Volume 1
Number 3
January 2001

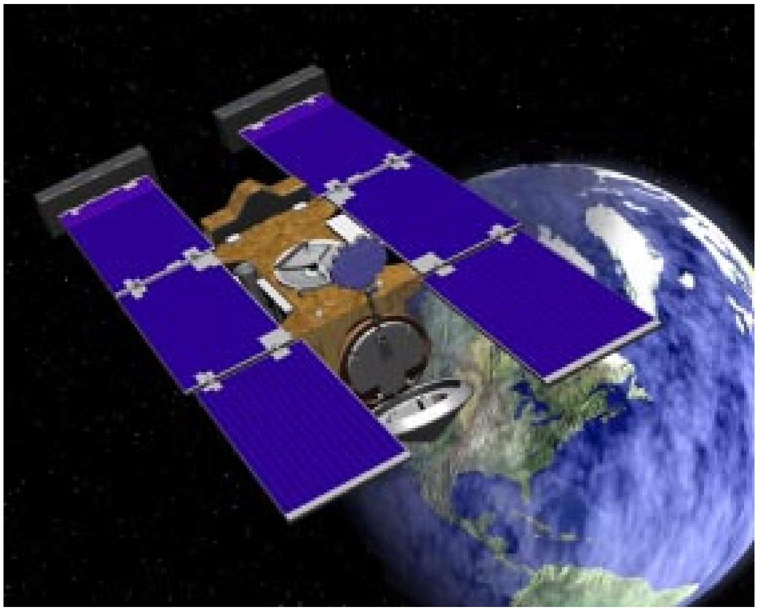
stardust

STARDUST on the Internet — http://stardust.jpl.nasa.gov

STARDUST Spacecraft to Fly By Earth

ED HIRST, JET PROPULSION LABORATORY

STARDUST is the first U.S. mission dedicated solely to a comet and will be the first to return extraterrestrial materials from outside the orbit of the Moon. STARDUST's main objective is to capture a sample from a well-preserved comet called Wild 2 (pronounced "Vilt 2").



NASA's STARDUST spacecraft was launched February 7, 1999, from Cape Canaveral, Florida. The STARDUST mission is to send a spacecraft flying through the cloud of dust that surrounds the nucleus of a comet — and, for the first time ever, bring cometary materials back to Earth.

Comets are thought to hold many of the original ingredients of the recipe that created the planets and brought plentiful water to Earth. They are also rich in organic materials, which provided our planet with many of the carbon-based molecules that could give rise to life. Comets may be the oldest, most primitive bodies in the Solar System, a preserved record of the original nebula that formed the Sun and the planets.

The STARDUST spacecraft starts the Earth Gravity Assist (EGA) phase of its mission on Tuesday, November 14, 2000, at 62 days from closest approach to Earth. On that day, the spacecraft will execute the first of three flight-path corrections planned for the EGA phase. The primary objective of the EGA phase is to provide STARDUST with an energy boost as a result of flying past Earth. The boost, which comes from being sling-shot around Earth, i.e., a "gravity assist," will increase the spacecraft's orbital period around the Sun from 2 years to 2-1/2 years and alter its flight path to intercept Comet P/Wild 2 on January 2, 2004.

Spacecraft activities are fairly quiescent on approach to Earth, with only engineering housekeeping on the agenda. An attitude-maintenance turn is performed on Tuesday, December 5, 2000, to keep the spacecraft's forward-looking medium-gain antenna pointed toward Earth while maintaining adequate sunlight on the spacecraft's power-generating solar arrays.

A second flight-path correction is scheduled for Friday, January 5, 2000. This maneuver will fine-tune the spacecraft's flyby path, ensuring that the correct amount of energy is provided to the spacecraft during the flyby. The spacecraft's orientation is frozen for the perigee passage on Wednesday, January 10, 2000, five days prior to closest approach.

Earth closest approach will occur on Monday, January 15, 2001, at approximately 11:20 UTC (4:20 a.m. MST; 3:20 a.m. PST). The spacecraft flies over a point just southeast of the southern tip of Africa, at a distance just over 6,000 kilometers (3,700 miles) from the surface and a speed of approximately 10 kilometers per second (36,000 kilometers per hour, or 22,400 miles per hour).

Once past Earth, the spacecraft will transfer communications from its medium-gain antenna to its aft-looking low-gain antennas.

