DEEP IMPACT

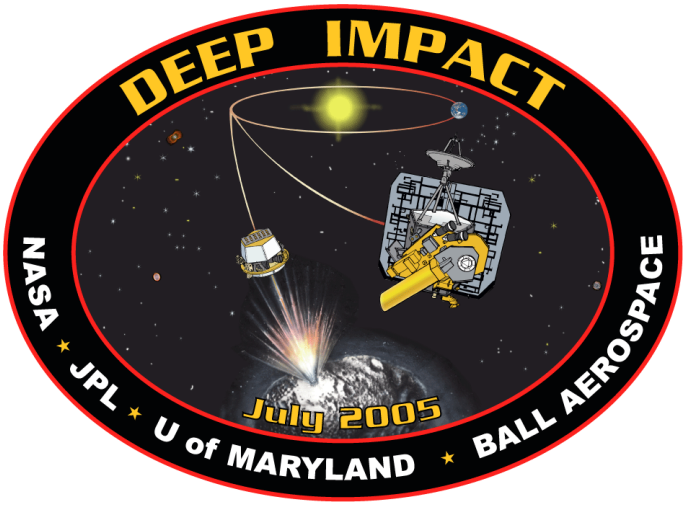


FIGURE 1: DEEP IMPACT MISSION PATCH

WHAT IS THE NAME OF THE SPACE PROBE?

The Space Probe that I have chosen is Deep Impact. Deep Impact (spacecraft)

MISSION SUMMARY

Nation	United States of America (USA)
Objective(s)	Comet Flyby and Comet Impact
Spacecraft	DIF + DI Impactor
Spacecraft Mass	1,430 pounds (650 kilograms)
Mission Design and Management	NASA / JPL
Launch Vehicle	Delta 7925-9.5 (no. D311)
Launch Date and Time	Jan. 12, 2005 / 18:47:08 UT
Launch Site	Cape Canaveral, Fla. / SLC-17B
Scientific Instruments	**Flyby Spacecraft:** 1. High-Resolution Instrument (HRI) 2. Medium Resolution Instrument (MRI) **Impactor:** 1. Impact or Targeting Sensor (ITS)

WHY DID YOU CHOOSE THIS MISSION?

I chose this mission as I went to see it crash into the comet at the Edinburgh Royal Observatory at about 5:30-6:30 am on my son's 5th birthday on July 3rd 2005. After the event; which I don't remember much about but I don't think it was really exciting, we came back and went back to bed for a couple of hours after bacon butties.

WHO WAS INVOLVED IN THE MISSION?

The Mission patch suggests that NASA, JPL (the Jet Propulsion Lab), University of Maryland and Ball Aerospace were the main people involved in the mission.

The University of Maryland was responsible for overall Deep Impact mission science, and project management was handled by NASA's Jet Propulsion Laboratory, Pasadena, California.

The spacecraft was built for NASA by Ball Aerospace & Technologies Corporation, Boulder, Colorado.

JPL is a division of the California Institute of Technology, Pasadena.

WHEN AND WHERE WAS IT LAUNCHED?

Deep Impact was a NASA space probe launched from Cape Canaveral Air Force Station on January 12, 2005 aboard a Delta II 7925 rocket.

Emerging through the smoke and steam, the Boeing Delta II rocket carrying NASA's Deep Impact spacecraft lifts off at 1:47 p.m. EST from Launch Pad 17-B, Cape Canaveral Air Force Station, Fla. A NASA Discovery mission, Deep Impact is heading for ...

https://www.nasa.gov/mission_pages/deepimpact/main/index.html#.YU9mYrhKhaC

"Details on the Delta II Launch Vehicle

Deltas are expendable launch vehicles (ELVs), which means they are only used once.

