Success Story

From Earth to Mars

Image courtesy Nasa Ames

Breakthroughs at NASA Ames

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– G. Scott Hubbard,
Director,
NASA Ames Research Center

Since 1958, NASA Ames Research Center has remained one of the best-kept secrets among Silicon Valley's technology innovators. That is now changing in a big way. While high-profile companies and universities jostle for their share of the media spotlight, Ames has quietly pursued an ever-expanding spectrum of groundbreaking research. In fact, grasping the vast scope of work at NASA Ames is to understand that space is only part of the picture at NASA. Indeed, much of NASA Ames' efforts focus on what the agency likes to call "our home planet."

In addition to space exploration, the list of NASA Ames' achievements is long. Research includes enabling safer and more efficient air travel, climate change forecasting, long-term sustainability of the Earth's natural resources, and even disease outbreak prediction.

Underpinning many of these breakthroughs is SGI® technology. For more than two decades, the escalating requirements of NASA researchers have helped drive SGI visualization, computing and storage technologies to new levels of performance and efficiency. Ever more powerful computing systems from SGI in turn produce faster and more accurate results for NASA experiments and studies. And as NASA stakes new ground in science, its thirst to solve even more complex problems evolves into new system designs. And so the collaboration continues.

Earth to Mars: Help from SGI

While many NASA innovations have primarily interested the scientific community, the agency earned worldwide public acclaim with the successful execution of its Mars Exploration Rover (MER) mission. Indeed, as soon as the first Mars Rover safely landed on the Red Planet in January 2004, NASA once again became synonymous with technical and scientific

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brilliance. Millions of television viewers and armchair astronauts scrambled to learn the latest on Spirit, the first Rover to land and explore Mars, and Opportunity, which landed on the opposite side of the planet a few weeks later.

As it has across 20 years and on various projects, NASA depended on SGI technology throughout the planning and execution of the MER mission. At JPL, NASA scientists and engineers used four SGI® Origin® 2000 series servers to study and select MER landing sites. NASA used the systems—driven by a total of 302 processors—for descent analysis, trajectory studies, and other compute-intensive tasks. MER mission planners had to balance the concerns of scientists seeking geological "sites of interest"—where Rovers were most likely to find evidence of water—with the need for safe landings. This is particularly vital on a planet with mountains reaching up to 16 miles high and a string of canyons nearly 2,500 miles long and five miles deep.

NASA Ames' Reality Center has created a truly immersive environment in the largest facility of its kind on the West Coast.

