

AD ASTRA

To The Stars

THE MAGAZINE OF THE NATIONAL SPACE SOCIETY

FEATURES

The Challenge of Mars

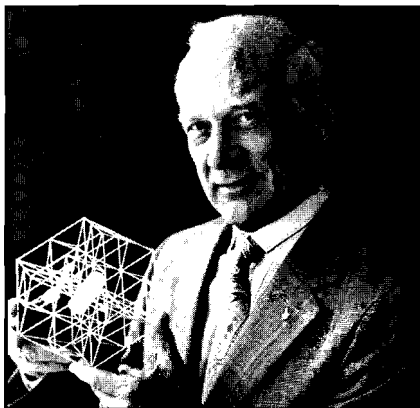
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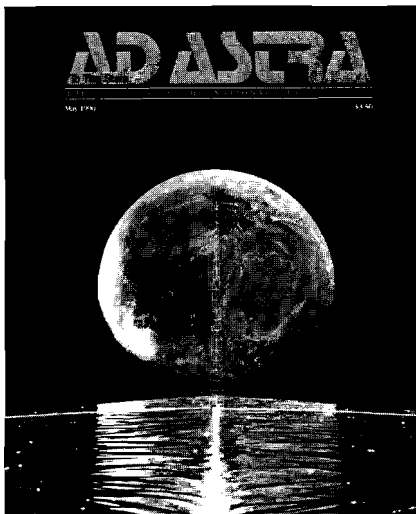
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On the cover: Reflections of the Red Planet on a cargo-carrying mylar solar sail are featured on this month's cover. Artwork: Carter Emmart, 1989.



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The greatest adventure of our time — the human exploration of Mars — will soon become the catalyst for a new course of human evolution in space. In addition to spectacular adventure, Mars offers humankind important new scientific knowledge, a compelling stimulus for technological growth, potentially great economic return, biological and cultural security and a profound opportunity for the evolution of civilization and consciousness into the cosmos.

The exploration and settlement of Mars should involve a coherent, well thought-out plan initially involving human operations on our lunar surface, which serve as a stepping stone to Mars. However, Mars must be the focal point of any space exploration initiative. Lunar outposts do not possess the broad public appeal of human settlements sprawled across the most spectacular piece of extraterrestrial real estate in the Solar System — Mars.

While the technical feasibility of human

The Challenge of Mars

The why of exploration is as important as the how.

by Bruce Cordell

missions to Mars is no longer seriously questioned, establishing a civilization on Mars remains a large, complicated endeavor. It will become the topic of intensive debate in political and policy-making decision circles.

The major challenges facing civilization may be grouped into four areas: 1) world peace, 2) global prosperity, 3) advances in science and technology, and 4) education, including the elevation of the human spirit. All four are interrelated in complex ways and represent global challenges that could be profoundly influenced by an ambitious, internationalized space program, particularly one with the human settlement of Mars as its centerpiece.

The aggressive expansion of humanity into the Solar System will require innovative and powerful forms of international management and cooperation resulting in new global relationships and increased understanding. Many space planners have recognized that large space endeavors can have extremely positive effects on the socio-political structure of society. One of NASA's advanced planners, Jesco Von Puttkamer, has remarked that "from such massive [space] undertakings, greater socio-political, cultural and philosophical unanimity and a new planetary consciousness are likely to arise." Astronomer Carl Sagan has also actively promoted the idea of joint Soviet-U.S. Mars missions as a means of cementing friendly international relations.

Unfortunately, historical evidence supporting

these assertions is not abundant. An earlier foray into joint Soviet-American space missions—Apollo/Soyuz in 1975—failed to produce hints of such positive developments. The project was far too small and did not require much Soviet-American cultural, financial or industrial intertwinement. Von Puttkamer suggests that the defense industry capacity of nations should be reoriented toward the utilization, development and management of technologies and resources required



Artwork: Mike Smith/General Dynamics

The next giant leap for humankind: the first footfalls on the Red Planet.

Large
agriculture
game supports
Mars settlers

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Solar System—
Mars

for the joint Soviet-American exploration of Mars. He concluded that large international space endeavors "may indeed provide the potential of helping to bring peace on Earth and to advance human development toward a more unanimous mankind."

Multinational human Mars exploration has received considerable support recently by Alan Willoughby of Cleveland's Analex Corp. He advocates a strategy that allows nations to share the excitement, prestige and costs of exploring Mars. Willoughby contends, as do others, that until we understand the Mars environment and its possible ecosystems, the most responsible place from which to study the planet is Phobos and/or Deimos, the moons of Mars. In Willoughby's scenario, major space powers would establish a space transportation and orbital infrastructure (i.e. the interplanetary highway system) enabling personnel and cargo transport to Mars orbit. Participating nations would then have the opportunity to sponsor any number of the several dozen (possibly hundreds of) robotic surface rovers needed to explore Mars in detail. Astronaut crews engaged in Mars telescience from Phobos or Deimos can be populated with individuals from even small nations, thus increasing national prestige by their participation.