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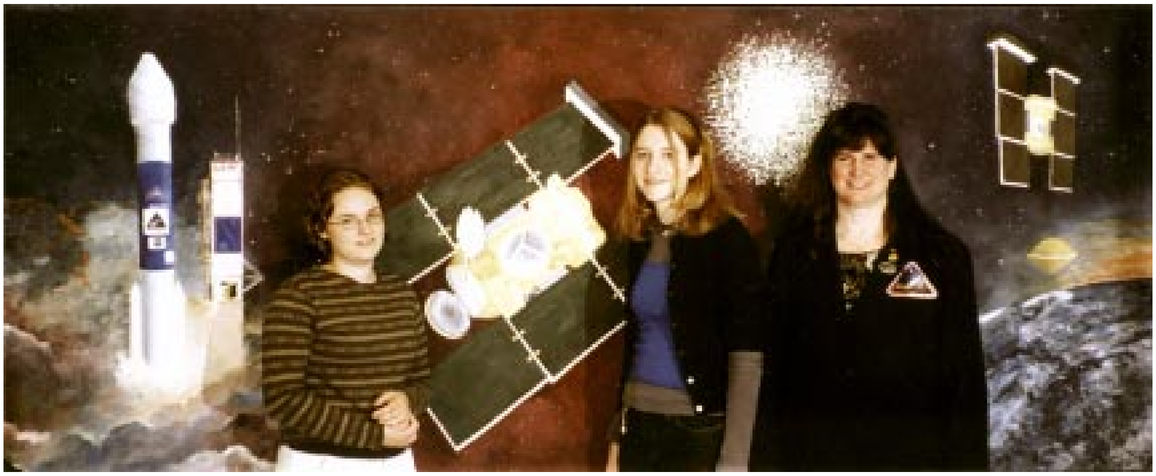

Minnesota art students Rebekah Sorensen and Sarah McCready with teacher and JPL Solar System Educator Fellow, Dee McLellan.

STARDUST Receives a Gift: Mural on Display at JPL

BARBARA SPRUNGMAN, EDITOR

Two Minnesota art students have STARDUST in their eyes. The product of their enchantment is a 5-by-10-foot mural focused on the STARDUST mission. The mural is now on display at JPL and will soon be on loan to NASA Headquarters in Washington, D.C.

The work of art, executed in acrylic on canvas, is divided into three sections: the launch of STARDUST, its encounter with Comet P/Wild 2, and the spacecraft's rendezvous with Earth and release of the sample return capsule in 2006. Last spring, two 10th-graders at Meadow Creek Christian School, Sarah McCready and Rebekah Sorensen, responded to an art project request. They answered the call of art teacher Donna Heinrich and Dee McLellan, a math and computer teacher.

McLellan is one of 47 JPL Solar System Educator Fellows. She participated in the Solar System Educators Institute last March at JPL.

"As a teacher," McLellan explains, "my theme is straightforward. Do a good job on your assignments because you never know what might happen to them. Today they might be at school. . .tomorrow they might be at some university. . .and the next day they might be at NASA!"

The mural was created as part of an exhibit display for the JASON Project 2000. A gathering marking the event was held at Minnesota Bell Museum of Natural History on the campus of the University of Minnesota. The JASON Project, one of STARDUST's educational partners, featured spacecraft such as STARDUST at their annual educational project earlier this year. After the event, the mural remained on display for three months at the museum.

Teacher Dee McLellan expressed the enthusiasm they all felt. "The students and I thought it was such a privilege to have the mural hang at the University of Minnesota. But when the STARDUST Project Office at JPL was interested in displaying it, they just thought — Wow!"

Student McCready, co-creator of the artwork, said: "It's really cool, but it's kind of over our heads."

STARDUST Spacecraft

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Approximately 15 hours after closest approach to Earth, the spacecraft will fly within 98,000 kilometers (61,000 miles) of the Moon.

Approximately 20 days after closest approach, the spacecraft performs another attitude-maintenance turn. The turn also allows STARDUST to transfer all communications from its low-gain antennas back to the medium-gain antenna. The EGA phase comes to a close on Wednesday, February 14, 2001, when the spacecraft performs the last of the EGA flight-path corrections. This final maneuver will correct errors incurred in the spacecraft's flight path since its maneuver on December 5, 2000.

Facts About Aerogel — "Mystifying Blue Smoke"

DR. STEVE JONES, JET PROPULSION LABORATORY

To collect interstellar and cometary particles without damaging them, STARDUST will use an extraordinary substance called aerogel: a silicon-based solid with a porous, sponge-like structure in which 99.8 percent of the total volume is empty! Aerogel is 1,000 times less dense than glass, another silicon-based solid, and is currently the lightest-known solid.

What is aerogel used for?

The STARDUST mission is using aerogel as a capture medium — it will be used to collect very small interstellar and cometary particles as they embed themselves in the porous aerogel. Because of its unique physical properties, aerogel has been proposed for a wide variety of uses, including thermal insulation, acoustical insulation, optical components, filters, and much more.

Who invented aerogel?

