AMERICAN ASTRONOMICAL SOCIETY STATEMENT ON THE VISION FOR SPACE EXPLORATION

SUMMARY

The American Astronomical Society urges that a vigorous, focused program of scientific research form the core of the implementation of the *Vision for Space Exploration*. The President's initiative for the civilian space program places emphasis on exploration of the Moon, Mars, and beyond by humans and robots. Science *is* exploration, whether it involves directly sampling the surface of Mars, or gathering in the faint and ancient light of distant galaxies. Exploration without science is tourism.

The adventure of exploration will capture the hearts of Americans: but the scientific discoveries that come from that exploration will capture their minds. Scientific discoveries from NASA's new space program will provide its most meaningful legacy. We are learning where we are, where we came from, and we have discovered surprising new features of the way the world works. Based on NASA's leadership in space science, we see the Earth as one planet among many we can now study, we see the origin of chemical and biological matter as woven into the history of cosmic change, and we have learned the surprising fact that, on the largest scales, our Universe is not organized by the material we can see, but is made mostly of dark matter and governed by the properties of a mysterious dark energy we have only recently discovered. We have much to explore. The Universe holds a great deal of "beyond."

Science is essential to implement the Vision for Space Exploration. New technologies to implement the Vision for Space Exploration will depend on scientific advances, and, in turn, will afford new opportunities for scientific work. These notions are laid out in the June 2004 report of the *President's Commission on Implementation of United States Exploration Policy* and National Research Council's assessment: *Science in NASA's Vision for Space Exploration*. As we learn how to explore, we will create opportunities for better scientific research, for more stimulating science education, and we will contribute toward our nation's ability to compete in a world based on technology.

We are all explorers whenever we encounter something new. By motivating Exploration for scientific purposes, the Vision for Space Exploration will benefit science and society. The great successes of space science in the past decades arise from a strong partnership between NASA and the scientific community. The astronomical community, through its decadal surveys and other consultations has set priorities, and worked with NASA to make these dreams into reality. The astronomical community embraces the opportunity to continue to work with NASA to implement the Vision for Space Exploration on a sound scientific basis with broad input from the scientific community.

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BACKGROUND WHITE PAPER

Context

The history of US science, and of NASA in particular, have been profoundly altered by key federal administration initiatives. A mandate to place a human on the Moon in the 1960s, and the directive for the study and development of the International Space Station are clear examples. Where scientific objectives have been integrated with technological goals, tangible positive outcomes have resulted for science and society. President Bush's January 14, 2004 announcement of his vision for the civilian space program: a *Vision for Space Exploration* represents another opportunity to entwine scientific research with the motivation to explore the Moon, Mars, and beyond through advancement of human endeavor, robotic activity and the supporting technologies.

The Vision for Space Exploration was prompted in part by the need for an inspiring long-term vision for NASA's human space flight program after the tragic loss of the Space Shuttle Columbia in February of 2003. If this vision, whose "fundamental goal is to advance U.S. scientific, security, and economic interests through a robust space exploration program", is to succeed, science must play a central role. The Vision for Space Exploration falls within the umbrella of the National Aeronautics and Space Act of 1958 which states that "The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives: [one being] the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space."

In June 2004, the "President's Commission on Implementation of United States Exploration Policy" produced a report describing the Exploration implementation. The Commission stated ten *Findings* and fourteen *Recommendations.* Significantly, many of these involve science (5/8 and 10/14 respectively). The specific research areas identified by the Commission include scientific activities that are stimulated by the Vision for Space Exploration and activities that help implement it.

The National Research Council also conducted an independent assessment of "Science in NASA's Vision for Space Exploration." Their report, published in 2005[1] recommends five guiding principles for implementation of the Vision for Space Exploration. In essence, these principles articulate that exploration, as a form of science, should target the Earth where we live, the objects of the solar system where humans may be able to visit, the broader solar system including the Sun, and the vast universe beyond. In addition, the pervasive idea was that exploration should concentrate on the areas that provide the greatest opportunity to advance our understanding of how the universe works, who we

[1] *Science in NASA's Vision for Space Exploration*, Space Studies Board, National Academy Press, Washington, DC, 2005

are, where we came from, and our ultimate destiny. This NRC report said that robotic spacecraft, human spaceflight and related technologies should be used to fulfill scientific roles in NASA's mission to explore and must include research to resolve fundamental engineering and science challenges.

