NASA Facts

National Aeronautics and
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New Millennium Program

NASA's New Millennium program, a series of missions to test cutting-edge technologies never before flown, will pave the way for a 21st century fleet of affordable, frequently launched spacecraft – perhaps 10 to 15 per year – with highly focused science objectives.

New Millennium's Deep Space 1 will test ion propulsion and other technologies when the spacecraft flies by an asteroid and later possibly a comet (above).

New Millennium will develop and validate the essential technologies and capabilities required for these new types of missions. The program is designed to initiate a revolutionary new way of exploring Earth, the solar system and astrophysical events in and far beyond the Milky Way galaxy. These new missions will ensure NASA's technological readiness for post-2000 space and Earth science missions.

Begun in 1994, New Millennium features missions launched so frequently that they will be able to create armadas in space. Some of these probes will combine to create a network of spacecraft capable of discerning trends, examining planetary climates and atmospheres, or landing to study such surface phenomena as seismic and meteorological activity. Other sets of spacecraft could form a constellation uniquely suited to study solar systems beyond our own.

These goals require significant changes in almost all aspects of spacecraft design and deployment. New Millennium experimental technology flights will validate key technologies required to move toward. Testing these technologies in flight will speed up their infusion into the marketplace. Some of the space instruments of tomorrow may become as small and lightweight as a pocket wallet.

Drawing on diverse sectors of the country's science and technology expertise – from universities, nonprofit organizations, the aerospace industry and other government agencies to the specialized services of high-technology companies – new technologies will emerge in the next several years that will enable more autonomous spacecraft to be developed.

The Selection Process

The New Millennium program was designed to help fulfill the need for new technologies that can provide high scientific payoffs and a continuous flow of data from space to Earth. To ensure this goal is met, a science working group representing the fields of planetary science, space physics, astrophysics and terrestrial science has assisted in identifying key challenges facing the scientific community in its quest to find out more about the universe. This group has also catalogued the type of science missions that could conceivably fly in the post-2000 era to address these challenges, as well as the key capabilities that would be required for such missions. Their vision provides the basis for New Millennium's selection of technologies for flight validation.

Technologies to be validated in New Millennium flights will be determined in a three-phase process. In the first phase, identification of a broad suite of technologies is given over to six teams made up of members from private industry, academia, nonprofit organizations, other NASA centers and government agencies, so that they can design road maps for the development of breakthrough technologies to meet the science goals of the mission. The groups, called "integrated product development teams," are charged with recommending a coherent program of technology development to render the highest priority capabilities currently ready for space flight validation.

The specialty areas of New Millennium's six integrated product development teams are: spacecraft autonomy; microelectronics systems; in-situ instruments and microelectromechanical systems; instrument technologies and architectures; communications; and modular and multifunctional systems.

The teams will make priorities among innovative concepts being sought from all sectors of the engineering and science communities. Technologies that are designated high priority by the teams are expected to provide revolutionary advances in capability that will allow New Millennium missions to leap ahead in reducing the cost of 21st century space flight. Additional factors considered in identifying these technologies include their applicability to a wide range of missions and their ability to address science goals at an affordable cost.

In the second phase of the selection process, technologies being considered for flight development are further winnowed by assessing their long-term impact on science return, their cost, the revolutionary nature of the technologies and the degree of risk reduction offered by flight validation. Evaluation of the technologies in this phase will be done by program management in consultation with the science working group and flight teams. At the end of this phase, a host of technologies with a corresponding set of flights will be recommended to NASA Headquarters.

The third phase of the selection process involves delivery of technologies for flight. A set of readiness checkpoints will ensure timely delivery of the technologies for flight. Those which meet the schedule of checkpoints will be integrated and flight validated by New Millennium. Selection of technologies for a particular validation flight requires a match between the development cost and readiness dates of a given technology, in addition to the ability to ready the technology for flight given budget constraints and flight opportunities available for New Millennium. This final step will be carried out by program management, with consideration given to the balance and interrelationships between high-priority technologies needed for 21st century science missions.

Facilities and Funding

NASA's Jet Propulsion Laboratory was chosen to manage the New Millennium program in part because of its expertise in developing advanced space technologies. Facilities such as its Microdevices Laboratory place JPL in the forefront of emerging micro-technologies for space flight. As a federally funded research and development center, the Laboratory has broad-based funding resources for technology development work.

The Laboratory has reengineered its project design process to reduce the cost of developing a space flight mission. Construction of a JPL Project Design Center, a computer-aided facility capable of creating several spacecraft designs and options in very little time, represents a new approach in automated mission design and verification. The Laboratory's Flight System Testbed complements the Project Design Center in developing concurrent engineering systems for new spacecraft and identifying incompatibilities early in the design phase.