The major elements of the Delta Rockets are shown below. Each launch vehicle consists of:

Stage I: Fuel and oxygen tanks that feed an engine for the ascent

Solid Rocket Motors: Used to increase engine thrust; 9 total, 6 of which are lit at liftoff, 3 a minute into flight

Payload Fairing: Thin metal shroud or nose cone to protect the spacecraft during the ascent through Earth's atmosphere

Stage II: Fuel and oxidizer and the vehicle's "brains"; fires twice, once to insert the vehicle-spacecraft stack into low Earth orbit and then again to orient the third stage prior to it firing

Stage III: Solid rocket motor provides the majority of the velocity change needed to leave Earth orbit and inject the spacecraft on a trajectory to Mars; connected to the spacecraft until done firing, then separates"

https://mars.nasa.gov/mer/mission/launch_vehicle.html

KEY DATES

Jan. 12, 2005: Launch

July 1, 2005: Comet P/Tempel 1 rendezvous

July 4, 2005: Comet impact

Aug. 2005: End of the primary mission

Nov. 4, 2010: Flyby of 103P/Hartley 2 comet

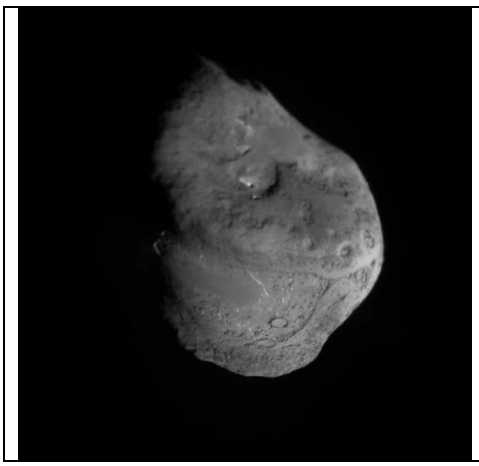
Aug. 11-Aug. 14, 2013: Communications lost

Sept. 20, 2013: NASA ends efforts to contact spacecraft

WHAT WERE THE MISSION AIMS AND OBJECTIVES?

The aim of the mission was a flyby of comet Tempel 1, but also it was to impact on the comet, which had never previously been attempted.

The primary mission of NASA's Deep Impact was to probe beneath the surface of a comet. The spacecraft delivered a special impactor into the path of Tempel 1 to reveal never-before-seen materials and provide clues about the internal composition and structure of a comet.

