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VAST 3D

A cosmic journey through time and space

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[An image of Earth in slow rotation]

Space is unimaginably vast. Thanks to our curiosity and desire for knowledge, humans are driven to explore space and learn more about the universe. Yet there is still so much more to discover. We are going on a journey further out into space than any other human being has ever been before. Everything we are going to see on our journey is based on real data collected thanks to mankind's technological progress and many years of research.

[Zooms in towards the ISS]

Many satellites and spacecraft orbit our planet Earth. The International Space Station, or ISS, is one of them. It orbits approximately 400 kilometres above the Earth's surface, at a tremendous speed of 28,000 kilometres per hour. It takes 90 minutes for the ISS to travel one lap around our planet. The space station is a fantastic project of international collaboration. It has been permanently inhabited for more than 20 years, and this is the only place outside Earth's atmosphere with a permanent human presence. Two of the astronauts who have been here are the Swedes Christer Fuglesang and Jessica Meir. They and the other astronauts on the ISS conduct research that, among other things, helps us to understand how people are affected by living in space.

[Zooms out from Earth and satellites become visible]

We have sent up thousands of satellites that travel around the Earth. Here we can see satellites in their actual orbits as everything we see is based on real measured data. Some of these satellites can be seen with the naked eye, as they travel across the sky before sunrise or after sunset.

[Turns on another layer of satellites (GPS) and zooms further out]

A little further out are the GPS navigation satellites. They send out synchronized time signals using atomic clocks on board. When we receive these signals on the ground, we can, by measuring the time differences between them, instantly calculate where on Earth's surface we are with just a few metres accuracy.

[Turns on the geostationary orbit]

The geostationary orbit is almost 36,000 kilometres from Earth. These satellites travel around our planet in 24 hours, which means that they are stationary in the sky above us. We use them for satellite communication and television because we can point a fixed antenna towards one specific satellite.

[We leave Earth behind us and see our moon]

In 1969, after many years of research and technological development, the first humans landed on the moon. This is one of humanity's greatest achievements. Between 1969 and 1972 a total of 12 astronauts landed on the lunar surface, but since then no one has been here.

[The journey continues towards Mars and focuses for a while on its two moons]

However, humans will visit other places in the universe. It is just a matter of time. Here we have our neighbor Mars and its two moons - Phobos and Deimos. Mars is mankind's next destination. Travelling there will take at least six months, depending on how Earth and Mars line up with each other. We already know a lot about Mars thanks to the rovers that have landed on its surface and space probes that are in orbit around the planet. One of the space probes that has given us access to high resolution images of the surface of Mars is called MRO, which stands for Mars Reconnaissance Orbiter. It allows us to experience Mars in this unique way.

[We approach the surface of Mars and one of its poles]

Mars is a very inhospitable planet. The atmosphere is very thin and consists of 96 percent carbon dioxide. The average temperature on the surface is about minus 60 degrees Celsius, but can vary between minus 100 and plus 30 degrees. There is frozen carbon dioxide and frozen water at the poles. In other words, there is ice on Mars, but we also believe that a very long time ago, there was liquid water on this planet.

[We fly past Olympus Mons]

The landscape on Mars is incredible. Here we find the tallest mountain in the solar system - Olympus Mons, a mountain that covers an area the size of France and stands 26 kilometres high, three times the height of Mount Everest.

[Flies towards Valles Marineris]

In front of us we see Valles Marineris, a 4,000-kilometre-long canyon that extends across the Martian surface. We could compare it to the Grand Canyon on Earth, only 10 times longer.

[Down towards Candor Chasma]

This is one of the most amazing things about research and visualization technology. The fact that we can travel across the surface of a planet which would be difficult to visit in reality. We don't need to expose ourselves to the dangers and difficulties that the first astronauts travelling to Mars will face. We can learn more about distant places before we ever go there.

We are now approaching a spot in Valles Marineris where we can see real data with a resolution of 25 centimetres. We can begin to see things on the human scale. We would be able to see houses, cars and even people if there were any here.
The sand dunes that appear in front of us are around 50 to 100 metres high. A long time ago water probably flowed here and the wind has helped to create formations that look like the sand dunes we see on Earth.

[We fly towards the asteroid belt between Mars and Jupiter]

Between Mars and Jupiter there is something really quite special to look at - the asteroid belt. Asteroids are a collection of large rocks and boulders that revolve around the sun.

[Turns on data set on potentially dangerous asteroids]

These asteroids are special, because they could collide with Earth at some point in the next two thousand years. The risk is incredibly small, so there is no need to worry. Researchers are monitoring these potential dangers very carefully. But if an asteroid like this hits Earth, it would cause unimaginable destruction. A collision with an asteroid is believed to have killed the dinosaurs on Earth 66 million years ago.

[*Flies slowly out of the solar system*]

Let's now reflect on some of mankind's exploration of space. Humans have created the International Space Station, we have been to the moon and we are going to Mars. We have even sent spacecraft beyond the solar system.

[Shows Pioneer and Voyager while constantly zooming out]

Back in the 1970s the Pioneer and Voyager spacecraft were launched. The red line we see represents the path of Pioneer, while the yellow one is Voyager. We are still receiving weak radio signals from the Voyager spacecraft. They have left the solar system and are heading further out into the universe.