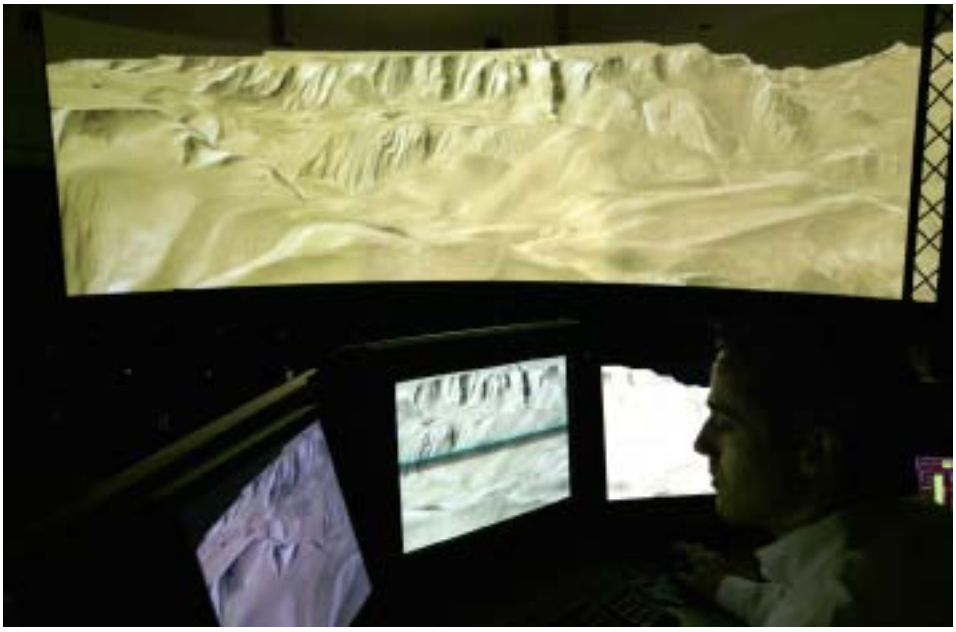

Image courtesy Nasa Ames/JPL

SGI visualization technology also is helping NASA engineers safely pilot the Spirit and Opportunity Rovers while compensating for round-trip space communication lag times of up to 20 minutes. JPL is using SGI® Onyx® 300 InfiniteReality4™ graphics systems and the OpenGL Performer™ real-time graphics API to combine daily 360-degree photographic images with terrain data to create a virtual Mars environment. This environment integrates the 3D visualization of the surrounding Martian geography with an interactive model of each Rover. As a result, NASA engineers can safely pilot the vehicles across rocky Martian terrain.

A Visitor Center Turned Reality Center

It was only natural for NASA Ames to turn to SGI once more when it wanted to find a high-impact way to display the agency's achievements to the general public. The MER landings in early 2004 gave NASA Ames administrators an opportunity to bring this latest chapter in NASA's history of achievement into full focus for area residents. Located in a former Space Camp tent, the new NASA Ames Mars Center sits just outside NASA Ames main gate at Moffett Field, Calif. Open to the public year-'round, the center distills NASA Ames innovations into a multimedia experience that is the envy of science museums the world over. And the foundation of that powerful venue is the West Coast's largest SGI® Reality Center® immersive visualization facility.

SGI Reality Center facilities have spawned an entirely new level of interactive education in planetariums, science centers, and museums around the globe. For the first time ever, people have the ability to interactively explore the universe, fly through a strand of DNA, discover the chambers of an Egyptian tomb, and

