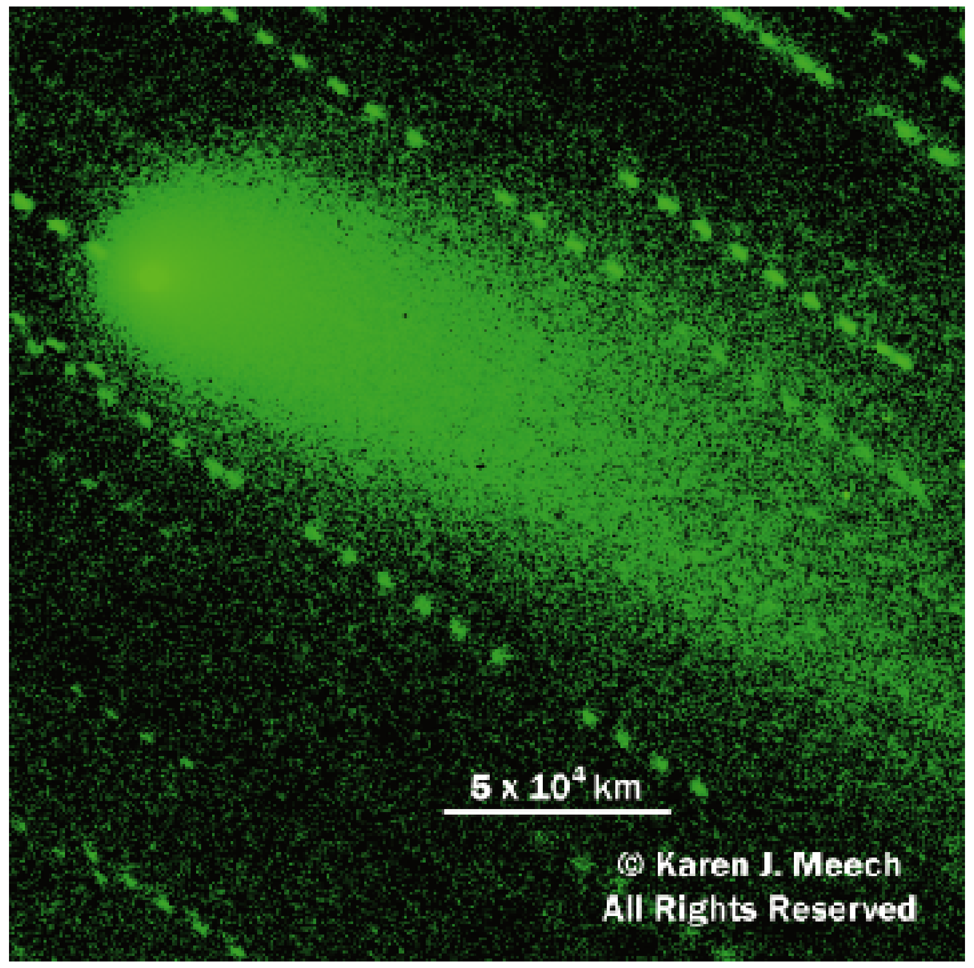
DEEP IMPACT First Look Inside a Comet

http://deepimpact.umd.edu **http://deepimpact.jpl.nasa.gov**

What's Deep Inside a Comet?

Comets are time capsules holding clues to the formation and evolution of our solar system. Comets are made of ice, dust and gas-primitive debris from the solar system's earliest and coldest period 4.5 billion years ago. Deep Impact is a NASA Discovery Mission designed to be the first ever to explore beneath the surface of a comet and reveal some of the secrets stored in a comet's interior.

What Is a Comet?



Comet Tempel 1, August 21, 2000

Comets are frozen debris from the formation of the solar system. Most comets are in the far reaches of the solar system in regions known as the Oort Cloud arethe Kuiper Belt. In the outer solar system, a comet is just its nucleus-a dirty snowball composed of ice and dust with diameters ranging from a few to tens of kilometers.

The passing of a nearby star can give a comet a gravitational push that sends it towards the Sun in an elliptical orbit. As a comet gets closer to the Sun, the temper-ature of its nucleus rises and its outer layers turn from ice into gas. This gas forms a cloud called the coma that can extend out 100,000 kilometers in all directions. In the vacuum of space, tails then form from the comet.

