



This picture of the Tadpole galaxy was taken by the Advanced Camera for Surveys, which was installed aboard Hubble Space Telescope in March, 2002. The spiral's distorted shape was caused by a small hit-and-run galaxy whose gravitational pull created a long tail of debris of stars and gas. The galactic carnage and torrent of star birth are playing out against a spectacular backdrop: a "wallpaper pattern" of 6,000 galaxies. More information can be found at <http://spacescience.nasa.gov/>.

### THEMES



**Solar System Exploration (SSE)**



**Mars Exploration (MEP)**



**Astronomical Search for Origins (ASO)**



**Structure and Evolution of the Universe (SEU)**



**Sun-Earth Connection (SEC)**

# SPACE SCIENCE

## PURPOSE

Thousands of years ago, on a small rocky planet orbiting a modest star in an ordinary spiral galaxy, our remote ancestors looked up and wondered about their place between Earth and sky. Like them, we ask the same profound questions, such as how did the universe begin? Today, we are beginning to answer these questions. Using tools of science that range from abstract mathematics and computer modeling to laboratories and observatories, humans are filling in the details of the amazing story of the universe. In the last 40 years, space probes and space observatories have played a central role in this fascinating process, and NASA's Space Science Enterprise will continue to address these four profound questions:

**How did the universe begin and evolve?** We seek to explain the earliest moments of the universe, how stars and galaxies formed, and how matter and energy are entwined on the grandest scales.

**How did we get here?** We investigate how the chemical elements necessary for life have been built up and dispersed throughout the cosmos, for evidence about how the Sun affects Earth, about similarities between Earth and other planets, and how comets and asteroids in our solar system affect Earth.

**Where are we going?** Our ultimate place in the cosmos is wrapped up in the fate of the universe. Humanity has taken its first steps off our home world, and we will contribute to making it safe to travel throughout the solar system.

**Are we alone?** Beyond astrophysics and cosmology, there lies the central human question: Are we on Earth because of an improbable accident of nature? Or is life, perhaps even intelligent life, scattered throughout the cosmos?

## ENTERPRISE: Space Science

Answers to these questions will not be extracted from narrow inquiries, but will be built up by combining innumerable individual clues over the years to come. The broad outlines of much of the puzzle are discernible now, but a clear picture of the whole is years away.

### FY 2002 ACCOMPLISHMENTS

The Mars Odyssey spacecraft went into successful orbit around Mars. Initial findings indicate the presence of huge amounts of subsurface water taking the form of ice close to the surface. This seems likely to confirm what has long been a subject of conjecture, and to strengthen the view of our nearest neighbor as a planet that possesses a key life-enabling feature.

A successful servicing mission by the Space Shuttle installed the new Advanced Camera for Surveys (ACS) on the Hubble Space Telescope and revived Hubble's Near Infrared Camera and Multi-Object Spectrometer (NICMOS). These improvements substantially increased Hubble's capabilities. Initial images were released in March. Among the photographs demonstrating the ACS camera's capabilities is a stunning view of a colliding galaxy dubbed the "Tadpole" which, with its long tail of stars, looks like a runaway pinwheel firework. Another picture depicts a spectacular collision between two spiral galaxies that presages what may happen to our own Milky Way several billion years from now when it collides with a neighboring galaxy in the constellation Andromeda. Closer to home, the camera imaged the "Cone Nebula," a craggy-looking mountaintop of cold gas and dust. Peering into a celestial maternity ward called the Omega Nebula or M17, it also revealed a watercolor fantasy-world of glowing gases, where stars and perhaps embryonic planetary systems are forming.

Investigating our stellar backyard, the NICMOS camera and spectrometer peeled back the outer layers of the Cone Nebula to see its underlying dusty "bedrock." The camera also penetrated the dusty disk of a galaxy like our Milky Way all the way to the galaxy's core. Astronomers were surprised to see what appears to be a ring of stars 720 light-years across encircling the galaxy's nucleus, an unprecedented sight in this type of galaxy. The camera then gazed across the universe and spotted a four-galaxy traffic accident that is creating a torrent of new stars. The colliding galaxies glow fiercely in infrared light due to the dust clouds that the flocks of new stars are generating.