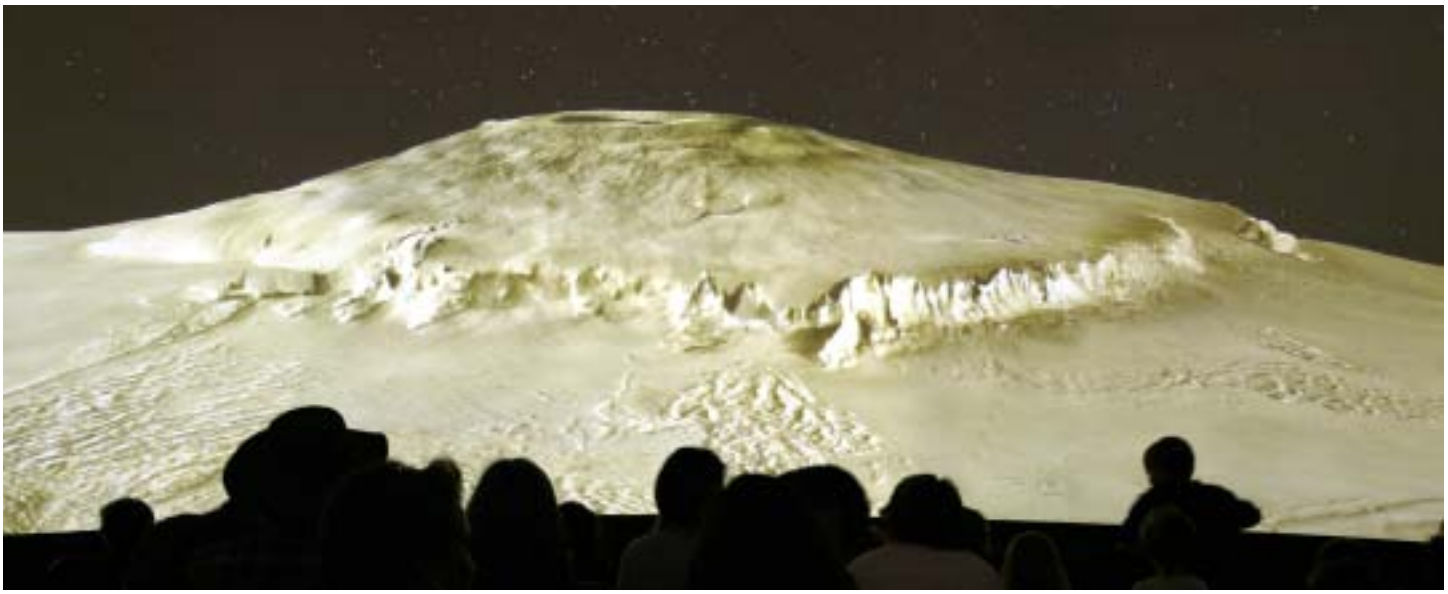

Image courtesy Nasa Ames/JPL

With a new theater powered by SGI Reality Center technology, NASA Ames can present panoramic images of the surface of Mars.

examine minute details of priceless works of art. When deployed in companies and research organizations, Reality Center facilities also allow teams of technical and creative professionals to engage in interactive, real-time engineering and design review, data analysis, critical training, presentation, or command-and-control operations. Collaborative teams are immersed in virtual environments that allow them to explore, understand, and communicate about data in ways not possible in the physical world.

For the general public, the Reality Center facility is the main attraction at NASA Ames Mars Center. The curved display, measuring 14 feet tall and 36 feet wide, is capable of immersing audiences in interactive 3D visualizations, multimedia presentations, and panoramic images that can be navigated in real-time. The large screen was custom-designed to SGI specifications by SEOS, with a curve radius of 22 feet. The curved screen actually allows a full 40-feet of imagery to be displayed from end-to-end. SGI Professional Services installed the theater using three Barco Galaxy 5000 DLP™ Projectors, each of which produces 5000 ANSI lumens of brightness. A 5.1-channel Surround Sound system and an AMX™ wireless touch-screen control panel complete the output components, which can display computer graphics, DVD, VCR or broadcast TV images.

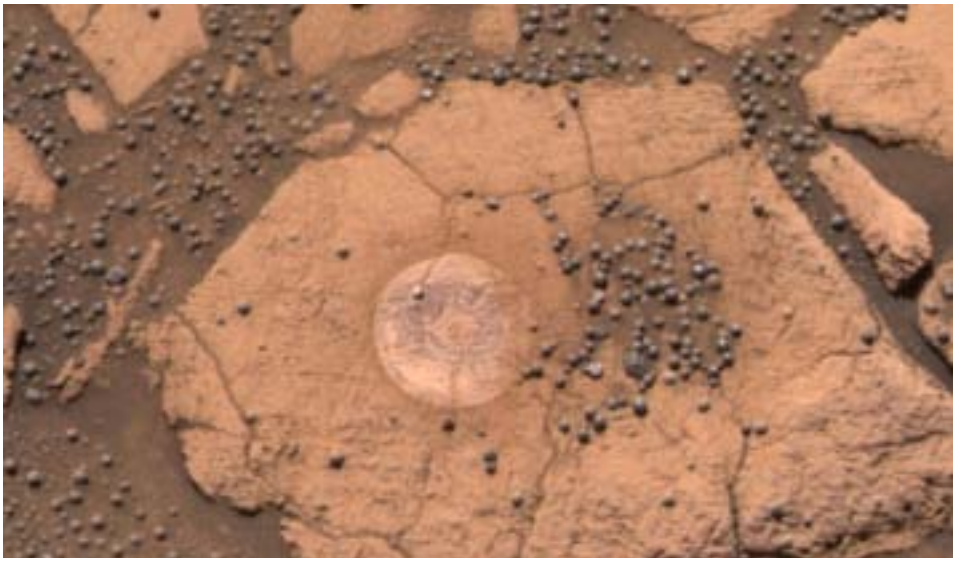

Image courtesy NASA/JPL/Cornell

Rendering the Mars experience in startling, up-close detail was possible only by using an SGI Onyx 350 with three fully loaded InfiniteReality4 graphics pipes. A full gigabyte of dedicated texture memory per graphics pipe enables interactive panning and zooming.