The New Millennium Program is a multi-year-level program funded at approximately $60 million per year for the space science portion of the program, and at $50 million for the Earth-orbiting portion.

Integrated Product Development Teams

Integrated product development teams have been established in six technology areas. Teams are made up of anywhere from four to 22 members. Roughly half of the members come from NASA and other government agencies. The remainder were selected through an open competition with industry, nonprofit laboratories and academia based on the technology concepts that were proposed, in addition to their relevance to New Millennium objectives and the stage of maturity of these technologies.

The six integrated product development teams will address the following areas:

❑ The **autonomy team** will focus on software and end-to-end system architecture that enables autonomous spacecraft operation, thereby reducing the ground operations costs. Technologies of interest include real-time and fault tolerant spacecraft systems; those technologies which can guarantee fault detection, isolation, recovery and avoidance; products such as computer-aided software engineering tools and knowledge-based software; and tools for advanced software architecture.

These technologies will support functions such as overall mission control, spacecraft sequencing, spacecraft health and resource management, payload data collection and analysis, guidance and navigation. These systems will also support station-keeping of multiple spacecraft and be capable of managing and disseminating spacecraft information and data.

❑ The **microelectronics team** will develop the technology for an integrated, three-dimensional microelectronics architecture that will replace a spacecraft's avionics functions, which are provided by separate individual subsystems such as attitude control, command and data processing, power and mass data storage.

Such integrated architectures can improve system performance while drastically reducing the mass and power requirements, and eliminating many discrete components and external interfaces. Enhanced performance will support information processing onboard spacecraft, giving them more autonomy and the capability of working in concert with several other spacecraft forming a constellation in orbit.

❑ The **in-situ instruments and microelectromechanical systems team** will focus on revolutionary advances in science instruments and miniature electrical and mechanical devices that offer new and affordable approaches to collecting science data or to providing spacecraft engineering data.

Sensors the size of a computer chip and integrated instrument packages will be developed to enable new capabilities and reduce component sizes and costs. New approaches for designing, simulating and packaging novel microinstrument technologies will also be addressed.

❑ The **instrument technologies and architectures team** will define technology validation for new instruments and combine them in a system architecture that reduces the cost of science measurements and makes possible the acquisition of new science measurements.

❑ The **communications team** will develop small, highly integrated modular telecommunications systems for deep space and near-Earth space flight missions. Deep space and near-Earth missions require advances in ultra low noise and ultra high bandwidth capabilities, respectively. Innovations will be necessary to increase efficiency in higher frequency radio systems, to share transceiver hardware with navigation and science data acquisition and to implement new approaches in data coding and operational concepts.

❑ The **modular and multifunctional systems team** will address revolutionary advances in mechanical and thermal systems, energy generation and storage, and propulsion alternatives that offer affordable solutions for science missions in the next century. New approaches will be developed to reduce the structural mass of spacecraft and to use solar electric power even in missions that take place far from the Sun.

Teaming with NASA

The New Millennium program has actively solicited the participation of industry, universities, nonprofit organizations, other NASA centers and government agencies to form innovative relationships within these integrated product development teams. The integrated product development teams will identify, deliver and implement breakthrough technologies for specific missions. Concurrent engineering teams will be assembled to carry out flight and ground-system engineering for each New Millennium flight. All categories of participants will be eligible to become members of any of these teams.

Universities that are prepared to deliver flight hardware or software can compete directly for membership in an integrated product development team, or they can team with an industrial organization that already has membership in a team. This and similar technology development programs under the sponsorship of other government agencies are part of the nation's technology pipeline, from which New Millennium will select its technologies for flight validation.

Small businesses that are ready to develop and deliver hardware and software can become members of the integrated product development teams in the same way as universities. They are also eligible for funding to develop relevant technologies through NASA's Small Business Innovation Research program.

A number of government sponsors, including the U.S. Air Force Phillips Laboratory, the Defense Advanced Research Projects Agency and the National Science Foundation, have expressed an interest in coordinating their technology development programs to match those of New Millennium and other NASA technology development programs currently in place. The synergy created by these pooled resources and expertise offers benefits to all parties.

Some government agencies already hold membership in some of the integrated product development teams. The technologies they are developing can be carried out in government, nonprofit, industrial or academic laboratories. Some government laboratories, such as the Department of Defense or the Department of Energy, may participate in specific New Millennium missions, contributing to such activities as mission/trajectory design and navigation, spacecraft instrumentation, fabrication or testing, and mission operations.