We have long understood that energy flows from the Sun, not only in the form of visible light, but also as solar flares and the "solar wind" made up of atomic particles and magnetism. This energy interacts with Earth and the near-Earth environment, called geospace. But we do not fully understand the details of these processes. The Sun's impact on space weather in Earth's upper atmosphere can affect power grids and communications systems on Earth as well as satellite communications and tracking, spacecraft lifetimes, and the reentry of piloted vehicles. One of the important current puzzles is determining why some solar activity has significant geospace impact and some does not.

### THEME DISTRIBUTIONS

Budget Authority (\$ in millions)	FY 2002	FY 2003 President's Budget, As Amended	FY 2004 President's Budget
Solar System Exploration	638.9	975.7	1,358.6
Mars Exploration	456.9	495.5	570.2
Astronomical Search for Origins	650.1	698.1	877.0
Structure and Evolution of the Universe	350.1	331.0	431.7
Sun-Earth Connection	412.9	544.2	769.6
<u>Institutional Support</u>	<u>392.9</u>	<u>369.8</u>	<u>=</u>
Total	2,901.8	3,414.3	4,007.1

Note: For all formats, the FY 2002 column reflects the FY 2002 Congressional Operating Plan dated 9/30/02. The FY 2003 column reflects the FY 2003 Presidents Budget Submit (PBS) as Amended. FY2004 column is in full cost.

  Indicates budget numbers in Full Cost.

# ENTERPRISE: Space Science

## **Solar System Exploration**

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This theme seeks to understand how our own solar system formed and evolved, and about possible life beyond Earth. The planets of our solar system and the ancient icy bodies far from the Sun are Rosetta stones that can tell unique stories about the evolution of our solar system. As we learn more about the origins of living systems on Earth and our solar system's planets and moons, we may learn that life has also arisen on some of them. Highlights for FY 2004 include:

### **Overall budget**

FY 2004 request is \$1,359 million, a \$312 million or 30 percent increase over FY 2003 President's Request (full cost):

- \$177 million for three missions in development; MESSENGER mission to explore Mercury, DAWN mission to orbit around two asteroids, and Deep Impact mission to probe below the surface of a comet.
- \$130 million for New Frontiers program to explore the outer planets in the solar system, including funding for the New Horizons mission to Pluto and the Kuiper Belt.
- \$68 million for Astrobiology research to improve the ability to find and identify life on other planets.

### **New Initiative – Project Prometheus**

Request includes \$279 million for this new initiative (\$3 billion over five years). This consists of \$186 million (\$1 billion over five-years) from the Nuclear Systems Initiative introduced in FY 2003 and adds \$93 million (\$2 billion over five-years) for a first flight mission, Jupiter Icy Moon Orbiter, to be flown within a decade.

- Nuclear technology will enable unprecedented science data return through high power science instruments and advanced communications technology.
- Jupiter Icy Moon Orbiter will search for evidence of global subsurface oceans on Jupiter's three icy Galilean moons: Europa, Ganymede, and Callisto. These oceans may harbor organic material.
- Mission will set the stage for the next phase of exploring Jupiter and will open the rest of the outer solar system to detailed exploration.

### **New Initiative – Optical Communications**

Request includes \$31 million for this new initiative (\$233 million over five years):

- Offers potential for many orders of magnitude improvement in communication data rate. Example: using conventional radio frequency communications, the Mars Reconnaissance Orbiter will take 21 months to map 20 percent of the surface of Mars; if used optical communications then would allow the *entire* surface to be mapped in 4 months.
- Critical technology exists, but must be demonstrated. Plan first demonstration at Mars in 2009 using telecom satellite around Mars that relays data to high-altitude Earth balloons. The balloon receiver technology will be demonstrated by the middle of this decade.
- Promises dramatic reduction in cost per byte of data returned and could, ultimately, replace the Deep Space Network.