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For interactive content—such as real-time navigation of images or 3D visualizations—the NASA theater relies on SGI visualization technology. NASA's Reality Center facility is powered by an SGI® Onyx® 350 with three fully loaded InfiniteReality4 graphics pipes and 12 R16000™ 64-bit MIPS® processors. Each graphics pipe comes with 1GB of dedicated texture memory—the most of any computing platform—enabling massive amounts of imagery to be visualized in an immersive environment. The Onyx® system provides a seamless image across the three projectors, a feat that simply cannot be matched by clustered PCs or other solutions. With it, NASA Ames staff can give visitors a view of Earth or outer space that no still image, television news report, or small-format panorama can possibly match.

Image courtesy of Maas Digital/Cornell/NASA/JPL

Part of NASA Ames' Mars presentation is a high-definition animation of the MER approach and landing. For maximum resolution and impact, NASA feeds the 36GB animation directly from the facility's disk array onto the Onyx 350 system.

Lights, Camera, Immersion

Few Silicon Valley technology leaders can tell their stories so dramatically. For instance, NASA Ames' Mars presentations open with a multimedia program produced by NASA's Jet Propulsion Laboratory (JPL). The eight-minute, pre-rendered production gives a visual history of Mars, tracing man's earliest medieval observations of the red planet through NASA's series of Mars exploration missions. The program, which is some 180GB in size, feeds onto the 3480-by-1024-pixel display from an SGI® InfiniteStorage Performance TP9300 storage array with 4TB of data capacity feeding the system at up to 230MB per second.

The introductory sequence then brings the Mars story fully up to date with a four-minute, high-definition animation by Dan Maas of Maas Digital. Commissioned by NASA to create the flagship animation for the MER mission, Maas worked with Principal Investigator Steve Squyres at Cornell University to render in extreme detail the launch, flight, entry, landing, and surface exploration of a Mars Rover vehicle. Like the JPL production, the 36GB entry and landing animation feeds directly from the disk array onto the Onyx system.

Afterward, Mars Center guests view the latest high-resolution Mars images and panoramas downloaded from JPL. Engineers at JPL's Pasadena, Calif., mission control facility receive 168 separate photographs snapped by each

Mars Rover. NASA engineers then stitch together the images to create panoramas capable of 360-degree immersion with the highest resolution panorama at 24,000 by 8,000 pixels – so large that they contain over 50 times more detail than previous NASA panoramic images. (By comparison, IMAX® film resolution is 4,000 by 4,000 pixels.) At NASA Ames, these panoramas are read by a special utility written by SGI to fit the format of the theater.

While JPL relies on the stereographic images to determine driving routes for the Rovers, NASA Ames can use them to give the public a rare close-up look at the surface of a planet 106 million miles from Earth. Mars Center visitors use stereographic images to view the Martian panoramas in even greater depth and detail.

NASA will also be able to show content from the Virtual Science Network – a group of scientists and researchers (all of whom are SGI users) who contribute content for museums, science centers, and education outreach institutions like the NASA Mars Center. The NASA Ames theater also takes visitors on a tour of reconstructed images captured by the Hubble Space Telescope. In these sequences, viewers voyage deep into the heart of the Orion Nebula. The San Diego Supercomputer Center, astrophysicists and artists at the American Museum of Natural History's Hayden Planetarium, and C. R. O'Dell of Rice University all worked together to produce a 3D model of the star-forming region some 1,500 light years from Earth.

