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Successes, Vision Prompt New Look at Solar System Exploration

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Four decades after the first spacecraft began leaving the Earth-Moon system to explore the solar system, the United States is re-examining its priorities for space exploration. This exercise is being driven by two significant developments: the wealth of data pouring in from a decade's worth of highly successful planetary exploration missions by the United States and Europe, and the new vision for NASA that was laid out by U.S. President George W. Bush in early 2004.

Bush's mandate was accompanied by a significant budget increase for NASA -- at least compared to the spending approved for other non-defense U.S. government agencies.

While the money and the mandate are in a state of near-rendezvous, the melding of space science objectives with human exploration goals is still a work in progress. Also uncertain are the prospects for international collaboration in these formative years of the development of a new exploration agenda.

Vision implementation

"The scientific exploration agenda NASA has been pursuing for the past decade or so is bearing enormous fruit, providing key early inputs to how NASA implements the vision," said James Garvin, NASA's chief scientist. "Initial robotic steps in the vision implementation will inform and guide future decisions that will ultimately steer how human beings explore the Moon and Mars," said Garvin, who works at the agency's headquarters in Washington.

Later this year, NASA will launch the Mars Reconnaissance Orbiter (MRO), a "scientific gateway step," Garvin noted, that will collect data at unprecedented spatial and spectral resolutions. The MRO, he said, will help NASA researchers optimize the approach they take to search for any evidence of life on the red planet.

"MRO adds a vital early dimension to our exploration strategy," Garvin said, "by also providing essential new data relevant to human precursors and even to human landing site possibilities. As such, MRO is a key part of the earliest parts of the vision."

Likewise, the role of the Lunar Reconnaissance Orbiter, which is scheduled to be launched in 2008, will open our eyes to the "new Moon," Garvin said. In addition to getting to know the Moon better in general, scientists need specific, high-quality data to guide very near-term decisions that will allow human beings to serve as effective explorers, Garvin said.

Garvin said an essential element of realizing the president's vision is "cross-prioritization" across various scientific disciplines to maintain diversity, balance and responsiveness to discoveries yet to come.

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"How we at NASA do in the next five years will be critical with the Mars Reconnaissance Orbiter and Lunar Reconnaissance Orbiter as two examples that can open our eyes to how we must explore in a new partnership with people and machines 'on site,'" Garvin said.

Wellspring of science

The complexion of space exploration is changing, said Stephen Mackwell, director of the Lunar and Planetary Institute in Houston. NASA is moving forward with a very aggressive robotic program, one that will provide a wellspring of science data to support future human explorers beyond low Earth orbit, he said.

Given Bush's direction to return humans to the Moon by 2020 and eventually send astronauts to Mars and other destinations, Mackwell senses there won't be any dilution of the science through this process.

Robotic precursor missions will be central to success of the subsequent wave of human explorers, Mackwell said. "Getting the most scientific return from those missions -- that's a huge issue," Mackwell said. For example, honing the ability for future explorers to live off the land -- using equipment that can convert local resources into water, oxygen and fuel supplies -- is essential.

The science that helps determine how best to identify and characterize those resources is vital, Mackwell added. "We're going to be winners on this for sure, scientifically."

As spacecraft reach various parts of the solar system, one issue that needs to be addressed is operational autonomy, researchers said. Such autonomy will be an essential tool that can be used to help reduce mission costs. The lengthy radio transmission times between Earth and distant explorers demands increased spacecraft autonomy.

"What we need to build in is some really efficient operations," said G. Jeffrey Taylor, a professor of geophysics and planetology at the University of Hawaii in Honolulu. A manned Mars mission, for instance, cannot have mission control in constant contact with the crew because of the radio transmission times, he said.

Techniques to handle local control situations for a human Mars expedition can first be practiced on the Moon, Taylor said.

A taste of Titan

Robert Pappalardo, a planetary scientist at the University of Colorado, Boulder, said what is sorely needed is a program for systematic exploration of the outer planets.

"Mars is half the story in our solar system," Pappalardo said.

Thanks to the European Space Agency's hugely successful Huygens lander -- Europe's contribution to NASA's Cassini mission to Saturn -- scientists now have a tantalizing glimpse of Titan, Saturn's largest and so far most intriguing moon. The Cassini mission is now flooding the space science community with new data, and that information flow is expected to continue for many years to come.

Similarly, Jupiter's icy satellite Europa cries out for exploration, Pappalardo said. That moon could well harbor an ice-covered ocean that many scientists suggest could be a home for life.

"In my view the outer planets are important because of the astrobiological potential," Pappalardo said. "Europa, Titan, maybe Neptune's Triton are active worlds that are also, potentially, habitats ... or [they] may at least tell us about the types of extreme environments that may exist beyond our own solar system."

Now being readied for launch in early 2006 is the New Horizons mission to faraway Pluto and its moon, Charon. Arrival time is 2015. From there, the probe is to visit the Kuiper Belt, a vast reservoir of icy objects located just outside of Neptune's orbit and extending outward into deeper space.

NASA and its international partners need to orchestrate a methodical march of robot explorers to the outer planets, Pappalardo said. The outer planets are the records of the building blocks of the solar system, he said.

Search for balance

In the meantime, a wealth of data is streaming in from a spacecraft located bit closer to home: a pair of Mars orbiters and the Spirit and Opportunity Mars rovers. These and other missions are the product of investments that were made over the past several years, said James Head, professor of geology at Brown University in Providence, R.I.

"It's very clear that automated exploration is coming into a completely new era," Head said. Robotic spacecraft are attacking fundamental scientific problems, as well as preparing the way for humans that will follow, he said.

"We really need to use a totally robust and productive automated program to lead the human exploration effort," Head said. He noted that today's environment is very different from that of the 1960s, when Cold War politics fueled a space race between the United States and the former Soviet Union that culminated with the Apollo astronaut landings on the Moon.

"If you are not doing something that is fundamental ... the taxpayer is not going to support human exploration just for footsteps, flags and footprints," Head said. "If we put all our eggs in the basket of saying we're going to explore because it's the human thing to do ... people aren't going to buy that."

Balance is important, Head said.

"It would be a complete tragedy if we ended up getting out of balance between human and automated exploration because there's so much fundamental science to be done," Head said.

International collaboration

There is another paramount issue facing the American space science and human exploration communities: The role of international collaboration.

"It's a much more competitive world," said Mackwell, who noted that a number of space exploration missions are being planned by India, Japan and China. In addition, Europe intends to build upon its experience with the Smart-1 mission to the Moon, the Mars Express mission and the Huygens Titan lander.

Mackwell suggested that far more collaboration between countries would be good for all.

"Potentially, international collaboration is going to be a huge component going into the future," Mackwell predicted. "There is kind of a friendly rivalry now. But at the same time, we gain a lot more by cooperating than we do by building on the rivalry."