Comets have three kinds of tails, each composed of different particles: dust, ions (charged gases), and neutral sodium. A comet's tail will always point away from the Sun in the direction of the solar wind. On its trip back to the outer regions of the solar system, the tail will precede the comet. Some comets orbit the Sun in as little as five years. Other comets return to the outer reaches of the solar system and only approach the Sun every few centuries. Still others pass through only once, never to return.

The Mission

On July 4, 2005, the Deep Impact spacecraft will impact Comet Tempel 1 with a 370- kg (820 pound) mass, producing a crater ranging in size from a house to a football stadium and two to seven stories deep. The impact will eject ice and dust from the surface of the crater and reveal fresh material beneath. The impact will also create a tremendous amount of heat. As the heat and ejected debris flow into the vacuum of space, a dramatic brightening will be produced that will fade slowly as the impact debris dissipates.

While this is happening, spacecraft cameras will collect and send images back to Earth of the approach, impact and its aftermath. From some places on Earth the impact will be visible using telescopes. Scientists will analyze these images which will expand our knowledge about the formation of the solar system, the comet's interior and the implications of comets colliding with Earth.

The Deep Impact Mission is a partnership among the University of Maryland, the California Institute of Technology's Jet Propulsion Laboratory and Ball Aerospace & Technology Corp. Deep Impact is a NASA Discovery Mission, eigth in a series of low cost, highly focused space science investigations. Deep Impact offers an extensive outreach program in partnership with other comet and asteroid missions and institutions to benefit the public, educational and scientific com-munities.
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Excavating Cratering Education Module developed by Gretchen Walker, University of Maryland
Collaborative Decision Making Education Module developed by McRel
Poster production managed by Kathleen Holmay
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Poster Graphics by Phoenix Graphics, Inc.
Cratering simulation visuals from Peter Schultz, Brown University and the Ames Vertical Gun Range, NASA Ames Research Center

You Are Invited to Join the Deep Impact Mission

Your first mission exercise is on this poster. After you complete it, you will find more mission information and activities on the Deep Impact website. The website is updated often so that you will be able to monitor mission progress, find out where to view the impact on July 4, 2005, and learn about other ways to participate in this unique space exploration. So bookmark the web address and become part of the mission's Internet team. How old will you be and what do you think you'll be doing when impact occurs?

Deep Impact's Scientific and Engineering Questions

The scientists and engineers involved with Deep Impact are using the mission to answer the following questions:

1. What are the basic properties of a cometary nucleus and interior?
2. How do comets evolve?
3. What is the composition of primordial ices in comets?
4. If a comet collided with Earth, what would happen?

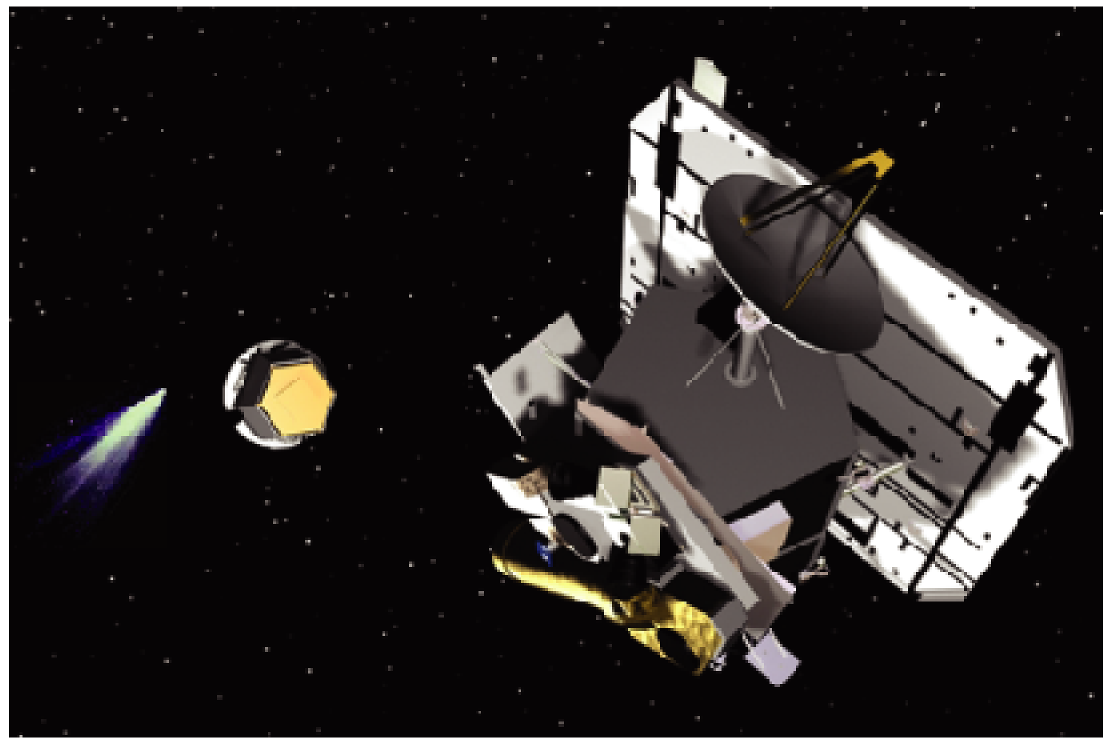
Do you think Deep Impact mission team members have challenged themselves with the rightquestions? Would you add any new questions to this list? Or would you take any off the