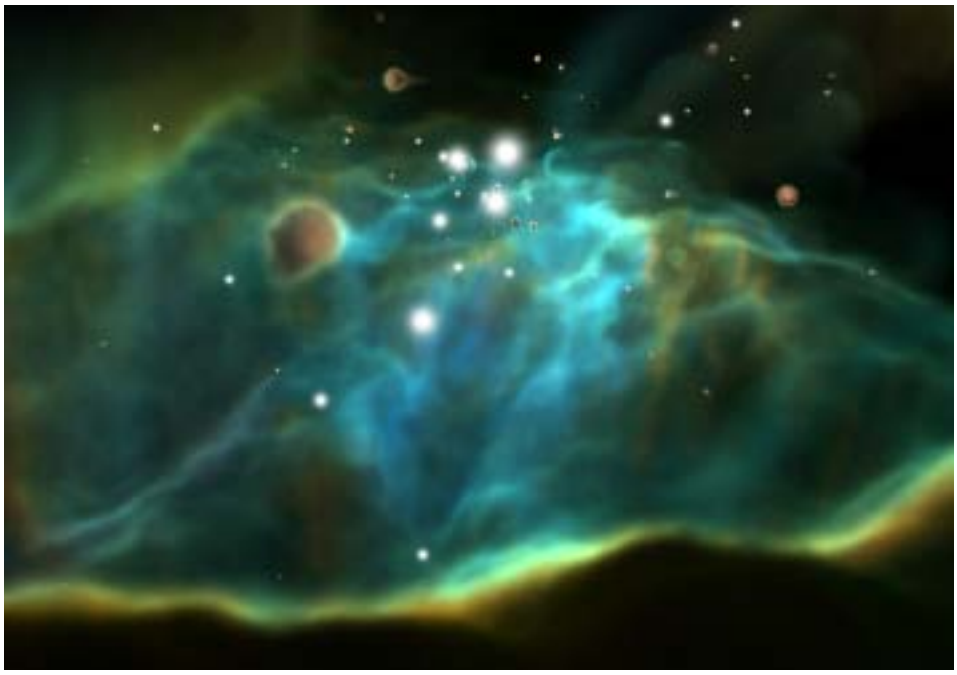

Image courtesy San Diego Supercomputer Center

At NASA Ames, visitors can travel 1,500 light years to the Orion Nebula. The virtual tour uses reconstructed images from the Hubble Space Telescope.

Another show sequence takes viewers from Earth through the Milky Way, out to the Virgo Cluster and past nearly 35,000 galaxies that have been charted correctly by Brent Tully, a researcher at the University of Hawaii. Based on the best available knowledge of nearby galaxies, the 3,000-by-1,000-pixel rendering was created by National Computational Science Alliance Cosmology team, and Jeremiah Ostriker and Paul Bode of Princeton University.

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– Walt Brooks, Chief of the NASA Supercomputing Division, NASA Ames

"The Reality Center theater installed at NASA Ames is a resounding success," notes G. Scott Hubbard, director of NASA Ames Research Center, which attracted more than 80,000 visitors in its first several weeks of Mars-related presentations. "Nowhere else can students, teachers and parents experience NASA's achievements in startling depth and detail. We're delighted to set a new standard for interactive education on the West Coast, while showcasing our contributions to space exploration and Earth science."

In the future, the NASA Ames Mars Center may also offer additional presentations designed to provide a behind-the-scenes perspective on the amazing projects on which NASA is working. Examples include projects such as Future Flight Central, which is developing new ways to improve safety and efficiency at commercial airports, and the computational fluid dynamics studies underway at NASA Ames' supercomputing facility.

Some of that work already is in the spotlight. NASA Ames' supercomputing facility made headlines in late 2003 when NASA engineers, working closely with SGI, installed the world's first 512-processor SGI® Altix® supercomputer to run on a single Linux® kernel. For NASA, achievements like these will in turn result in further innovations that help scientists understand the impact of man's presence on Earth.

"NASA's use of supercomputers like the NASA Ames 512-processor Altix system is vital in our modeling of global climate change and scientific research," notes Walt Brooks, Chief of the NASA Ames Supercomputing Division. "As computing technologies advance, we are achieving insights into climate change faster and more efficiently, helping us to better understand and protect our home planet."

