

Solar System Secrets

Nuclear-powered mission to Neptune could answer questions about planetary formation.

BY JANE M. SANDERS

@ A mission to Neptune and its moons could reveal information about the early formation of our solar system. A Georgia Tech radio scientist is helping to plan the vision for such a mission, which could launch by 2016.

In 30 years, a nuclear-powered space exploration mission to Neptune and its moons may begin to reveal some of our solar system's most elusive secrets about the formation of its planets — and recently discovered ones that developed around other stars.

This vision of the future is the focus of a 12-month planning study conducted by a diverse team of experts led by Boeing Satellite Systems and funded by NASA. It is one of 15 "Vision Mission" studies intended to develop concepts in the United States' long-term space exploration plans. Neptune team member and radio scientist Professor Paul Steffes of the Georgia Institute

of Technology's School of Electrical and Computer Engineering calls the mission "the ultimate in deep space exploration."

NASA has flown extensive missions to Jupiter and Saturn, referred to as the "gas giants" because they are predominantly made up of hydrogen and helium. By 2012, these investigations will have yielded significant information on the chemical and physical properties of these planets. Less is known about Neptune and Uranus — the "ice giants."

"Because they are farther out, Neptune and Uranus represent something that contains more of the original — to use a 'Carl Saganism' — 'solar stuff' or the nebula that condensed to form planets," Steffes says. "Neptune is a rawer planet. It is less influenced by near-sun materials, and it's had fewer collisions with comets and asteroids. It's more rep-

resentative of the primordial solar system than Jupiter or Saturn."

Also, because Neptune is so cold, its structure is different from Jupiter and Saturn. A mission to investigate the origin and structure of Neptune — expected to launch between 2016 and 2018 and arrive around 2035 — will increase scientists' understanding of diverse planetary formation in our solar system and in others, Steffes notes.

The mission team is also interested in exploring Neptune's moons, especially Triton, which planetary scientists believe to be a Kuiper belt object. Such balls of ice are micro planets that can be up to 1,000 kilometers in diameter and are generally found in the outermost regions of our solar system. Based on studies to date, scientists believe Triton was not formed from Neptune materials, like most moons orbiting planets in our solar system. Instead, Triton is likely a



IMAGE COURTESY OF NASA

NASA's Deep Space 1 was hurled into space on Dec. 24, 1998 by a Boeing Delta II rocket. The first flight in NASA's New Millennium Program, Deep Space 1 was designed to validate 12 new technologies for scientific space missions of the next century, including the ion propulsion engine.



A mission to investigate Neptune is expected to launch between 2016 and 2018 and arrive around 2035. This artist's conception depicts a nuclear-electric-powered orbiter equipped with electrical and optical sensors. The mission would deploy three probes for sensing Neptune's atmosphere and two landers for exploring Triton, Neptune's largest moon (fore - ground).

SEVERAL MEMBERS OF THE NEPTUNE VISION MISSION TEAM HAVE DISCUSSED THE ENTHUSIASM PROMPTED IN 1968 WHEN THEY SAW THE ARTHUR C. CLARKE NOVEL-INSPIRED MOVIE "2001: A SPACE ODYSSEY." IT PROMOTED THE IDEA THAT LARGE-SCALE, DEEP-SPACE EXPLORATION WOULD BE CONDUCTED AT THE BEGINNING OF THE 21ST CENTURY.

“ No one is thinking we have the resources for manned missions to the outer planets, but now it looks like Arthur C. Clarke's idea of a nuclear-electric propelled mission will actually occur as it did in the book and the movie. So it's exciting to those of us from that generation.”

— Professor Paul Steffes



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“ We believe Kuiper belt objects like Triton were key to the development of our solar system, so there’s a lot of interest in visiting Triton.”

Paul Steffes,
Professor, Georgia Tech
School of Electrical and
Computer Engineering

Kuiper belt object that was accidentally pulled into Neptune’s orbit.

“Triton was formed way out in space,” Steffes says. “It is not even a close relative of Neptune. It’s an adopted child.... We believe Kuiper belt objects like Triton were key to the development of our solar system, so there’s a lot of interest in visiting Triton.”

Though they face a number of technical challenges — including entry probe design, and telecommunications and scientific instrument development — the Neptune Vision Mission team has developed an initial plan. Team members, including Steffes, have been presenting it at a variety of scientific meetings to encourage feedback from other experts. Their final recommendations are due to NASA in July 2005.

The plan is based on the availability of nuclear-electric propulsion technology under development in NASA’s Project Prometheus. A traditional chemical rocket would launch the spacecraft out of Earth orbit. Then an electric propulsion system powered by a small nuclear fission reactor — a modified submarine-type technology — would propel the spacecraft to its deep-space target. The propulsion system would generate thrust by expelling electrically charged particles called ions from its engines. The technology is expected



This is an artist's view of a Kuiper Belt binary object, icy bodies usually found at the fringe of our solar system. Scientists believe these objects are key to the solar system's development. A NASA-funded vision mission team is interested in exploring Neptune's moon Triton, which may be a Kuiper belt object.

to be used first in the Jupiter Icy Moons Orbiter (JIMO), which will explore Europa and Jupiter’s other satellites. It might also be used to power a robotic lab on the surface of Mars within the next decade.