# ENTERPRISE: Space Science

## **Mars Exploration**

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This theme explores the mysteries of the history and present conditions on Mars. Dry and cold today, the Martian surface shows the traces of a wet and warmer past. Frozen water at its poles and hints of relatively recent liquid water flows make Mars the most likely place to seek evidence of ancient or present extraterrestrial life. Contrasts between the current and past geology, atmospheres, and magnetic fields of Mars and Earth promise insights into why these neighboring planets differ so much today. Advances in our understanding of Mars would be useful for future human exploration. Highlights for FY 2004 include:

### **Overall budget**

FY 2004 request is \$570 million, a \$20 million or 3.6 percent increase over FY 2003 President's Request (full cost):

- \$184 million for development of 2005 Mars Reconnaissance Orbiter, an orbiter that will map Martian surface features as small as a basketball (20-30 cm).
- \$29 million for 2007 Scout Mission, a unique opportunity for scientists and industry to compete and provide innovative ideas for Mars exploration.
- \$118 million for 2009 Mars Smart Rover/Lander, a rover that will traverse tens of kilometers over Mars and last over a year, digging and drilling for unique samples to study in its onboard laboratory.
- \$9 million (\$336 million over five-years) added for a new mission, a telecommunications satellite around Mars in 2009, to enhance science data return and demonstrate the first interplanetary optical communications link.

## **Astronomical Search for Origins**

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This theme strives to answer two questions: Where did we come from? Are we alone? The theme seeks to observe the birth of the earliest galaxies and the formation of stars, find planetary systems in our region of the galaxy, including those capable of harboring life, and learn whether life exists beyond our solar system. We need to understand the building blocks of life, the conditions necessary for life to persist, and the signatures it writes on the sky. By exploring the diversity of other worlds and searching for those that may harbor life, we hope to understand the origins of our own world. Highlights for FY 2004 include:

### **Overall budget**

FY 2004 request is \$877 million, a \$78 million or 10 percent increase over FY 2003 President's Request (full cost):

- \$239 million for Hubble Space Telescope operations as well as funding for a Shuttle servicing mission in 2005 and a Shuttle retrieval mission in 2010 as the Hubble ends its operations.
- \$255 million for development of James Webb Space Telescope planned for launch about 2010 and promising to build on the legacy of Hubble Space Telescope.
- \$80 million for development of Space Interferometry Mission planned for launch in 2009 to detect planets around other stars.

# ENTERPRISE: Space Science

## **Structure and Evolution of the Universe**

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This theme seeks to understand the nature and phenomena of the Universe. It seeks to understand the fundamental laws of space, time, and energy and to trace the cycles that have created the conditions for our own existence. This is accomplished in part by observing signals from the Big Bang, mapping the extreme distortions of space-time about black holes, investigating galaxies, and understanding the most energetic events in the universe. We also must try to understand the mysterious dark energy that pervades the universe and determines its ultimate destiny. Highlights for FY 2004 include:

### **Overall budget**

FY 2004 request is \$432 million, a \$33 million or 8.3 percent increase over FY 2003 President's Request (full cost):

- \$116 million for development of Gamma-ray Large Area Space Telescope (GLAST), a mission to study high-energy objects like black holes.

### **New Initiative – Beyond Einstein**

Request includes \$59 million for this new initiative (\$765 million over five years):

- Offers potential to answer three questions left unanswered by Albert Einstein's theories: What powered the Big Bang? What happens to space, time, and matter at the edge of a black hole? What is the mysterious dark energy expanding the universe?
- Laser Interferometer Space Antenna (LISA) will use three spacecraft "formation flying" 5 million kilometers apart in a triangle to observe the distortion of space due to gravity waves.
- Constellation-X will use a team of powerful X-ray telescopes working in unison to observe black holes, investigate "recycled" stellar material, and search for the "missing matter" in the universe; it will be 100 times more powerful than any single X-ray telescope that has come before it.
- Einstein Probes, a program that will begin later this decade, consists of fully and openly competed missions (in the manner of the Discovery, Explorers, and New Frontiers programs) to conduct investigations that benefit Structure and Evolution of the Universe science objectives.

## **Sun-Earth Connections**

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This theme investigates our Sun and how its structure and behavior affect Earth. The Sun's energy is responsible for the Earth's present ecosystem, but the Sun is a variable star. Its small variability profoundly affects the Earth. Changes in its long-term brightness cause ice ages, and its 11-year cycle of activity causes aurora and other disturbances on the Earth. Solar flares affect the upper atmosphere and can damage satellites and disable the power distribution grid on the ground. The Sun is also our nearest star and is an ideal laboratory for basic physics and learning about other stars. Highlights for FY 2004 include:

### **Overall budget**

FY 2004 request is \$770 million, a \$95 million or 14 percent increase over FY 2003 President's Request (full cost):

- \$166 million for development of STEREO and Solar Dynamics Observatory.
- \$212 million for future flight missions.