Mission Development

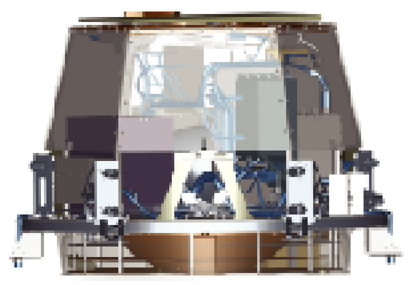
The Deep Impact mission is six years long from its start in 2000 to its finish in 2006. Planning for the mission began in 2000 with an engineering design accepted by NASA in May 2001. Building and testing of a two-part spacecraft followed. The developmental schedule is driven by the January 2004 launch date.

Two Spacecraft

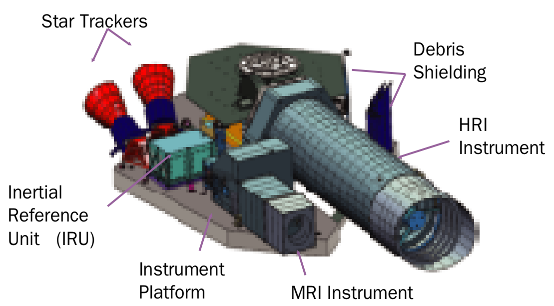
The Deep Impact mission is using a larger "flyby" spacecraft that will carry a smaller "impactor" spacecraft. The two spacecraft are connected until 24 hours before impact. The flyby has an antenna that sends data back to Earth, solar panels that generate power to control its instruments, jets fueled by hydrazine gas to drive the spacecraft, and computers to monitor and control the health of the entire system.



Impactor and Flyby



Impactor

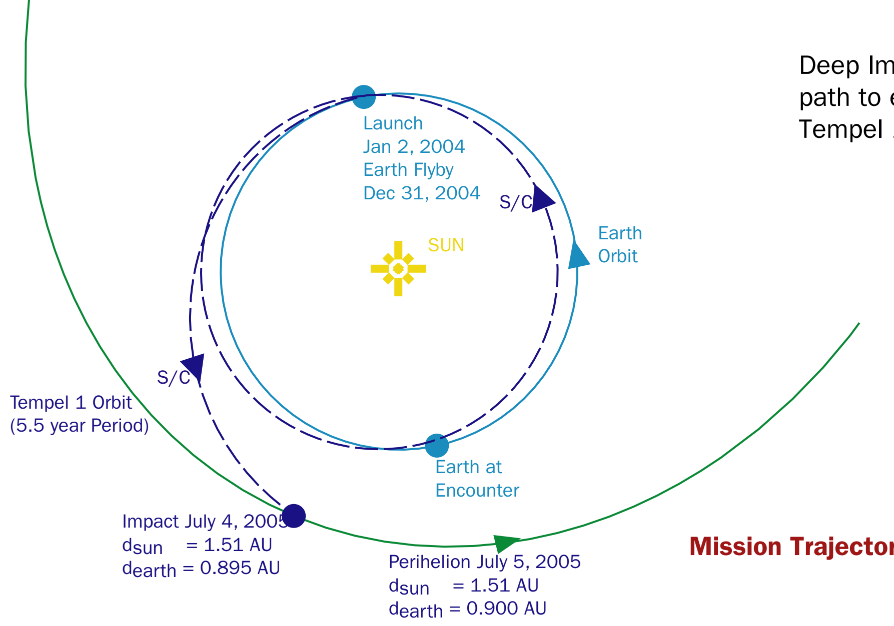


Instruments

The impactor is a battery-powered spacecraft that can operate independently for just one day. It is called a smart impactor because, after its release, it takes over its own navigation and maneuvers itself into the path of the comet. The impactor has a camera that will relay images up until the time it collides with the comet.