Aerogel was first made in the 1930s by Samuel S. Kistler, who obtained several patents for making a variety of types of aerogel, including silica, alumina, chromia, tin, and carbon.

What happens if I touch it?

Silica aerogel is semi-elastic, in that it will return to its original form if slightly deformed. If further deformed, a dimple will be created. However, if the elastic limit is exceeded, aerogel will shatter catastrophically, like glass.

What does it feel like?

Aerogel is extremely porous, so it feels like the volcanic glass pumice or even a very fine, dry sponge, except that it is much lighter.

Why is aerogel blue?

Aerogel is blue for the same reason that the sky is blue. The very small particles that compose the aerogel scatter blue light, the same as our atmosphere scatters blue light.

Where can I get some aerogel?

Aerogel is commercially available, but at JPL we currently only produce aerogel for use in space flight.

How much does aerogel cost?

Aerogel is relatively expensive, primarily because it is currently made in very limited quantities. While increasing the scale of aerogel production will reduce the cost, the basic process and raw materials are still somewhat costly. For relatively small quantities of aerogel, e.g., one liter, the cost is about $1.00 per cubic centimeter.

Why is it called a gel?

During the production of aerogel, a wet gel is formed, which is then dried through a baking process and becomes filled with air. Thus the name aerogel, which means air gel.

Is it solid?

Aerogel is made up of microscopic beads or strands, which are connected to form a continuous network. Since the network fills space and supports itself, it is considered a solid.

STARDUST's Dust Flux Monitor Instrument

DR. ANTHONY TUZZOLINO, UNIVERSITY OF CHICAGO

When the STARDUST spacecraft encounters Comet P/Wild 2 in 2004, the Dust Flux Monitor Instrument will be one of four stars of the show. The goal of the dust-monitoring system will be to monitor the dust environment to ensure the protection and health of the spacecraft; measure the spatial and temporal variations of particle flux and mass distribution during the flyby; and provide the context for the collected dust samples. In addition, the system will provide real-time measurements of large impacting comet dust particles and early determination of potential hazards during the beginning of the encounter.

> **Dr. Tuzzolino's advice to students who are interested in careers related to physics: "Take all the math you possibly can. Math is critically important. You can't do physics without the math. It's just that simple."**

The Dust Flux Monitor Instrument will measure the size and frequency of dust particles in the comet's coma as small as a few microns. The instrument consists of two film sensors and two vibration sensors. The film material responds to particle impacts by generating a small electrical signal when penetrated by dust particles. The mass of the particle is determined by measuring the size of the electrical signals. By counting the number of signals, we determine the number of particles. Using two film sensors with different diameters and thickness, the instrument will provide data on particle sizes encountered and the size distribution of the particles.

The Dust Flux Monitor Instrument is derived from the flight heritage obtained from earlier and current dust instruments and sensors. These instruments make exclusive use of the polyvinylidene fluoride (PVDF) dust sensor developed at the University of Chicago's Laboratory for Astrophysics and Space Research of the Enrico Fermi Institute.

Duxbury Named Project Manager of STARDUST Mission

MARTHA HEIL, JET PROPULSION LABORATORY

Thomas Duxbury has been named project manager of NASA's STARDUST mission to collect a comet sample and return it to Earth. The mission is managed for NASA by the Jet Propulsion Laboratory of the California Institute of Technology in Pasadena, California.

Duxbury, who has served as STARDUST's acting project manager for the past year, replaces Dr. Kenneth Atkins, who now heads a JPL program to develop the leadership of the Laboratory's projects.

Duxbury joined the STARDUST project as mission manager in 1996 and was responsible for a wide range of elements, including navigation, mission design, the ground data system, science data management and archiving, and mission operations.

A native of Fort Wayne, Indiana, Duxbury attended Purdue University in West Lafayette, Indiana, where he earned his bachelor's and master's degrees in electrical engineering. Upon graduating in 1966, he started work at JPL in the field of optical navigation on the Mariner 6 and 7 missions to Mars.

Duxbury has served on numerous planetary mission teams, including the Mariner 6, 7, 9, and 10 missions; the Viking mission that sent two landers and two orbiters to Mars; Pioneers 10 and 11 missions to Jupiter and Saturn; Voyagers 1 and 2 to the outer planets; the Soviet Phobos mission to Mars; the Mars Observer mission; the Department of Defense/NASA Clementine mission that studied the Moon; and the Russian Mars 1996 mission. In addition to his new STARDUST role, Duxbury is a member of the science teams for the Mars Global Surveyor's laser altimeter and the European Space Agency's Mars Express orbiter and lander. He is also the lead scientist for geodesy and cartography in the JPL Mars Exploration Office.