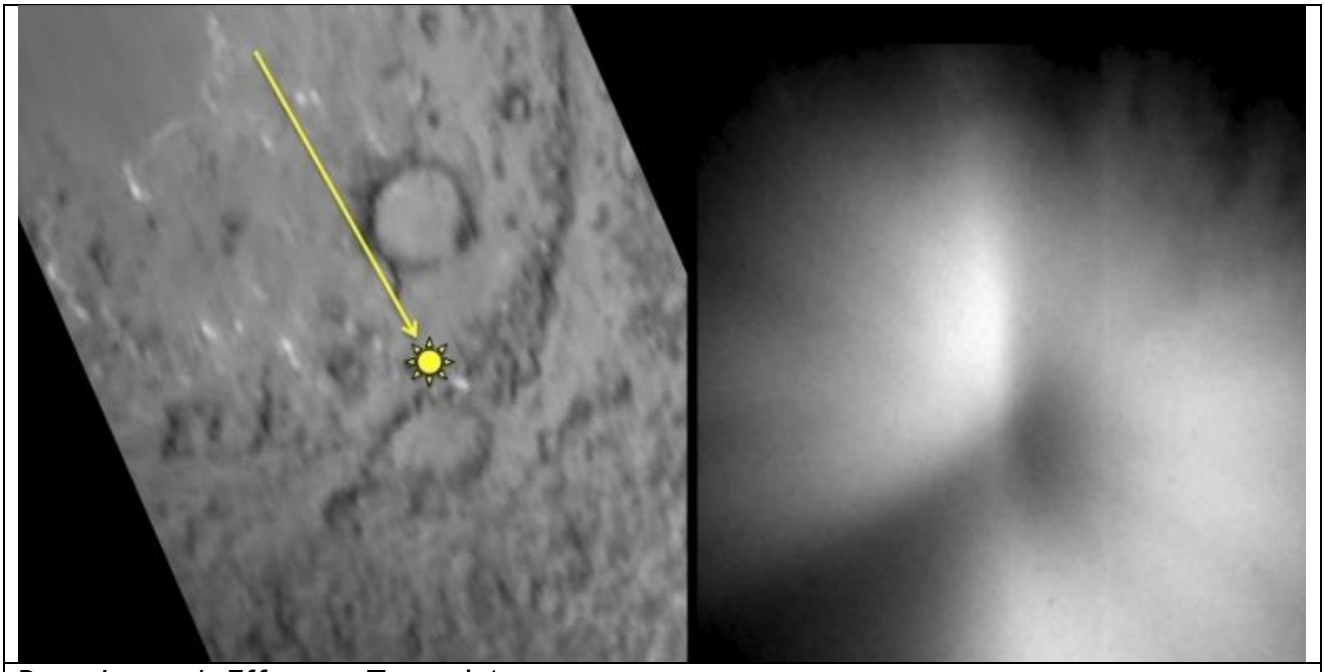


Tempel 1 Composite Map
This composite image was built up from scaling all images to 5 metres per pixel, and aligning images to fixed points. Each image at closer range, replaced equivalent locations observed at a greater distance. The impact site has the highest resolution because images were acquired until about 4 seconds from impact or a few metres from the surface.

Image credit: NASA/JPL/UMD

DID THE MISSION MEET ITS OBJECTIVES?

Yes the mission managed to impact on the comet and information from this has changed Scientists ideas about how life started on Earth.



Deep Impact's Effect on Tempel 1
This pair of images shows a before-and-after comparison of the area on comet Tempel 1 targeted by an impactor from NASA's Deep Impact spacecraft in July 2005. The left-hand image is one of the last obtained of the Tempel 1 surface by the impactor's high resolution imager before the impactor hit the surface. An arrow shows the direction the impactor traveled toward the surface, with a yellow spot that shows the impact target. The right-hand image shows the plume of material kicked up by the impact that obscures the surface. It was obtained about 700 seconds after the impact.
Image credit: NASA/JPL-Caltech/University of Maryland

Image credit: NASA/JPL-Caltech/UMD 	This image of comet Tempel 1 was taken 67 seconds after it obliterated Deep Impact's impactor spacecraft. The image was taken by the high-resolution camera on the mission's flyby craft. Scattered light from the collision saturated the camera's detector, creating the bright splash seen here. Linear spokes of light radiate away from the impact site, while reflected sunlight illuminates most of the comet surface. The image reveals topographic features, including ridges, scalloped edges and possibly impact craters formed long ago.
	Tempel Fades into Night Images taken by Deep Impact's flyby spacecraft after it turned around to capture last shots of a receding comet Tempel 1. Earlier, the mission's probe had smashed into the surface of Tempel 1, kicking up the fan-shaped plume of dust seen here behind the comet. Impact occurred at 10:52 p.m. Pacific time, July 3, 2005. Image credit: NASA/JPL-Caltech/UMD

July 2005: Data from Deep Impact shows that a cloud of fine powdery material was released when the impactor slammed into the nucleus of comet Tempel 1.

September 2005: Researchers discover a number of surprising facts about comet Tempel 1 from the Deep Impact experiment: Tempel 1 has a very fluffy structure made up of a fine dust that is weaker than a bank of powder snow, but that's held together by gravity; what appear to be impact craters can be seen on the surface of the comet; a huge increase of carbon-containing materials were detected when analyzing the comet's ejection plume, indicating that comets contain a substantial amount of organic material and may have brought that material to Earth at one time; and the comet's interior is well shielded from solar heating, meaning that the ice and other material deep within the comet nucleus may be unchanged from the early days of the solar system.

September 2005: Astronomers, using data from NASA's Sptizer Space Telescope and Deep Impact, come up with a list of compounds thought to be the recipe for planets, comets and other bodies in the solar system. Included are silicates, or sand, clay, carbonates, iron-bearing compounds and even aromatic hydrocarbons.

February 2006: The Deep Impact team discovers water ice on comet Tempel 1.

Autumn 2013 Although the exact cause of the loss of Deep Impact is unknown it is likely that a problem with computer time tagging could have led to loss of control for Deep Impact's orientation. That would affect the positioning of its radio antennas, making communication difficult, as well as its solar arrays, which would in turn prevent the spacecraft from getting power and allow cold temperatures to ruin onboard equipment, essentially freezing its battery and propulsion systems.

INSTRUMENTS

High-Resolution Instrument (HRI)

Medium-Resolution Instrument (MRI)

Impactor

Impactor Target Sensor

WHAT DID THE MISSION SHOW/ HOW HAS IT IMPROVED OUR KNOWLEDGE OF LIFE ON EARTH AND SPACE?