The Launch

In January 2004, come to the Deep Impact website to get details about the launching of the two spacecraft on a Delta II rocket. In January 2005 the two spacecraft will pass close to Earth. (See Mission Trajectory) At this time scientists and engineers will test and calibrate the scientific instruments on board and then redirect the spacecraft toward Comet Tempel 1. The two spacecraft will approach Tempel 1 and collect images of the comet before the



Deep Impact's orbital path to encounter Comet Tempel 1

Mission Trajectory

Impact!

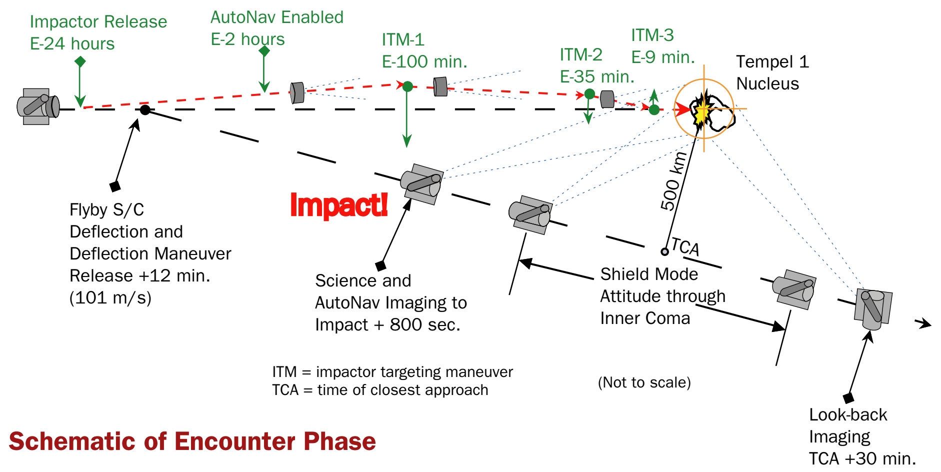
Early in July 2005 the flyby spacecraft will point precision tracking telescopes at the comet and release the impactor on a course to hit the comet's sunlit side. Twenty-four hours later, with thousands of people watching from Earth, the impactor will hit the comet.

Because the difference between the momentum of the comet and that of the impactor is so great, the impact will not significantly disturb the comet in its orbit around the Sun. Like a small pebble hitting the windshield of a large truck, the impactor will not perceptibly disturb the larger moving object.

Collecting Valuable Information

The flyby spacecraft, after releasing the impactor, will divert to a new path allowing it to pass approximately 500 km (300 miles) from the comet. From this distance, the flyby will record data about the impact, the ejected material blasted from the crater, and the structure and composition of the comet's interior. The flyby will then pass through the comet's coma, will turn itself to look at the comet again, and will record additional data from the other side of the nucleus—all the while observing changes in the comet.

Meanwhile, professional and amateur astronomers using large and small telescopes on Earth will observe the impact and its aftermath. Impact results will also be available on the Internet so that you can be part of this pioneering space mission.