Science Motivates Exploration and Enables the Vision for Space Exploration

Humankind explores its surroundings for many reasons. There is the innate curiosity that drives us to look over the next hill, towards uncharted territory. There is the undeniable thrill of discovery, along with the satisfaction of meeting and conquering a challenge. NASA's space mission portfolio has a distinguished history of driving technological development through principles of discovery, scientific research, and exploratory activities. The Apollo program, like other investigative journeys before it, exemplified human learning, especially scientific learning, coupled with technical achievement. NASA's space science robotic telescopes such as Chandra, Hubble, and WMAP (among many others) have altered our perception of the universe, now characterized as flat, accelerating, and largely comprised of dark energy and dark matter. We have probed galaxies at a time when the universe was a small fraction of its current age. We have employed the remarkable trio of spacecraft SoHO, TRACE, and Yohkoh to understand the Sun's interior and to observe the violent space weather that affects astronauts and robots in space, and life here on Earth. Furthermore, we have used ground-based telescopes and space telescopes to discover over a hundred planetary systems quite unlike our own solar system, and we are starting to investigate which, if indeed any, of them show signs of the raw materials of life.

Through space telescopes, we have opened up most of the seventy octaves of electromagnetic spectrum using an ensemble of orbiting facilities to reveal worlds that are unremarkable when seen through the narrow window of visible light – giant clusters of galaxies swimming in an ocean of hundred million degree gas; neutron stars, no larger than a small town, with magnetic eruptions that can shake Earth's atmosphere; huge jets of radio-emitting plasma that squirt out nearly at the speed of light of black holes a billion times more massive than the Sun in the centers of galaxies. Changing interstellar conditions and cataclysmic events like supernovae and gamma ray bursts may well have punctuated the evolution of living creatures. Through the eyes of the Spitzer Space Telescope we have penetrated dense clouds of dusty molecular hydrogen to witness the birth of new stars and the potential cradles of planetary systems. The GALEX ultraviolet telescope allowed us to locate the massive hot stars that "live fast and die young" as they thermostatically control the interstellar gas and their own replacement in the cycle of life. This is not the stuff of fantasy novels or escapist movies, but fact far stranger than fiction. These discoveries, part of the exploration of the great "beyond" that is our Universe, form a lasting benefit from space science.

The same is true in our own solar system. Through our robotic probes we have seen the subtle and dramatic changes of planets over time. Recent missions to Mars indicate that it once had vast seas. Venus may have been temperate in its youth. The rocky debris left over from our planetary system's formation is still roaming our solar system, presenting a

small but calculable risk to life on Earth. Learning what the solar system is, and how it came to its present state, is unfinished business that NASA should aspire to complete.

The President's Commission identified three "Imperatives for Success" for the Vision for Space Exploration, namely sustainability, credibility and affordability. Science lies at the core of sustainability and credibility, and contributes substantially to affordability. Scientific research, stimulated to achieve understanding, provides a solid context for the motivation to sustain the push outward from Earth through the solar system and beyond. The specific achievements of these investigations show that these efforts are worth the cost. The rewards of scientific investigations are returned directly to the public as new information and improved understanding. What is more, the technical demands of exploration will demand advances in technology that are based on our deeper understanding of the physical world.

Science Inspires and Educates

Perhaps the ultimate measure of success for a science driven Vision for Space Exploration lies in the ability of the discoveries of today to inspire and instruct the next generation of explorers, and compounds its investment far beyond NASA's immediate returns. Inspiration works at many levels in our society. At a public and visible level, science discoveries captivate the general audience through the media, periodicals and popular magazines. Breathtaking new views from Hubble, Spitzer, Chandra, Cassini, and Huygens, the sight of comets plunging into Jupiter and the Sun, the progress of the Mars Rovers in charting new lands capture and convey the excitement that exploration brings. The consequences of this inspiration are difficult to measure, but they are real.

Scientific research also works at a more enduring level, through science, mathematics and technology education. Engaging students through the process of exploring to gain new knowledge enhances the technical competence of the nation and stimulates progress and innovation. Science breakthroughs have long inspired young people to pursue studies in all areas of science and technology. Nobody doubts that the economic interests of the nation rest squarely on the availability of an educated and technically literate workforce. These aspects are even more important now than in the past: competitiveness in the world economy depends on technological competency. A vigorous scientific program that is the key element in the implementation of the Vision for Space Exploration will inspire the youth of today and tomorrow to learn the language of mathematics and science to pursue careers that enrich our society.

Conclusion

We are poised to continue to make great discoveries by moving forward with a bold vision. Although we should plan carefully, we expect to be surprised as we pursue the scientific priorities worked out through broad community discussions. The strategy for exploration should be diverse and balanced, encompassing every aspect from Earth observation to cosmology. The quest to find life elsewhere and the desire to transport

human understanding to another planet are immense and extremely difficult undertakings. With scientific research as the underpinnings, the Vision for Space Exploration can be a success.

The science community is eager to participate in the implementation of the Vision for Space Exploration. We can define the research objectives that are aimed at breakthrough science that both benefits from and informs exploration, be it robotic or human. By motivating Exploration through scientific endeavors, the Vision for Space Exploration will achieve specific goals benefiting science and society. The astronomical community has had a fruitful collaboration with NASA in crafting the strategy for space science exploration. The Astronomical community embraces the opportunity by promoting broad community input and helping to set priorities as NASA seeks to implement the Vision for Space Exploration.