

A New Paradigm for Space Exploration

John H. Marburger, III
Science Advisor to the President and
Director, Office of Science and Technology Policy
Executive Office of the President

Neil Armstrong's first footsteps on the moon in 1969 inspired universal wonder and excitement. In that moment it seemed the unimaginable had become reality, and a course established for an enterprise in space in which anything was possible.

Today we know much more about the difficulties of space exploration by humans or machines, and our thinking about space has evolved with our growing awareness of its costs and hazards. Remarkably, those first footsteps continue to inspire. President Bush's remarks on the Columbia tragedy capture a widespread sentiment: "Mankind is led into the darkness beyond our world by the inspiration of discovery and the longing to understand. Our journey into space will go on."

Now the President has given shape to this quest through a plan for space exploration that is at once visionary and pragmatic. Described by the President as "a journey, not a race," this plan differs profoundly from the Apollo paradigm of a single massive project requiring a large budget spike and a demanding schedule. In this new vision, milestones are established to guide planning on a series of discrete and mutually reinforcing projects, whose aim at each step is to reduce the cost and risk of all subsequent missions.

A long history of imaginative space literature has blurred some basic facts that strongly constrain interplanetary exploration, and the President's vision takes these facts into account. Above all is the need to propel spacecraft with rockets, whose size must accommodate enormous amounts of fuel. To reach Earth's escape velocity entails a huge ratio of fuel to payload. The Mars rover Spirit was utterly dwarfed by the rocket mass at launch. Bringing Spirit home would have required sending along another great mass of fuel to escape Mars. If that fuel, or any other of the material needed for the mission, were shipped from outside Earth, the rocket size and hence cost would be dramatically less, but only if its source were also outside Earth. The closest source of mass outside Earth is the Moon, which explains its attractiveness as a base. The next closest source is Mars – 200 to 1,000 times farther away from Earth – so far that a round trip radio signal takes from 8 to 40 minutes, depending on planetary alignment.

Because Earth orbits nearly twice as fast as Mars, closest approaches are separated by two years, which more or less determines the duration of a single Mars mission. This can't be rushed because spacecraft drift through space on well defined "transfer orbits." Any method of speeding the journey would once again require large amounts of fuel, regardless of the means of propulsion. During the long flight, interplanetary craft are bombarded with cosmic radiation at hundreds of times the intensity on Earth, which makes the journey hazardous, even for robots. These are facts of life of deep space exploration, and they must be faced and overcome.

The President's new paradigm takes these facts seriously, balances robotic and human roles in dealing with them, and mandates a step-by-step approach to address the risks and costs within a

steady and realistic flow of resources. With respect to human exploration, it implies a fundamental change in ground rules. The idea is to "explore space and extend a human presence across our solar system... [making] steady progress – one mission, one voyage, one landing at a time." The emphasis is on sustained exploration and discovery through all appropriate means, at a pace we can afford in terms of risk as well as cost.

NASA's capabilities are compatible with this new paradigm. The International Space Station provides an important laboratory for understanding the effects of weightlessness, as well as opportunities for exploiting physical phenomena in the weightless environment. The President's first goal is to complete it, and that requires returning the shuttle fleet to service, which in turn entails effective responses to the recommendations of the Columbia Accident Investigation Board (CAIB). The President's 2010 deadline to complete the station and retire the shuttle fleet acknowledges the CAIB conclusion that the orbiters should not be used beyond that date without recertification.

The second Presidential goal ensures a means of human transport beyond low Earth orbit. The idea is not simply to repeat the Apollo exercises, but to ensure a human presence to establish and oversee what must eventually become complex operations at the lunar base, the third goal. This is not a question of 'colonization' but of enabling the development of serious and sophisticated infrastructure in a hostile environment in order to support subsequent exploration to Mars and elsewhere.

For more than thirty years, we have witnessed an astounding series of revelations about our space environment, in pursuit of which we developed new technologies with immense and unexpected benefits to society. We know there are fascinating places within our solar system that bear close and detailed scrutiny, and whose exploration will continue to enrich our lives. President Bush has provided a practical framework to bring these goals within our reach.