Volume 1
Number 2
January 2000

stardust

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

The most interesting thing about tiny dust particles from space is that they contain "leftovers" of many dead stars and, along with the meteorites, they brought water to Earth — most likely with the ingredients for life. How did this happen? If all goes well, we should know soon after 2004.

Why Are We So Interested in Comets?

DR. JOCHEN KISSEL

Comets are not only among the most spectacular events in the sky, but they are also unique, in that they are known to be the best preserved raw material in our Solar System. Comets are cold bodies, commonly known as "icy travelers." We see them only because the gases in their coma and tails fluoresce in sunlight and because of the sunlight reflected from the solids.

Comets are regular members of the Solar System family, gravitionally bound to the Sun. They are generally believed to be made of materials that originated in the outer parts of the Solar System, but that did not get incorporated into its leftover "debris." Because they are thought to be composed of such unchanged primitive materials, they are extremely interesting to scientists who wish to learn more about the conditions during the earliest period of the Solar System.

Comets are very small in size relative to planets. Their average diameter is about 5-10 kilometers; however, they are irregular in shape, with the longest dimension often twice the shortest. The best evidence suggests that comets are also very fragile. If you had a large piece of cometary material, you could simply pull it in two with your bare hands, as if it were a poorly compacted snowball.

From the relatively recent results of the Comet Halley mission, we know that comets have a nucleus. We also know about the close intermixture between the mineral component and the organic material, where one component is only formed at a high temperature when the other would already be lost as vapor.

Comets are believed to have brought water and an abundant variety of organic molecules to Earth in its late phase of evolution. Scientists also believe that comets have contributed an essential, if not a leading, part to the start of life on Earth. It is only through our complex investigations that we hope to learn more about the nature of cometary molecules and the role of comets in more detail.

While our main goal is to determine the volatile component, the samples returned from the STARDUST mission will be distributed to specialized laboratories at NASA's Johnson Space Center where they will undergo a variety of complex analyses. Will we then know everything about comets and their makeup? Certainly not. Each step in understanding produces new and more detailed questions. These studies will be the work of future generations!

More Comet Missions

Deep Impact
will probe deep beneath a comet's surface to study impact debris and pristine interior material.

http://discovery.jpl.nasa.gov/deepimpact.html

Deep Space 1
will validate new, high-risk techolologies in space, while adding to our knowledge of near-Earth asteroids and comets.

http://nmp.jpl.nasa.gov/ds1

Contour
will greatly improve our knowledge of comet nuclei and our ability to assess their diversity.

http://sd-www.jhuapl.edu/sdhome/Discovery/contour

Chasing Particles in Space: Comet and Interstellar Dust Analyzer

DR. JOCHEN KISSEL, MAX-PLANCK-INSTITUT

The Comet and Interstellar Dust Analyzer will help scientists around the world to unravel the mysteries surrounding the birth and evolution of the Solar System.

The STARDUST mission, sponsored by the National Aeronautics and Space Administration (NASA), plans to fly by comet Wild 2 and, for the first time ever, bring pristine samples of cometary materials back to Earth. In addition, STARDUST plans to collect and return grains from a newly discovered stream of particles coming into the Solar System from interstellar space.

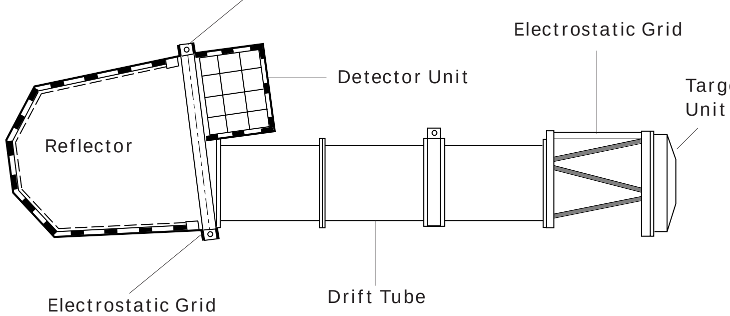
These samples will provide a window into the distant past, helping scientists around the world unravel the mysteries surrounding the birth and evolution of the Solar System.