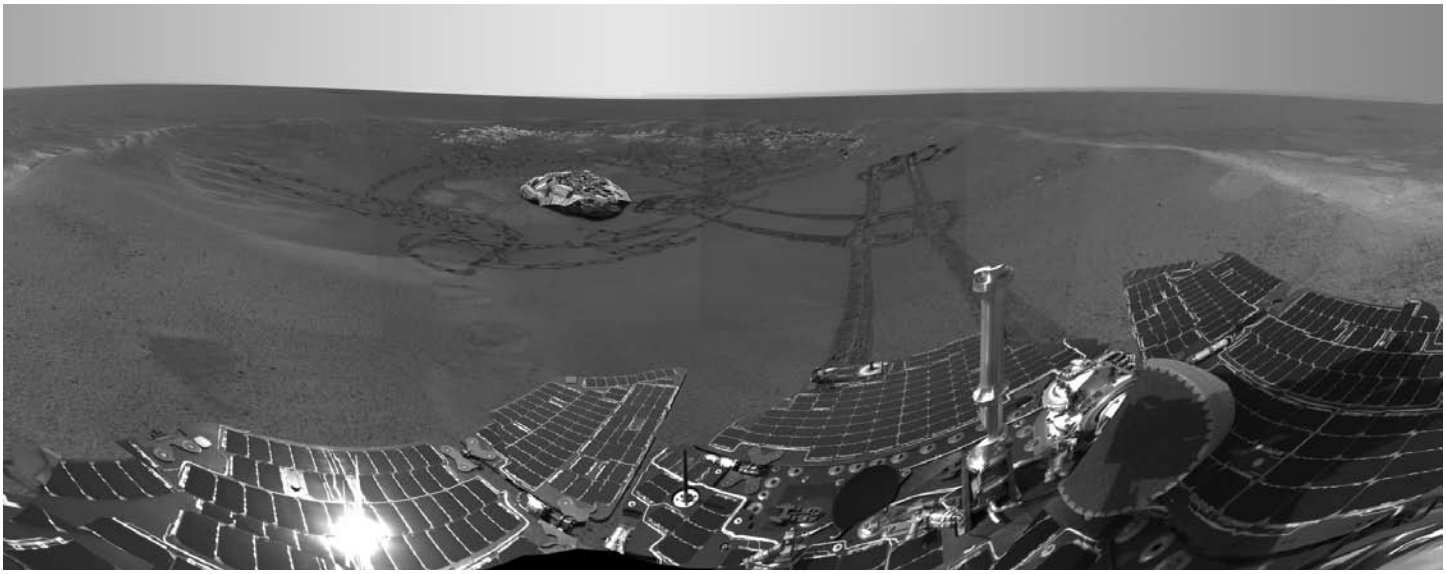

Image courtesy NASA/JPL/Cornell

Using software developed for NASA by SGI, engineers stitch together images snapped daily by Mars Rover vehicles to create towering panoramas of the Red Planet.

Image courtesy NASA/JPL/Cornell

To help safely pilot the two Mars Rovers, engineers at NASA JPL used SGI visualization technology to combine panoramic images of the surface of Mars with topographical terrain data.

"With this theater, we can spark in young minds a lifelong passion for science, enabling them to witness firsthand the leadership that NASA has achieved in space and Earth science."

– Bonnie Dalton, Deputy Director, Astrobiology and Space Research, NASA Ames

A Powerful Experience

No matter what direction science takes as a result of NASA's explorations, the Reality Center facility at NASA Ames will serve as a powerful reminder of the agency's achievements. The Mars Center serves as a testament to the intellectual and technological investment that has shaped NASA for decades.

"The work we do here requires some of the most advanced computing and visualization technology available, which made the SGI Reality Center facility an ideal choice as the foundation of our theater," says Bonnie Dalton, deputy director for Astrobiology and Space Research at NASA Ames. "With this theater, we can spark in young minds a lifelong passion for science, enabling them to witness firsthand the leadership that NASA has achieved in space and Earth science."

The Mars Center theater, after all, can do some fairly wondrous things. "We now have the ability to send schoolchildren over 100 million miles to the surface of Mars, and get them back home in time for lunch," says Dalton. "Even in the heart of Silicon Valley, it's hard to imagine something with more impact."