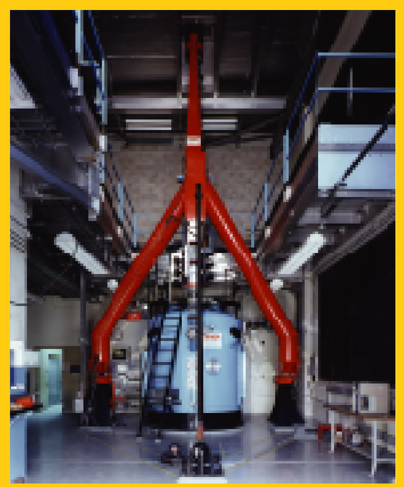
Schematic of Encounter Phase

What We Know and What We Don't Know About Comets

What We Know	What We Want to Know	How Deep Impact Can Help Us Find Out
Comets are frozen material left over from the formation of the solar system.	What are the basic properties of a comet nucleus and its interior?	By viewing and excavating Comet Tempel 1's nucleus, we will examine the interior of a comet for the first time.
From observations and space missions, we know the chemical and physical properties of cometary comas.	How do comets evolve? What happens to them over time?	A close-up view of the nucleus and the impact will provide new information.
CO_2 ice is found at temperatures below –79° C and formed far from the Sun.	Where did comets form in relation to the Sun? What is the chemical composition of the interior?	A spectrometer will look at newly exposed ice for CO_2.
Many comets break up. In 1994 Shoemaker-Levy 9 was disrupted by Jupiter's gravity. Comet LINEAR S4 broke up without an obvious reason.	How strong is Tempel 1? Will this knowledge help us mitigate a disastrous collision of a comet with Earth?	The size, shape, and formation time of the crater should tell us about the strength of the comet's surface and

Excavating Cratering

The Deep Impact mission is to excavate a crater 25 m deep on Comet Tempel 1. The major question facing the team of astronomers, engineers, and other scientists assembled for the mission is exactly how do we make a crater on a comet? This activity invites you to explore this



Ames Vertical Gun Range
NASA Ames Research Center

Materials:

- Deep pans or trays
- A variety of loose materials to use as comet surfaces - sand, flour, sugar, gravel, etc.
- A variety of objects to use as impactors (ball bearings, styrofoam balls, superballs, clay, weights, etc.)
- Meter stick
- A piece of string between 0.5-1.0 meters in length
- Balance (or scale)

Directions:

1. Make some predictions: Brainstorm a list of factors that you think will affect the size of a crater. Write down everything that occurs to you as a possibility; don't worry about whether or not it is correct at this stage.
2. Create some craters: Gather the materials listed above and come up with your own ways to test out the different factors on your list. Use the meter stick and string to measure the depth and diameter of the craters.

Possible Things to Try:

- Drop objects from different heights
- Drop objects of different weights
- Drop objects of different sizes
- Drop objects of different shapes

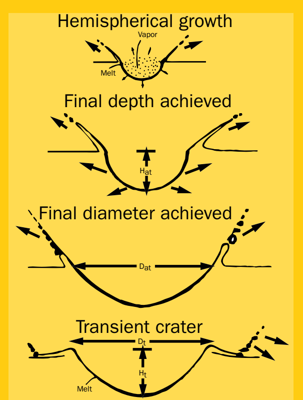
- Compact the surface material (pack down the flour, sand, etc.)
- Add water to your surface material

Things to Measure and Observe:

- Crater depth
- Crater diameter
- Shape of the crater

Things to Record:

- Keep notes on what tests you tried and the measure-ments and shapes of the craters that resulted.



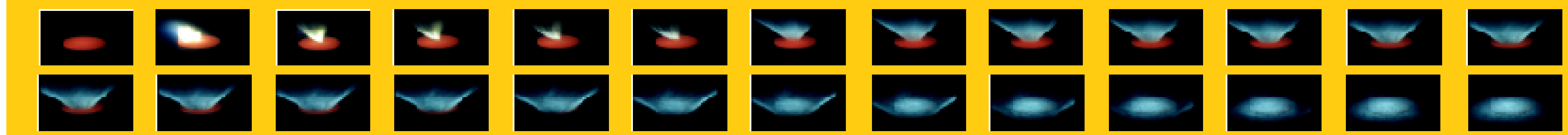
From *Impact Cratering* by H.J. Melosh, Oxford University Press, 1989

1. Review your predictions: Look back over your list. What factors seem to influence crater size? What effect did they seem to be having? Which ones seemed more important to you? Are there other things you would add to the list after experimenting?
2. Investigate Further: Now pick one of the factors from your list. How would you design an experiment to test just that factor? Why do we want to test one factor at a time?

Interested in learning more?

This is an excerpt from a longer classroom activity put together by Deep Impact's scientists and engineers. The full activity involves learning experiment design skills, looking for patterns in data, making predictions from the data, and becoming familiar with the work done by Deep Impact scientists and engineers. You can find the complete activity, Excavating Cratering, at:

http://deepimpact.jpl.nasa.gov/educ/ or
http://deepimpact.umd.edu/educ/



This simulation, one in a series of experiments produced at the Ames Vertical Gun Range, can be seen on the Deep Impact web site by clicking the Speaking of Impacts icon on the home page. Produced by Peter Schultz, Ph.D.