Because of the large scientific payload a nuclear-electric propelled spacecraft can carry and power, the Neptune mission holds great promise for scientific discovery, Steffes

says. Unlike the large amount of propellant required for a traditional ther-

mo-chemical powered spacecraft, the amount of material that will be ionized to run the new spacecraft’s nuclear reactor is about the size of a concrete block. This increased energy efficiency will make possible a 20,000-pound spacecraft, roughly equivalent to the size of a tractor-trailer truck. Current orbiters Voyager and Cassini are similar in size to a minivan and a large conversion van, respectively.

The mission will employ electrical and optical sensors aboard the orbiter and three probes for sensing

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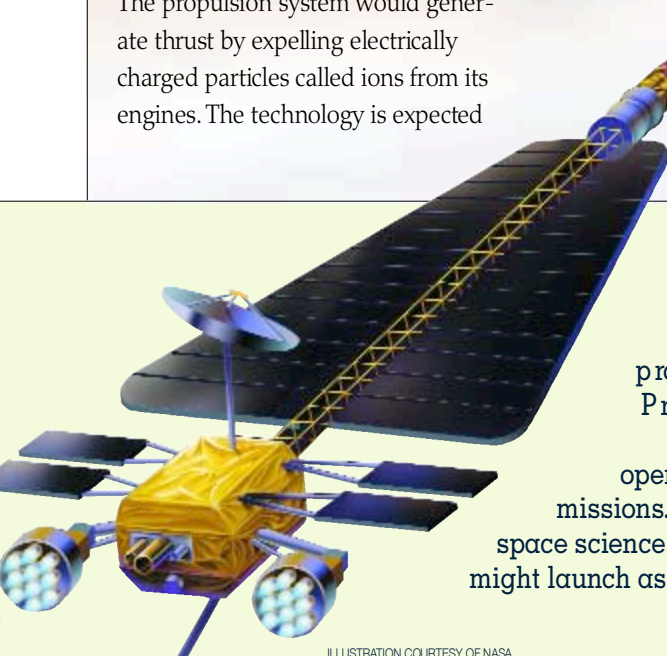


ILLUSTRATION COURTESY OF NASA

NASA’s Project Prometheus was established in 2003 to develop technology and conduct advanced studies in radioisotope power systems and nuclear power and propulsion for the peaceful exploration of the solar system. Project Prometheus is developing the first reactor-powered spacecraft capability and demonstrating that it can be operated safely and reliably in deep space on long-duration missions. The proposed Jupiter Icy Moons Orbiter may be the first space science mission to potentially incorporate this new capability. It might launch as early as 2015. The Neptune Vision Mission would follow.

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BELOW:
 Professor Paul Steffes is a member of a scientific team planning a possible mission to Neptune.

the nature of Neptune's atmosphere, says Steffes, an expert in remote radio sensing of planetary atmospheres. Specifically, the mission will gather data on Neptune's atmospheric elemental ratios relative to hydrogen and key isotopic ratios, as well as the planet's gravity and magnetic fields. It will investigate global atmospheric circulation dynamics, meteorology and chemistry. Sensors will measure winds, trace gases, cloud structure and microphysics, and photochemical and thermochemical processes. On Triton, two landers will gather atmospheric and

geochemical information near geysers on the surface.

The mission's three entry probes will be dropped into Neptune's atmosphere at three different latitudes – the equatorial zone, a mid-latitude and a polar region. Mission designers face the challenge of transmitting data from the probes through Neptune's radiowave-absorbing atmosphere. Steffes' lab at Georgia Tech has conducted extensive research and gained a thorough understanding of how to address this problem, he notes.

The mission team is still discussing how deep the probes should be deployed into Neptune's atmosphere to get meaningful scientific data. "If we pick a low enough frequency of radio signals, we can go down to 500 to 1,000 Earth atmospheres, which is 7,500 pounds of pressure per square inch (PSI)," Steffes explains. "That pressure is similar to what a submarine experiences in the deep ocean."

However, that depth will probably not be required, according to the mission team's atmospheric modelers, Steffes says. The probes will be able to obtain most information at only 100 Earth atmospheres, or 1,500 PSI.

Though realizing the mission's goals won't occur for at least several decades, Steffes and his colleagues

are nonetheless excited by their Vision Mission project. When the study got under way, several members of the team recalled the enthusiasm they felt in 1968 when they saw the movie "2001: A Space Odyssey," inspired by Arthur C. Clarke's novel. It promoted the idea that large-scale, deep space exploration would be conducted at the beginning of the 21st century.

"No one is thinking we have the resources for manned missions to the outer planets, but now it looks like Clarke's idea of a nuclear-electric propelled mission will actually occur as it did in the book and the movie," Steffes says. "So it's exciting to those of us from that generation."

@ Read more at: gtresearchnews.gatech.edu/newsrelease/neptune.htm



NASA's Project Prometheus reached an important milestone in November 2003 with the first successful test of a High Power Electric Propulsion (HiPEP) ion engine that could lead to revolutionary propulsion capabilities for space exploration missions throughout the solar system and beyond.

“ You have a scientific interest in Neptune driven by the rawness of the planet. Also, because it's so cold, the whole structure of the planet is so different from Jupiter and Saturn. It's an ice giant, rather than a gas giant.”

— Professor **Paul Steffes**



PHOTO BY GARY MEEK