Deep impact

- is history's most travelled deep-space comet hunter
- showed that a comet's surface layer is very porous
- discovered that hyperactive comets are driven by carbon dioxide.

(Hyperactive comets are a small family of comets whose activity levels are higher than expected. They seem to emit more water than they should for the size of their nucleus.)

Deep Impact, which released an impactor on comet Tempel 1 to expose materials on its surface, revealed a number of new findings about comets and their composition, including evidence of water ice and organic materials. Researchers now believe that comets may have transported these compounds to Earth at one time, playing an essential role in the formation of the solar system and life on Earth.

WHEN WAS THE MISSION DUE TO FINISH?

Deep Impact spent almost nine years in space.

The mission included an unprecedented 4th of July impact and subsequent flyby of a comet, an additional comet flyby, and the return of approximately 500,000 images of celestial objects.

NASA's Deep Impact mission ended in September 2013.

IS THE MISSION CONTINUING BEYOND ITS EXPECTED END DATE?

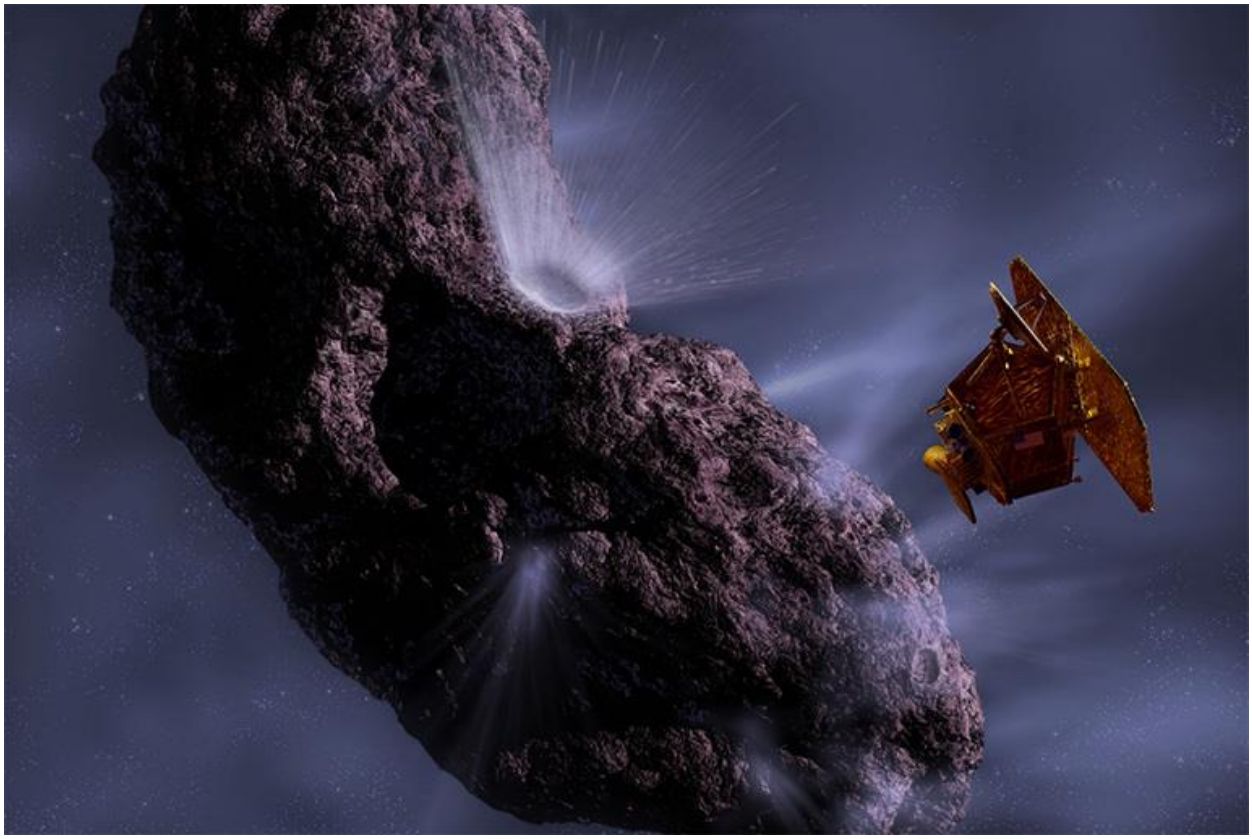
Deep Impact's mission was extended to include another comet flyby and observations of planets around other stars that lasted from July 2007 to December 2010. Since then, the spacecraft was continually used as a space-borne planetary observatory to capture images and other scientific data on several targets of opportunity with its telescopes and instrumentation.