One of the instruments that will assist the STARDUST spacecraft in its particle analysis is the Comet and Interstellar Dust Analyzer (CIDA). The CIDA target will be exposed to the dust particle stream, which is expected to collide and impact the spacecraft throughout the duration of the mission. These impacts are so violent that the particles are not only destroyed but are decomposed. During their decomposition they are returned to their smallest constituents, molecules and atoms, allowing the CIDA payload to begin its analysis. Some of these particles carry an electric charge and can thereby be manipulated by the payload. An electromagnetic field in front of the target sends particles into the inner part of the sensor where they separate according to their mass and initial energy. Heavier ions and those with less initial energy travel slower.

Because we are interested in the mass of these particles, we send them through yet another electromagnetic field, which makes them turn around and "fly," mirror-like, to the detector (multiplier). If properly tuned, all ions of equal mass arrive at the same time at the detector and are registered with their amount and flight time (a time-of-flight spectrum has been generated); this happens in one tenth of a thousandth of a second.

The electronics, which connect CIDA to the spacecraft, collect, and package this data for onboard storage and transmission back to Earth. Based on the time-of-flight spectra, we can calculate the mass spectra in turn, and derive the particle's composition, since each molecule and each atom has its own characteristic mass.

It is only through these complex investigations that we can try to understand the nature of these molecules and the role of comets in more detail.



Comet and Interstellar Dust Analyzer (CIDA)

Reaching Out to Parents

LINDA MORRIS,
PACCT PROJECT DIRECTOR

A new educational partner has joined the STARDUST team. **"P**arents **A**nd **C**hildren as **C**o-**T**ravelers (PACCT) in a World of Ideas" has joined this year's current educational partners. The PACCT project was developed at the Buehler Challenger & Science Center in Paramus, New Jersey, under the leadership of Linda Morris, one of the twenty-six STARDUST Educator Fellows. PACCT is funded in part by a National Science Foundation grant. The Challenger Center for Space Science Education is a partner in the project.

The key goal of the PACCT Project is to reach out to parent–child teams at the middle school level, and through the involvement of the parent to enhance childrens' science process and workplace readiness skills. An important aspect of the project is to involve

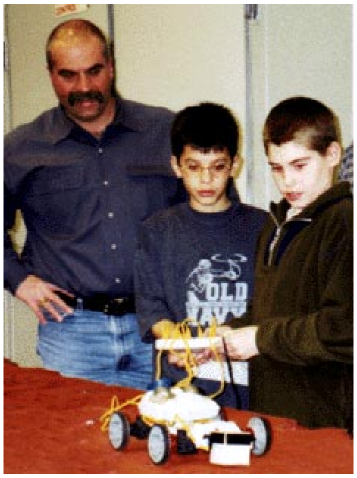
continued on page 3

parents that typically don't support science education.

There are four PACCT programs including different simulations from which families can choose. "Visit the Future," a hands-on career exploration with scientists, and "Lunar Challenge," an open-ended design challenge, are two of the simulations. At-home activities that support the classroom simulation are provided in "Crew Training." The fourth simulation, "Discovery Missions," includes three different problem-solving scenarios built on Lunar Prospector, Mars Pathfinder, and STARDUST content.

The STARDUST Mission has parent–child teams acting as JPL and Lockheed Martin Astronautics scientists and engineers tasked with building their own STARDUST spacecraft. They later "fly" as teammates on their unique mission to a comet. The families learn problem solving about the mechanics involved when designing a spacecraft, as they put their designs to the test during Spin Testing and Remote Communications checks. This innovative program will become available through at least ten Challenger Learning Centers across the country throughout 2000 and 2001.

PACCT Project Director, Linda Morris, explains: "When I tell the participants that they are going to build a spacecraft, they say: *I can't do this! It's too technical!* But we break it down to the simplest of steps and put each team in charge of their own design. The best part is that by the end of the day, they realize that they really *can* do something like designing a spacecraft. One fifth-grade participant became so excited that he did his science fair project on STARDUST, and he has created a binder which he updates regularly from the website."



Visit the PACCT website at: http://www.bcsc.org/pacct/

STARDUST Educators Go Backstage at JPL

Twenty-two of the twenty-six STARDUST Educator Fellows came to JPL last summer for the experience of a lifetime. A four-day workshop in August took them from Earth to Mars and out to the STARDUST spacecraft, which is now beyond the orbit of the Red Planet.

