewalk)*.
Credit: Bazelevs Production.

An unexpected adventure

The troubles didn't end there. During re-entry into Earth's atmosphere, the spacecraft's guidance system failed, and the crew landed in a remote forest, thousands of kilometres from where they were supposed to be.

For the next two days, they fought a broken hatch, a snowstorm, freezing temperatures and the threat of wild animals. Eventually, the cosmonauts' location was discovered by aircraft and supplies were dropped from the sky. The next morning, a recovery team arrived on skis, leading the cosmonauts to a waiting helicopter.

Despite the difficulties, this mission proved that spacewalks were possible.

"Provided with a special suit, man can survive and work in open space. Thank you for your attention." — Alexei Leonov.



American astronaut Ed White performed America's first spacewalk on June 3, 1965.

8 The First Spy Satellite

Discovery 13 launched on August 10, 1960

When the United States of America's **atom bomb** effectively ended the Second World War, it proved that advanced weapons win wars. By 1949, the Soviet Union had atom bombs, too.

The United States of America wanted information about Soviet weapons. They had spy planes, but those could be shot down. They knew the future of spying would be from space. The first spy satellite was named Corona. Its first successful mission, called Discovery 13, launched on August 10, 1960, and it forever changed how the United States of America spies on its enemies.

There were no digital cameras in 1960, so the spy satellites used film. To get the film back to Earth, the film canisters were ejected from the spacecraft. While descending by parachute, the canisters would be snagged from the air by a plane. The film canisters had a built-in self-destruct system in case they were lost.



Corona, the first spy satellite.



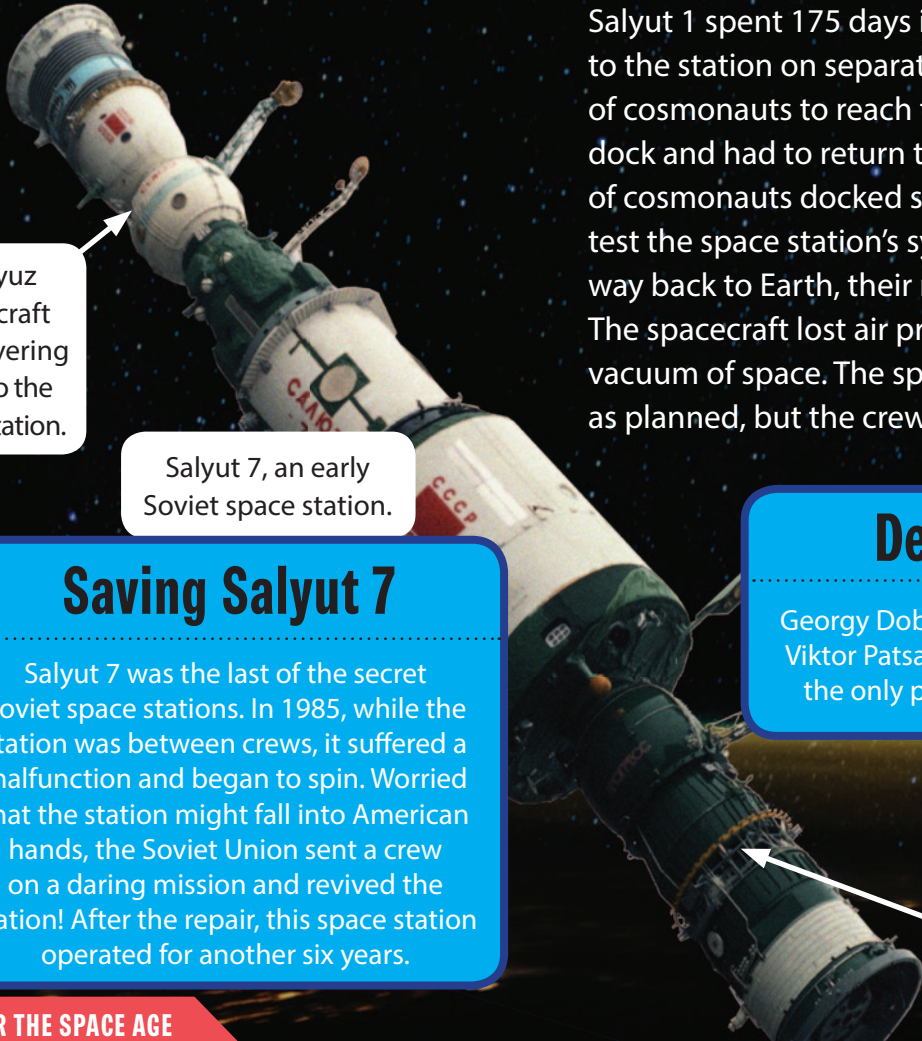
C-119 aircraft training to recover a film canister.

9 Secret Space Stations

Salyut 1 launched on April 18, 1971

The first space station was named Salyut 1 and launched in April 1971. It was built by the Soviet Union during the Cold War. The Soviets claimed that these early space stations were peaceful science missions. However, we later learned the Salyut 3 station was armed with a 23-mm cannon! The Soviet Union built 9 of these space stations, 7 of them were operational, but all paved the way for the much larger stations to come.

Salyut 1 spent 175 days in orbit. Cosmonauts flew to the station on separate spacecraft. The first group of cosmonauts to reach the station were unable to dock and had to return to Earth. The second group of cosmonauts docked successfully. Their job was to test the space station's systems. However, on their way back to Earth, their mission ended in tragedy. The spacecraft lost air pressure, exposing them to the vacuum of space. The spacecraft parachuted to Earth as planned, but the crew had perished.



A Soyuz spacecraft for delivering crew to the space station.

Salyut 7, an early Soviet space station.

Saving Salyut 7

Salyut 7 was the last of the secret Soviet space stations. In 1985, while the station was between crews, it suffered a malfunction and began to spin. Worried that the station might fall into American hands, the Soviet Union sent a crew on a daring mission and revived the station! After the repair, this space station operated for another six years.

Death in space

Georgy Dobrovolsky, Vladislav Volkov and Viktor Patsayev, the crew of Soyuz 11, are the only people to have died in space.

A Progress resupply spacecraft docked at the second port.

10 First Woman in Space

June 16, 1963

On June 16, 1963, a 26-year-old woman named Valentina Tereshkova launched into space atop a Soviet Vostok rocket. She was chosen to be a cosmonaut because of her experience as a skydiver. Early Soviet spacecraft required the cosmonaut to eject from the spacecraft during descent and parachute back to Earth.

Her flight lasted almost three days, during which she circled the Earth 48 times. The flight was used to study the effects of space travel on the female body, proving that women could be cosmonauts, too. Upon re-entering Earth's atmosphere, she ejected from the spacecraft and parachuted to the ground.

It was 19 years before the next woman, cosmonaut Svetlana Savitskaya, flew into space on a mission to the Salyut 7 space station.

Cosmonaut

The word cosmonaut is formed by the combination of two Greek words: "cosmos" meaning space and "nautes" meaning sailor.



"A bird cannot fly with one wing only. Human spaceflight cannot develop any further without the active participation of women." — Valentina Tereshkova



Inside the Vostok 6 capsule, Tereshkova's spacecraft's call-sign was Chaika, which means "Seagull."