THE NASA DISCOVERY STARDUST PROJECT

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The NASA Discovery STARDUST Project, a comet particle sample return mission, has been in flight for over 1 year and during this time period has operated all flight instrumentation: the Max Planck Institute Cometary and Interstellar Dust Analyzer (CIDA), the University of Chicago Dust Flux Monitor Instrument (DFMI), and the Jet Propulsion Laboratory Imaging Camera. The Aerogel Collector is deployed, currently collecting interstellar dust particles. Two engineering subsystems, Attitude Control and Radio Navigation, are also operating and will provide information on dust particle size and distribution at comet Wild 2, the primary target for collecting cometary dust in 2004 for return to earth in 2006.

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27 March 2001
4th NASA Discovery Project
- Mars Pathfinder, NEAR, Lunar Explorer prior Missions
1st NASA Unmanned Planetary Sample Return Mission
NASA, Univ of WA, JPL and LMA Partnership
Prof. Donald Brownlee, University of Washington, PI
- Co-I's
  - Drs. Martha Hanner, JPL, Fred Horz, JSC,
  - Tony McDonald, UK, Scott Sandford, ARC,
  - Zdenek Sekanina, JPL, and Mike Zolensky, JSC
- Co-I's with Payload Instruments
  - Aerogel Collector - Dr. Peter Tsou, Deputy PI, JPL
  - CIDA - Dr. Jochen Kissel, MPI fur Kernphysik,
  - DFCI - Dr. Anthony J. Tuzzolino, U of Chicago
  - NavCam - Dr. Ray Newburn, JPL
  - Radio Science - Dr. John Anderson, JPL
  - High Rate Attitude - Dr. Benton Clark, LMA
Primary Requirement: Collect 1000 Comet particles >15 μm at encounter velocity < 6.5 km/sec and return to Earth

Secondary Requirements: Collect 100 Interstellar particles >0.1 μm and return to Earth.
Provide ≥ 65 images of P/Wild 2, having a resolution of at least 67 μrad per pixel, taken within 2000 km of the comet nucleus through selected filters;
Provide in situ particle analysis for comet coma flythrough capable of resolving abundant elements in cometary solids

Tertiary Requirements: Provide in situ particle analysis for interstellar and interplanetary dust;
Measure dust mass fluence, large particles and comet mass upper limit
Provide dust flux measurement of $10^{-9}$ g to $10^{-4}$ g particles
EUROPEAN GEOPHYSICAL SOCIETY XXVI GENERAL ASSEMBLY

Loop 1: As Flown v. Plans

TCM-4, NavCam Htg, L+667d, 12/5
TCM-5, NavCam Images, L+696d, 1/5/01
EGA, L+708d, 1/15
Moon Images, L+709d, 1/16
Launch, L+0d, 2/7/99
DFMI On, L+12d, 2/19
CIDA On, L+15d, 2/22
Allstellar Safing L+25d, 3/7
CIDA/DFMI On L+32d, 3/11
NavCam Safing L+40d, 3/19
DFMI On L+44d, 3/23
CIDA Operational L+54d, 4/2
SSPA Anomaly L+65d, 4/13
DFMI Read Errors L+71d, 4/19
Start CIDA-1, L+82d, 4/30
DFMI Test/Off, L+88d, 5/6
SRC Unlatched, L+95d, 5/13
CIDA Reset L+104-111d 5/22-29
Start SSPA Cycling, L+134d, 6/21
HGA Checkout, L+137d, 6/24
PACI Safing, End CIDA-1, L+160d, 7/17
PACI Safing, L+178d, 8/4
DFMI Test/Off, CIDA On L+218d, 9/13
NavCam Images, L+200d, 8/26

Start CIDA-1, L+44d, 3/23
Telecom Checkout, SRC Unlatched by L+90d, 5/8

TCM-1, Transition to Allstellar by, L+15d, 2/22
NavCam Images, L+18d, 2/25

Solar Flare Safing, L+641d, 11/9
NavCam Images, L+618d, 10/17
CIDA On, C&DH to 20 MHz, L+657d, 10/6
Star Cam-FSW Safing, L+605d, 10/5
NavCam Images, L+597d, 9/26
NavCam Images, L+583d, 9/12
(not successful, high body rates)
L+570d, 8/30
DFMI Test
CIDA Off, C&DH-10MHz (for PACI)
NavCam Images, L+562-570d, 8/16-30
NavCam CCD Htr On, L+555-562d, 8/16-22
SSPA Anomaly, L+550d, 8/10
NavCam Images (solar flare), L+548d, 8/8
NavCam CCD htr, Aph pwr
L+534d, 7/25
solar flare, L+523d, 7/14

Loop 1 Trajectory
SEP<3'

End ISP-1, L+468d, 5/20
NavCam Images, L+478d, 5/30
TCM-3, L+472d, 5/24
Open/Close SRC backshell
End ISP-1, L+449d, 5/1

Start ISP-1, L+374d, 2/16
NavCam Images, L+380d, 2/22
CIDA On, L+059d, 2/1
Start ISP-1, NavCam Images, L+380d, 2/1
CIDA On, L+059d, 2/1
Transition to Allstellar, L+352d, 1/22
DSM-1, L+347d, 1/20
Allstellar FSW Patch, L+390d, 1/13/00
TCM-A, L+324d, 12/28
Battery Conditioning, L+314d, 12/18

NavCam Images, L+387d, 2/29
NavCam Images, L+387d, 2/29
NavCam Images, L+206d, 8/30

STAIRDUST

STARDUS

Duxbury

LOCKHEED MARTIN
LMA Spacecraft w/ SRC

- Solar Panels
- Aerogel Collector (comet side)
- HGA
- MGA
- Sample Return Capsule (open)
- Thruster cluster (1 of 4)
- Camera / Mirror
- Periscope
- DFM
- Whipple Shields

CIDA not shown. Mounted on +y deck.
LGAs: 1 on +z deck, 2 on -z deck.