With tears of excitement in their eyes, Fellows took control of a Mars rover in JPL's Mars Yard. They were thrilled by the Mars 3-D Tour video, and awed by peering in at an ion engine undergoing testing. On the "Shake and Bake" tour, they actually stood inside the Environmental Chamber and Test Laboratory.

In JPL's STARDUST mission control room, Flight Director Tom Duxbury explained the dynamics of spacecraft operations and control. Other highlights of the day were a tour, a barbecue, and a "star party" at the Mount Wilson Observatory.

The bus voyage to the DSN radio telescopes in Goldstone, California, was well worth the travel hours. The trip coincided with one of STARDUST's communications sessions with Earth. The session offered a perfect photo opportunity (as seen above).

Updates from the STARDUST team, education partners, and other Fellows helped energize the educators with invaluable information for use in presentations when they returned to their communities. As one Educator Fellow, Alan Landever of Connecticut, enthusiastically recalls, "Seeing JPL from behind the scenes and meeting with the scientists and engineers on their turf to discuss their projects, has energized me to a whole new level." The workshop was organized and coordinated by the STARDUST Opportunity and Outreach Team at JPL and the Mars K-12 Education Department at Arizona State University, with the Challenger Center for Space Science Education staff members.

STARDUST Educator Fellows at the DSN complex in Goldstone, California, stand in front of the 34-meter antenna as it receives STARDUST data.

From the Deputy Project Manager/Flight Director:

It is quite exciting at this point in time to be in my current position as NASA makes a bold leap towards further exploration of our Solar System. Years ago, as a simple country boy in Indiana, I would climb the highest oak tree and stare at the clear night sky on cold winter nights and extend my hand and run my fingers through the heavens.

I never thought that one day I would be the Deputy Project Manager and Flight Director of the STARDUST mission — extending the hand of humankind by reaching out into the heavens with our spacecraft to grab pristine cometary particles and bringing them back to Earth — helping investigators reach a better understanding of the beginnings of our Solar System and possibly of life here on Earth.

"...reaching out into the heavens with our spacecraft to grab pristine cometary particles..."

Mission Operations Update

Since launch, the STARDUST spacecraft has been put through most of its operational modes. All payload instruments, including the JPL Navigation Camera, the University of Chicago Dust Flux Monitor Instrument, and the German Max Planck Institut Cometary and Interstellar Dust Analyzer have been powered on and produced flight observations of stars and dust. Many updates to spacecraft parameter values and configuration files have been commanded, some as corrections and others for better flight performance. Currently the spacecraft is operating very well, cruising through the Solar System out beyond the orbit of Mars in the main asteroid belt.

Only a few minor changes need to be commanded to configure the spacecraft for the remainder of its 6.5-year journey, which will bring it back to Earth with dust particles from comet Wild 2, encapsulated within the aerogel.

STARDUST was using a gyro system to maintain the spacecraft's attitude — its orientation relative to the Sun and stars. This attitude task has now been delegated to the star camera, which uses a lot less power than the gyro system. This is important when the spacecraft is far from the Sun and is limited in producing power from its solar arrays.

As the spacecraft reached its farthest distance from the Sun on its first loop of three planned loops around the Sun before final Earth return, we turned on the spacecraft rockets to change the trajectory to swing by Earth at the end of the first loop.

STARDUST will use Earth's gravity to fling itself even farther from the Sun on the second and third loops, enabling us to encounter Wild 2. Now that the rockets are turned off, we will open the aerogel collector and point it at the interstellar particle (ISP) stream flowing through our Solar System in an attempt to capture some of these particles for return to Earth with the cometary particles to be captured on the third loop.

Therefore, even though we are in cruise mode around the Sun, we are still very busy with the weekly activities preparing the spacecraft for its first ISP collection from February to May 2000.

Tom Duxbury, Deputy Project Manager and Flight Director, STARDUST Mission

STARDUST Mission Partners

- University of Washington — Dr. Don Brownlee, Principal Investigator
- Jet Propulsion Laboratory, California Institute of Technology — Dr. Kenneth Atkins, 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 Tom Meyer (Web consultant)
- 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*

Outreach Programs

- 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 & 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 410-56-2 01/00

Mission Status — Homeward Bound

ALLEN CHEVRONT, LOCKHEED MARTIN ASTRONAUTIICS

The STARDUST spacecraft has successfully completed a three-part deep space maneuver which was designed to keep it on target for an Earth gravity assist in January 2001. That gravity assist will propel the spacecraft toward its 2004 rendezvous with the comet Wild-2 (pronounced "Vilt"-2).