Space could also become the strategic alternative to the nuclear arms race due to its potentially positive effects on military and economic strength and because of motivational impact. Ray Leonard, a space consultant with Ad Astra, Ltd. in Santa Fe, New Mexico, suggests that the need for global economic competitiveness will eventually force the world's major military powers to allocate more of their resources into non-military pursuits. The technology requirements of space could create an arena of productive international projects. Leonard suggests an infrastructure-centered approach involving international space stations, solar power satellites and facilities for anti-matter propulsion research.

Not everyone is convinced the road to peace on Earth involves a Soviet-U.S. "detour" to Mars. Space policy analyst John Logsdon argues that those who

Artwork: Mike Smith/General Dynamics

associate increased cooperation in space with improvements in superpower political and military relationships are ignoring historical precedents: "whether a dramatic, expressive, long-term undertaking like U.S.-Soviet cooperation in human exploration of Mars could transcend functional limits and influence the basic superpower relationship is an interesting speculation, but one that should be assessed with a high degree of skepticism," Logsdon argues.

Nevertheless, observers of the international space scene continue to postulate that major international partnerships in large human space programs have many intrinsic potential benefits, including better international understanding and an increased chance for peace. In the words of President Lyndon Johnson, "Men who have worked together to reach the stars are not likely to descend together into the depths of war." The recent extraordinary events in Eastern Europe and the Soviet Union suggest that the time may be ripe for major international cooperation in space. If properly structured and managed, cost-sharing might significantly reduce the total per nation price tag of the Mars endeavor.

Global prosperity will require that less developed nations not actively participating in space exploration be included in future programs. While this has already been occurring to some degree with communications satellites, poorer nations should be invited to share in the new knowledge, adventure and tangible economic assets that space will provide.

NASA Administrator Richard Truly recently reiterated that for every dollar invested in the Apollo lunar program, \$7-8 were returned in new technologies, products and other benefits to the economy. The future promises even greater prosperity from investment into technology development for a human Mars mission.

For example, recent studies have considered robotic shipments of enormous amounts of propellants to Earth orbit retrieved from the moons of Mars. These studies indicate that highly leveraged technologies and efficient space operations can result in delivery of propellants from Mars' system to low Earth orbit (LEO) at large savings (or profits if the operation is commercialized) relative to Earth-based sources. This would facilitate Earth-vicinity space operations and open up the Solar System to human exploration.

conservative late 20th century levels forever) it can be seen that the rate of human population growth of Mars in the 21st century closely approximates that experienced by colonial America in the 17th century.

What this means is that the distance to Mars and the transportation challenge that it implies is not a major obstacle to the creation of a human civilization on the Red Planet. Rather, the key questions become those of resource utilization, growing food, building housing and manufacturing all sorts of useful goods on the surface of Mars.

Can we do it? I think so. Unlike the Moon, Mars is rich in carbon, nitrogen and hydrogen—the key elements needed to support life. Bring a few packets of seeds, several breeding pairs of rabbits and goats and some inflatable greenhouses to Mars and a self-expanding agriculture can be established. Plastics, metals, glasses, brick and concrete can all be manufactured out of native materials and used to construct large-scale greenhouses, habitat complexes and even environmentally protected towns. Liquid fuels can be synthesized to propel high-powered ground vehicles and construction equipment. The required expanding electric power grid can be provided by importing a 850 kilowatt nuclear reactor every four years to start. Larger multi-megawatt units can be flown to Mars later in the colonization program.

One hundred years after the commencement of this effort the population of Mars will reach 80,000 people, by 200 years it will exceed one million and a sufficient industrial base will have been established for serious terraforming operations to commence. In 500 years, a span equal to that which separates the present age from that of Columbus, a civilization of more than one billion people will live on a new Mars, a world not discovered, but created by the courage and enterprise of the human spirit. ☆

Robert Zubrin is a senior aerospace engineer at Martin Marietta Astronautics. He will speak about Mars colonization and magnetic sailing at the 9th Annual Space Development Conference in Anaheim, Calif. May 25-28.

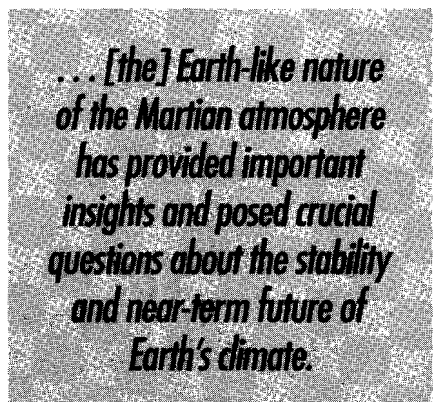
Also, the fact that the Moon is rich in helium-3 relative to Earth has sparked schemes to process and utilize this lunar energy source in commercial fusion power operations on Earth with potentially large profits relative to current energy production techniques.