From the Principal Investigator

Dr. Donald Brownlee, Principal Investigator, STARDUST Mission

On January 15, 2001, STARDUST will make a close flyby of Earth, passing only 6,000 kilometers (3,700 miles) above the African continent. This will be a major mission milestone and it will also be a celebration of the spacecraft's first two years in space. In the nearly two years that it took the spacecraft to finish its first elongated orbit of the Sun, Earth will have made nearly two full orbits and both will meet in almost the same spot in space where STARDUST was launched. The gravitational slingshot effect from the close encounter will propel STARDUST to an even more elongated solar orbit that will take it far beyond the orbit of Mars and into the asteroid belt. This larger, higher-energy orbit is needed for the 2004 flyby of Comet P/Wild 2. The coming Earth encounter will be a major mission event, and I expect that most of us will wave skywards that day cheering STARDUST onwards to the rest of its journey. The next time STARDUST gets this close will be in early 2006, when it drops off the sample return capsule for its landing in Utah.

How Does Being Involved with STARDUST Affect You?
As for myself, I look at the mission as a culmination of dreams that began in high school. My freshman year began in 1957, just a few weeks before the launch of Sputnik 1, the Soviet satellite that instantly started the space age. Like many kids of that time, I was totally captivated by space. I read everything I could about rockets and space, and spent endless hours in class sketching rocket nozzles and thinking about sending things into space. I also survived a common hobby of the time of making rocket fuel in the kitchen and launching a variety of pipes with fins and nozzles thousands of feet into the air.

Two years ago, when we launched STARDUST from Space Launch Complex 17 at Cape Canaveral, it was a very exciting time and it brought back vivid memories of my high school days and the beginning of the space age. The U.S. space program started just adjacent to where STARDUST launched. In just a short walk from SLC 17, I visited the actual launch pads where the first U.S. satellite, Explorer 1, was launched in 1958, and where Alan Shepard was launched in 1961 to become the first American in space. It was a genuine thrill to stand at these sites and just think about what has happened since Sputnik.

My personal journey to space continued into college where I became involved with ballooning. When I was a senior at Berkeley, I launched two balloon experiments, one to collect cosmic dust and the other to make measurements of the Sun in the ultraviolet. These were modest experiments but they did climb to 120,000 feet, above more that 99% of the atmosphere. Not quite space but almost. When I started graduate school, I intended to really get involved in space by building a small ultraviolet telescope to fly on the X-15 rocket plane. Unfortunately, the X-15 operations rapidly declined and the plane was in the Smithsonian before I had a chance to propose an experiment for it.

I did, however, get a phenomenal break as a beginning graduate student. My advisor (Paul Hodge) was asked if he could provide micrometeorite collecting plates for the Gemini manned missions. The astronauts would place them outside the capsule and recover them for the trip home. This was a truly unbelievable opportunity, and I got to design, build, and analyze those collectors. They flew on Gemini X and XII — and I was finally "in space." During the Apollo program, I worked on lunar samples and the parts of the Surveyor III Lander that were returned by Apollo 12. This was the foundation that ultimately set me up with Dr. Peter Tsou (from JPL) in about 1980 to design a mission to collect particles from comets and return them to Earth. Dr. Tsou came up with the idea of capturing high-speed particles in aerogel and other porous materials, and he had the imagination, drive, and audacity that eventually led to the selection of STARDUST as NASA's fourth Discovery mission.

STARDUST Mission Partners

- University of Washington — Dr. Don Brownlee, Principal Investigator
- Jet Propulsion Laboratory, California Institute of Technology — Thomas Duxbury, Project Manager
- Lockheed Martin Astronautics of Denver, Colorado — Joe Vellinga, Program Manager
- Boeing — Delta II Launch Vehicle
- Max-Planck-Institut, Germany, and the firm of von Hoerner & Sulger
- University of Chicago
- NASA Johnson Space Center

STARDUST Education Outreach Team

- Jet Propulsion Laboratory: Aimee Whalen, Ron Baalke, and James D. Rose
- Educational Consultants: Barbara Sprungman (Editor) and Ken Berry

Outreach Programs

- JASON Foundation for Education *http://www.jasonproject.org*
- Space Explorers, Inc. *http://www.space-explorers.com*
- Virginia Space Grant Consortium *http://www.vsgc.odu.edu*
- JPL Ambassadors Program *http://www.jpl.nasa.gov/ambassador/front.html*
- Challenger Center for Space Science Education *http://www.challenger.org*
- Omniplex at Kirkpatrick Science and Air Space Museum, Oklahoma City *http://www.omniplex.org*
- Parents and Children as Co-Travelers in a World of Ideas (PACCT) *http://www.bcsc.org/pacct/*

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL 410-56-3 01/01