[Continues zooming out, for Voyager]

It takes about eight minutes for light to travel from the sun to Earth. Where we are now, the light needs almost an entire day to reach us. In astronomy, we prefer to measure distances using the speed of light and we say that we are now 24 light hours from home. Radio signals also travel at the speed of light. Sending a signal from here to Earth would take 24 hours and then we would have to wait just as long to hear the response.

[We now continue travelling further out]

We are on a breathtaking journey out into the universe and are now a light year away from home. We are travelling much faster than the speed of light. Distances to the stars that make up the constellations, which we perceive from Earth as flat two-dimensional images, vary massively, from a few light years away to as much as 6,000 light years from earth. This becomes clear as we travel into interstellar three-dimensional space. The constellations in our visualization then start to look like one big hedgehog of dashes and lines.

[We continue out into the galaxy, turn on the radiosphere]

In the 1930s, the first radio transmissions were produced at a frequency and strength that could pass through the ionosphere and continue out into space. Let’s take the opening speech at the Olympic Games in Berlin in 1936 as an example. It has now reached this far, and if we had a huge radio telescope out here on the edge of the blue sphere, we would be able to capture the first human signals on their way out into the universe at the speed of light.

[Turns off the blue radiosphere and continues out, turns on the exoplanets]

So you might be wondering whether there is life out here that could be listening to us? All around us there are other solar systems of stars, planets, and moons. Every star that now has a ring around it we know with certainty has orbiting planets. They are called exoplanets. Some of the ones that we have discovered are quite similar to Earth and are located within the area around a star that we call the habitable zone. This is where there is just the right amount of heat and radiation for life to exist. These exoplanets are so far away that with current rocket technology it would take thousands of years for a space probe to arrive. But if there is life out here in the universe, perhaps we will be able to communicate in the future.

[We now see the Milky Way and our solar system is circled]

In front of us we see our galaxy – the Milky Way. The Milky Way alone has several hundred billion stars and in the centre of the galaxy there is a black hole keeping it together. It is 120,000 light years across, and it takes about 240 million years for the sun to complete one orbit around our galaxy. We live about 25,000 light years from the centre of the galaxy, in a sparsely populated part where there are few other stars.

[Turns on Tully Galaxy Catalog and travels even further out]

As we travel further we see other galaxies starting to appear. We are now looking at the Tully Galaxy Catalog, containing the 30,000 galaxies closest to us. It stretches out to a distance of approximately 900 million light years from Earth. Our nearest neighbor, the Andromeda galaxy, is located at a distance of 2.5 million light years away. We are now heading out into intergalactic space, and we can see clusters of galaxies and filamentary structures of galaxies – the underlying structure of the universe.

[Turns on the Sloan Digital Sky Survey and continues further out]

We are now one billion light years from home. The Sloan Digital Sky Survey contains more than one billion objects and more objects are detected and added all the time. Everything we see here is measured with telescopes from Earth and it is difficult to point these telescopes towards the plane of the Milky Way because there are so many stars and dust clouds blocking the view. The dark areas we see are simply areas that have not yet been charted from Earth. The universe does not look like a butterfly – there are galaxies everywhere.

Out here, the light from the galaxies we observe from Earth has been heading towards us for six to seven billion years. That means we are seeing the galaxies as they looked like a very long time ago, long before Earth was formed. The further out into the universe we travel, the further back in time we travel.

[Continues travelling out]

Somewhere out here galaxies do not yet exist. The light that reaches us from out here has been travelling for so long that we are seeing the universe as it looked like before galaxies were formed.

[Continues further out towards the quasars]

Out here we find quasars, which are extremely bright objects. Quasars puzzled astronomers in the 1950s when they were first discovered. We now believe that they are gigantic black holes that devour everything around them and send out lots of energy.

[Turns on the cosmic background radiation]

This far out there is only one thing left to see – the cosmic background radiation. Roughly 13.8 billion years ago the universe was created in the Big Bang. It generated so much energy that no light could escape for 300,000 years. Then, the universe cooled so that light could pass through, and photons, light particles, could move freely for the first time. In that moment the universe became transparent. It is these photons we measure on Earth today as the cosmic microwave background – the echo of the Big Bang. This is the absolute limit of what we can see. We will never be able to observe anything further away than this because then we would be seeing things that were older than the universe itself.

[We travel through the cosmic background radiation]

Here we have the whole known universe in a single sphere - our visualization. It is one of humanity's greatest achievements, that we have been able to measure all this data and put it together in a single model. From Earth, Mars, planets, stars, galaxies, quasars and the Big Bang – a journey that illustrates human curiosity and the desire for knowledge.

It is great to be able to visualize all this. But it is not just a scientifically accurate visualization. It's also incredibly beautiful. So we invite you to experience an epic journey home - all the way back to planet Earth.

[The journey home]

Welcome home! 13.8 billion light years in just a few minutes. We live on a planet that orbits one of a billion stars. In one of the trillions of galaxies in our universe. This is the only planet in the universe where we actually know that there is life. We humans have left our mark in space, and who knows how much we will be able to explore in the future. The journey we have been on gives us new perspectives on our presence and existence in an unimaginably vast universe and on the planet that is our spaceship on our journey through time and space.