Tim Larson, project manager of Deep Impact at JPL said that the mission was successful in the first six months, "But the science team kept finding interesting things to do, and through the ingenuity of our mission team and navigators and support of NASA's Discovery Program, this spacecraft kept it up for more than eight years, producing amazing results all along the way."

Another mission, Stardust-NExT visited Comet Tempel 1 on February 14th 2011 to study the area where Deep Impact released its impactor in 2005.

WHAT ARE THE MAIN THINGS YOU'VE LEARNED FROM COMPLETING THIS PROJECT?

I didn't know that Deep Impacts real mission name was EPOXI



WHAT FACTS/ FIGURES/ GRAPHICS CAN YOU OBTAIN ABOUT THE MISSION

These are seen throughout the project.

REFERENCES

1. Deep impact Mission Patch

https://upload.wikimedia.org/wikipedia/commons/9/99/Deep_Impact_Mission_Patch.png

2. Delta II rocket details

https://mars.nasa.gov/mer/mission/launch_vehicle.html

By NASA/JPL - http://deepimpact.jpl.nasa.gov/gallery/Flyby_w_Impactor.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=155967

4. Mission Launch

https://www.nasa.gov/mission_pages/deepimpact/main/index.html#.YU9mYrhKhaC

5. Comet Tempel I

https://www.nasa.gov/mission_pages/deepimpact/multimedia/pia02142.html#.YU9mt7hKhaA

https://www.nasa.gov/mission_pages/deepimpact/multimedia/pia13858.html#.YU9nqbhKhaA

Tempel 1 moving off into the distance image

https://www.nasa.gov/mission_pages/deepimpact/multimedia/pia02140.html#.YU9pArhKhaA

Deep Impact Mission Findings

https://www.jpl.nasa.gov/missions/deep-impact

Artist Impression of Deep Impact

https://solarsystem.nasa.gov/missions/deep-impact-epoxi/in-depth/

Scientific Findings of Deep Impact.

https://www.nasa.gov/mission_pages/deepimpact/media/deepimpact20130920f.html

This is material that I've just copied from a website as I ran out of time, but then I didn't have a month to do this like you!

APPENDIX 1

IN DEPTH: DEEP IMPACT (EPOXI)

Unlike previous cometary flyby missions, such as Vega, Giotto, and Stardust, the Deep Impact spacecraft, the eighth mission in NASA's Discovery program, was intended to study the interior composition of a comet by deploying an impact probe that would collide with its target.

The spacecraft was comprised of two parts: the main flyby spacecraft and an impactor. The flyby spacecraft weighed 1,325 pounds (601 kilograms), was solar-powered, and carried two primary instruments.

The high-resolution instrument (HRI), the main science camera for Deep Impact, was one of the largest space-based instruments ever built for planetary science. It combined a visible-light multi-spectral CCD camera (with a filter wheel) and an imaging infrared spectrometer called the spectral imaging module (SIM). The medium-resolution instrument (MRI) was the functional backup for the HRI, and like the HRI, it served as a navigation aid for Deep Impact.

The impactor weighed 820 pounds (372 kilograms) and carried the impactor targeting sensor (ITS), nearly identical to the MRI, but without the filter wheel, which was designed to measure the impactor's trajectory and to image the comet from close range before impact.

One of the more unusual payloads onboard was a compact disc with the names of 625,000 people collected as part of a campaign to "Send Your Name to a Comet!"

After launch, Deep Impact was put into low Earth orbit, then an elliptical orbit (about 100 x 2,600 miles or 163 × 4,170 kilometres), and after a third stage burn, the spacecraft and its PAM-D upper stage departed on an Earth escape trajectory.

There were some initial moments of anxiety when it was discovered that the spacecraft had automatically entered safe mode shortly after entering heliocentric orbit. By Jan. 13, 2005, Deep Impact had returned to full operational mode following a program to tumble the vehicle using its thrusters.