Deep Space 1

The first New Millennium deep space mission, Deep Space 1 features a 490-kilogram (1,080-pound) spacecraft that was launched October 24, 1998.

Deep Space 1 will demonstrate 12 advanced technologies that will help enable many ambitious deep space and Earth-orbiting missions planned for flight early in the next century. The spacecraft will also be the first to rely on solar electric propulsion for its main source of thrust, rather than conventional solid or liquid propellant-based systems.

Technologies to be demonstrated include new telecommunications equipment; autonomous optical navigation; advanced solar arrays; a minature integrated ion and electron spectrometer; microelectronic devices; and a miniaturized camera and imaging spectrometer that will take pictures and make chemical maps of asteroid 1992 KD, which the spacecraft will fly by in July 1999.

Among the most striking technologies is solar electric propulsion – in the form of a xenon ion engine – marking the first time that this long-studied form of propulsion has been used as the primary propulsion source in deep space. This futuristic engine, using heavy but inert xenon gas as propellant, will be driven by more than 2,000 watts from large solar arrays. Spectrum Astro Inc. of Gilbert, AZ, is the primary industrial partner on the first mission team. JPL's David Lehman is the flight project manager, and Dr. Marc Rayman is chief mission engineer and deputy mission manager. Further information is available on the web at http://www.jpl.nasa.gov/ds1news .

Deep Space 2

Two small probes weighing two kilograms (4.5 pounds) each will be sent to Mars in January 1999 onboard the Mars Polar Lander spacecraft to study Mars' soil and atmosphere.

The microprobes are designed to withstand both very low temperatures and high decelerations. Each highly integrated package will include an advanced microcontroller, a telecommunications microsubsystem, power microelectronics, an ultra low-temperature lithium battery, and flexible interconnects for system cabling.

In-situ instrument technologies for making direct measurements of the Martian surface will include temperature sensors for measuring the thermal properties of the Martian soil and a subsurface soil collection and analysis instrument to detect the presence of water ice in the soil.

The microprobes will be mounted on the lander spacecraft's cruise ring. The probes will separate and plummet to the surface using a single-stage entry aeroshell system. Upon impact, the aeroshells will shatter, and the microprobes will divide into a forebody and aftbody. The forebody, which will lodge 30 to 90 centimeters (one to three feet) underground, will contain the primary electronics and instruments. The aftbody, which will stay close to the surface, will collect meteorological data and relay data back to Earth using the currently orbiting Mars Global Surveyor spacecraft.

Deep Space 2 is led by Project Manager Sarah Gavit of JPL. Further information is available on the web at http://nmp.jpl.nasa.gov/ds2 .

Earth Orbiter 1

The Earth Orbiter 1 mission will fly three advanced land-imaging instruments and seven revolutionary spacecraft technologies. The advanced imaging instruments will lead to a new generation of lighter-weight, higher-performance and lower-cost imaging instruments similar to those flown on the existing Landsat satellites. Additionally, the mission will flight-validate a number of cross-cutting spacecraft subsystem technologies which, if successful, will enable future Earth and space science missions to be conducted using smaller, lower-weight, reduced-power spacecraft buses.

Three instruments - an advanced land imager, atmospheric corrector and a hyperspectral imager - will be flown on Earth Orbiter 1. Each instrument incorporates new land imaging technologies which will enable future Landsat and Earth-observing missions to more accurately classify and map land utilization globally.

Seven technologies reducing the cost, mass and complexity of future Earth-observing spacecraft will be demonstrated, enabling more scientific payloads to fly on future missions. The technologies are: X-band phased array antenna, carbon-carbon radiator, lightweight flexible solar array, wideband advanced recorder processor, pulsed plasma thruster, enhanced formation flying and fiber-optic data bus.

Scheduled for launch in December 1999, the spacecraft will be furnished by Swales & Associates Inc., Beltsville, MD, and Litton Industries, College Park, MD.

NASA's Goddard Space Flight Center manages Earth Orbiter 1 for NASA's Office of Earth Science. At Goddard, Dr. Bryant Cramer is the New Millenium Program Earth-orbiting implementation manager, Dale Schulz is Earth Orbiter 1 project manager and Dr. Stephen Ungar is Earth Orbiter 1 mission scientist. Further information is available on the web at http://eo1.gsfc.nasa.gov/ .

Program Team

The New Millennium Program is managed by the Jet Propulsion Laboratory for NASA's Offices of Space Science and Earth Science, Washington, DC. At JPL, Dr. Fuk Li is New Millennium program manager, Dr. David Crisp is chief scientist, and Dr. Barbara Wilson is program technologist.

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