VIEW: +x, -y, +z
+x, roll
+y, pitch
+z, yaw
To collect the 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 percent of the volume is empty space. Aerogel is 1,000 times less dense than glass, another silicon-based solid. When a particle hits the aerogel, it will bury itself in the material, creating a carrot-shaped track up to 200 times its own length, as it slows down and comes to a stop - like an airplane setting down on a runway and braking to reduce its speed gradually. Since aerogel is mostly transparent - sometimes called blue smoke - scientists will use these tracks to find the tiny particles.
Dr. Jochen Kissel with CIDA
**JPL CAMERA**

**CHARACTERISTICS**
- 200 mm VGR WA Optics
- 1024 x 1024 Cassini CCD
- 60 μrad / pixel
- 1 Deg-of-freedom Mirror (200 deg)
- 8 Filters
  - 5140 ± 60 C₂ (Blue)
  - 5800 ± 20 Yellow Continuum
  - 5900 ± 1000 Hi Res (Nucleus)
  - 6340 ± 60 O[D]
  - 6650 ± 75 NH₂
  - 7000 ± 2000 Navigation
  - 7130 ± 30 Red Continuum
  - 8700 ± 150 Near IR

Periscope - protect optics during approach

**Diagram**
- **Periscope**
- **Wild 2 During Approach**
- **Wild 2 Mirror Tracking**
- **During Flyby**

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STARDUST - T. Duxbury

27 Mar 01

STARDUST - Lockheed Martin
Nav Cam Cleanup

- Completed Nav Cam Heating Sequence #2
  - Removed 60% of Contamination
  - Additional Heating Under Study
EGA Close Flyby (Actual)

February 14, 2001

Range = 97,797 km [60,781 mi]
02:02:20 UTC

Jan 16, 2001

Speed = 10.3 km/s [27,700 mph]
Altiude = 6007.6 km [3,723.8 mi]; Lat = 40.5°; Long = 38.1° E
11:14:28 UTC

Jan 16, 2001

TCM 4
dec 05, 2000

TCM 6
c/a 10 days

C/A 4.1 days

EGA Signifcant Events

STARDUST EARTH GRAVITY ASSIST
Earth Gravity Assist

- EGA ON 15 Jan 2001 03:15 am PST
Post EGA Lunar Images

- 21 Lunar & 4 Dark Current Images
  - Perfectly Exposed & Pointed
- ESA Mars Express Orbiter and Beagle 2 Lander
- Japanese Nozomi Mars Orbiter
- MGS and MS’01 Odyssey Orbital Operations at Mars
- STARDUST Wild 2 Encounter
- MER-A and MER-B Landings at Mars
- Deep Impact & Messenger Launches
- Cassini Gravity Wave / Solar Occultation Experiment
- Etc., etc.

- New Radiometric Data Type Delta DOR - reduces Nav Tracking
- 20 Kw transmitters at all 34 m BWG’s
- New 34 m Station at Madrid
Wild-2 Encounter Geometry
closest approach: 01/02/2004 19:20:00 ET

150 km Flyby on Sunside

radius ~ 2 km
Approach Phase Angle 73 deg

V_∞ = 6.12 km/s

Sun 1.86 AU
Earth 2.60 AU
SPE angle 17 deg

S/C Attitude
+x // Vinf
+z to Earth
+y out of page

Earth is 16.7 degrees from XS and 1.9 degrees above the flyby plane
Vinf points 2.8 degrees below the ecliptic
Wild-2 heliocentric speed is 26.4 km, s/c is 21.7 km/s

Flyby plane coordinates (xₜ,yₜ,zₜ) defined by Vinf and Sun Vector
RELEASE OF PROJECT DATA to the PLANETARY DATA SYSTEM

Launch

Cruise 1

Earth Gravity Assist

Cruise 2

Wild 2 Encounter

Cruise 3

JPL NAIF-lead Data Management and Archive

PDS Delivery #1 #2 #3 #4 #5 #6 #7 #8

1999 2000 2001 2002 2003 2004 2005 2006

Particles to be Delivered to JSC Office of Curation International Analysis Program will Follow

STARDUST - T. Duxbury
Stardust will fly by Comet Wild 2 and, for the first time, return pristine samples of cometary materials to Earth for analysis by scientists worldwide.

**Education and Public Outreach Approach**
Stardust has established partnerships with numerous educational organizations and programs, museums, and science centers to provide opportunities for students, educators, and the general public to learn about small bodies and the mission.

- Challenger Center
- Virginia Space Grant Consortium
- NASA/JPL Ambassadors Program
- JASON Project
- Space Place for Kids
- From the Sun to the Star Nations: Native American Initiative
- Space Explorers, Inc.
- Parents and Children As Co-Travelers
- Omniplex at the Kirkpatrick Planetarium
- Young Astronaut Council
- United States Space Foundation

**“Think SMALL In A BIG Way”**
A comprehensive Educator’s Activity Guide for grades 5–8 focusing on asteroids, comets, and meteorites, the guide contains a dozen fun activities that are tied to mission events and correlated to national science education standards.

**“Be a Spacecraft Engineer”**
An educational program designed to excite and engage students in science and technology, this activity introduces students to elements of spacecraft design using the Stardust spacecraft and the International Space Station as examples.
VISIT US AT

http://stardust.jpl.nasa.gov