The spacecraft travelled 267 million miles (429 million kilometres) in six months (including course corrections on Feb. 11 and May 4, 2005) to reach Comet 9P/Tempel.

As the spacecraft approached its target, it spotted two outbursts of activity from the comet on June 14 and June 22, 2005.

On July 3, 2005, at 06:00 UT (or 06:07 UT Earth-receive time), Deep Impact released the impactor probe, which, using small thrusters, moved into the path of the comet, where it hit the following day, July 4, at 05:44:58 UT. The probe was traveling at a relative velocity of about 23,000 miles per hour (37,000 kilometres per hour) at the time of impact.

The impact generated an explosion the equivalent of 4.7 tons of TNT and a crater estimated to be about 490 feet (150 meters) in diameter.

Minutes after the impact, the flyby probe passed the nucleus at a range of about 310 miles (500 kilometres) and took images of the crater (although it was obscured by the dust cloud), ejecta plume, and the entire nucleus.

Simultaneous observations of the impact were coordinated with ground-based observatories as well as space-based ones, including the European Rosetta (which was about 50 million miles or 80 million kilometres from the comet), Hubble, Spitzer, the Swift X-ray telescope, and XMM-Newton.

The impactor also took images up to 3 seconds before impact that were transmitted via the flyby vehicle back to Earth.

Controllers registered about 4,500 images from the three cameras over the next few days. Based on the results of Deep Impact's investigations, scientists concluded that Comet Tempel 1 had probably originated in the Oort Cloud. The data also showed that the comet was about 75% empty space.

Although Deep Impact's primary mission was over, because the flyby vehicle still had plenty of propellant, on July 3, 2007, NASA approved a new supplemental mission for Deep Impact, known as EPOXI. The name was derived from the combination of the two components of this extended flight: Extrasolar Planet Observations (EPOCh) and Deep Impact Extended Investigation (DIXI).

This so-called "mission of opportunity" was originally focused on Comet 85P/Boethin. On July 21, 2005, Deep Impact was set on a trajectory to conduct a flyby of Earth in anticipation of intercepting Boethin. Unfortunately, scientists lost track of Comet Boethin, possibly because the comet had broken up.

Deep Impact was redirected toward Comet 103P/Hartley (or Hartley 2), starting with an engine burn on Nov. 1, 2007. EPOXI's new plan set Deep Impact on three consecutive Earth flybys, spread over two years (December 2007, December 2008, and June 2010) before the final trek to meet Comet Hartley 2.

These flybys essentially "stole some energy" from the spacecraft, thus dropping Deep Impact into a smaller orbit around the Sun.

Before the second Earth flyby, Deep Impact performed its EPOCh mission using the HRI instrument to perform photometric investigations of extrasolar planets around eight distant stars, returning nearly 200,000 images.

In the fall of 2010, Deep Impact began its investigations of Comet Hartley 2, conducting its flyby of the target at a range of about 430 miles (694 kilometres) at 15:00 UT Nov. 4, 2010. As with the encounter with Comet Tempel 1, Deep Impact used its three instruments to study Hartley 2 for three weeks.

Some of the images were so clear that scientists were able to identify jets of dust with particular features on the comet's nucleus. The data showed that the two lobes of Hartley 2 were different in composition.

Once past this second cometary encounter, Deep Impact had little propellant for further cometary investigations, but there was a possibility that the spacecraft, if still

in working condition, could be used for a flyby of Near Earth Asteroid 2002 GT in 2020.

With that goal in mind, thrusters were fired in December 2011 and October 2012 for targeting purposes. In the meantime, the spacecraft was used for the remote study of faraway comets such as C/200P1 (Garradd) in early 2012 and C/2012 S1 (ISON) in early 2013.

Communication with Deep Impact was lost sometime between Aug. 11 and Aug. 14, 2013, and after considerable effort to contact the spacecraft, NASA announced on Sept. 20, 2013, that it had officially abandoned efforts to contact Deep Impact.

Additional Resources

NASA Deep Impact Mission Profile

NASA Jet Propulsion Laboratory: Deep Impact Page

https://solarsystem.nasa.gov/missions/deep-impact-epoxi/in-depth/