The maneuver consisted of a trio of propulsion firings performed on January 18, 20, and 22 to achieve velocity changes of 58, 52, and 48 meters per second, respectively (about 130, 116, and 107 miles per hour). Each firing lasted for about 30 minutes. With these three engine burns plus a short firing of 11 meters per second (25 miles per hour) made in late December, the flight team changed the spacecraft velocity by about 171 meters per second (383 miles per hour), and put STARDUST on target for next year's swingby of Earth.

STARDUST's mission is to collect samples of comet dust from Wild-2 for return to Earth in 2006. While en route, the spacecraft will also attempt to gather samples of interstellar dust particles for study on Earth. Engineers plan to command STARDUST to extend its dust collector on February 22, 2000 in order to begin collecting interstellar dust from a stream that flows into our Solar System.

STARDUST was launched on February 7, 1999. The principal investigator for the STARDUST mission is Dr. Donald C. Brownlee of the University of Washington. The mission is managed by NASA's Jet Propulsion Laboratory, Pasadena, CA, for NASA's Office of Space Science, Washington, DC. Lockheed Martin Astronautics, Denver, CO, built and operates the spacecraft. Its instruments were provided by JPL, the University of Chicago, and the Max Planck Institut, Garching, Germany. JPL is a division of the California Institute of Technology, Pasadena, California.

How Do We Talk to The Spacecraft?

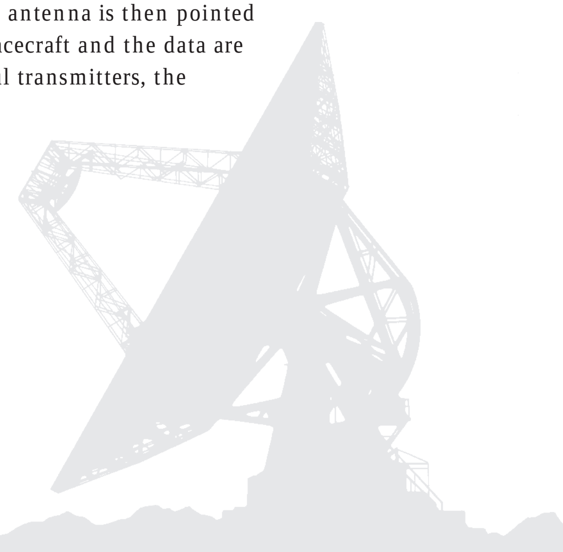
SHIRLEY WOLFF, JPL

The Jet Propulsion Laboratory's (JPL's) Deep Space Network (DSN) provides two-way communications between the STARDUST spacecraft and the mission operations team at JPL. Also, the DSN generates radio navigation data used to track and guide the spacecraft to its destination.

To assure continuous communication with spacecraft and compensate for Earth's rotation, three DSN complexes are located 120 degrees apart around the world — in Goldstone, California; Madrid, Spain; and Canberra, Australia. One complex always has STARDUST within view. Data from STARDUST, called telemetry, is received as a coded bitstream, then forwarded to the Deep Space Operations Center at JPL for processing and distribution to the mission managers and mission scientists.

By the time STARDUST's radio signal reaches a DSN antenna, it can be of extremely low wattage. Separating the spacecraft's faint signal from background "noise" requires sophisticated techniques that involve both the use of "low-noise" receivers to amplify the signal and also telemetry coding to reduce signal distortion. DSN antennas have parabolic reflector dishes, some as large as 70 meters (230 ft.) in diameter, to capture the signal. Typically, STARDUST signals are received on a 34-meter (112 ft) antenna.

The Mission Operations team generates commands for uplink to STARDUST. A "packet" of data, called a "sequence" is prepared and forwarded by the Deep Space Operations Center to the appropriate complex for transmission to the spacecraft. The antenna is then pointed precisely at the spacecraft and the data are sent using powerful transmitters, the largest of which is capable of generating up to 400 kilowatts.



Additional information is available at http://deepspace.jpl.nasa.gov/dsn