Working closely with SGI, NASA Ames announced in late 2003 that it had achieved the world's largest Linux supercomputer. The system was the world's first to scale a single Linux OS kernel across 512 Intel Itanium 2 processors.

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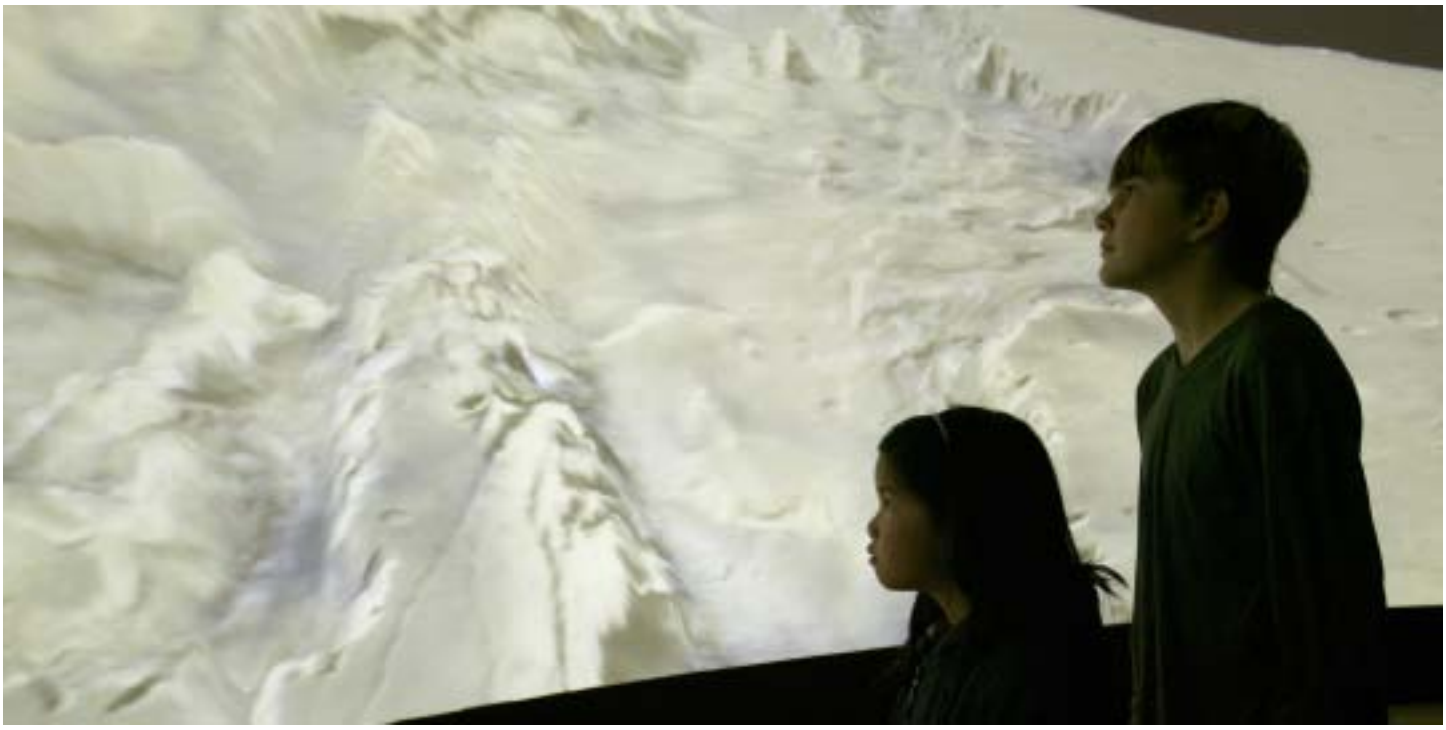

Image courtesy Nasa Ames/JPL

SGI Reality Center facilities like the NASA Ames center reveal what is possible at science centers, museums, and educational institutions around the world.

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