Profitable commercial space opportunities and important synergisms between Mars facilities, lunar outposts and Earth-vicinity operations should provide significant additions to the tangible economic returns from space that already benefit all the nations of Earth. As in the case of Apollo, technologies developed in support of human Mars missions should trigger numerous spinoffs and spark opportunities for financial gain. Importantly, international legal mechanisms are being formulated to ensure equitable access to anticipated profits from space.

Research required for long-duration human Mars missions is increasing our knowledge and understanding of human beings in several areas. Studies of human response to microgravity and radiation effects on the body are providing important insights to how the body responds to the stress of space travel and ultimately will improve our knowledge of human pathologies and the aging process (the need for healthy astronauts on long Mars missions will drive research to improve predictability of health in individuals over one or more years). The requirement for small groups of Mars-bound astronauts to survive for years in isolation and confinement that is unprecedented in human experience is stimulating research into areas involving the stability and health of everyday interpersonal interactions. The need for extremely reliable long-lived crew systems is stimulating groups within and outside NASA to further understand interactions between humans and our biosphere. These critical and fundamental scientific, medical and social challenges are already faced by our Earth-based civilization today.

Research into energy technologies, environmental science and comparative planetology is being prompted by our increasing interest in Mars exploration. The need for large, reliable sources of electric power at outposts on Mars and the Moon and in space and the possible use of nuclear systems for electricity and rocket propulsion will drive technology in these critical areas.

In the realm of planetary environments, the simpler, but Earth-like, nature of the Martian atmosphere has provided important insights and posed crucial questions about the stability and near-term future of Earth's climate. Studies of the dynamics of global Martian duststorms (including active weather modification experiments on Mars) will inevitably increase our ability to influence large, dangerous weather systems on Earth (e.g. hurricanes). Martian geology investigations will enhance our understanding of planets like Earth. And the ultimate question—the origin and nature of life—should be profoundly illuminated by future human explorations of the dry lakes and the polar dust/ice layers on Mars.



... [the] Earth-like nature of the Martian atmosphere has provided important insights and posed crucial questions about the stability and near-term future of Earth's climate.

No doubt, a further influence of adding a human touch to Mars is the affect on our planet's young people and, larger still, on the human spirit. Education and an elevated level of human consciousness are essential to survival and prosperity because they provide a larger, more human perspective into which historical events may be placed. Education should involve not merely the acquisition of skills, but an increase in perspective and the bolstering of the human spirit.

Large space programs and increased educational opportunities are historically linked. In the years following President Kennedy's 1961 announcement of the U.S. intention to go to the Moon, more technical Ph.D. degrees were awarded per year than any time before or since. During this time not only were more dollars available for educational pursuits, but students were highly motivated to continue their studies by an exciting American space program. A similar commitment by President Bush to a human Mars trip would stimulate education and provide a platform from

which he can validate his stated desire to be the "education president."

On a more humanistic level, human space adventurism serves as the latest form of exploration, a process some anthropologists consider fundamental to human nature. For tens of thousands of years, through our unique ability to develop technologies, we have transformed new, challenging environments into comfortable, new homes for humankind. Our profound need to experience adventure and exploration in space can serve as a motivational beacon for students disillusioned with the educational system.

The human exploration imperative and its effects on the human spirit are apparently manifested on the national, as well as personal, levels. Cataloging numerous factors affecting the advance and decline of great

logical context, University of Hawaii sociologist Ben Finney and Los Alamos astrophysicist Eric Jones speculate that through space exploration—and ultimately the colonization of increasingly distant extraterrestrial sites—a new, highly advanced species of homo sapiens will appear when our spacefaring cousins "experience that prerequisite for rapid evolution our ancestors once knew: isolation in small and distantly separated communities."

Frank White, author of *The Overview Effect*, notes that the psychological and spiritual development of many astronauts has been accelerated by their explorations of space. Seeing the Earth from orbit is a holistic experience that results in heightened awareness in which the "one-ness" of Earth's ecosystem and the unimportance of political boundaries is profoundly apparent—the "Overview Effect."

White claims that beyond the Overview Effect is the Universal Insight (experienced usually by lunar astronauts), involving a realization of Earth's smallness, a sense of the unity of the universe and an "understanding that our ultimate destiny is to become citizens of the universe." He sees the evolution of humanity into space as a moral imperative resulting in, initially, a maternal view of Earth. If we accept White's definition of spiritual development: greater personal identification with broader groups or systems (ultimately with the entire universe), then increased levels of consciousness and accelerated psychological and spiritual development on a global scale are a direct result of greater awareness of the universe and humanity's place in it—important payoffs in human space exploration. The Overview Effect may point to humankind's purpose as a species.

The prospect of the evolution of civilization into the cosmos offers humankind a superb opportunity to achieve continuance, expansion, prosperity and wisdom. Never have we needed these things more. We should aggressively pursue the human exploration and settlement of Mars. ☆

Bruce Cordell is manager of the Lunar/Mars Advanced Studies program at General Dynamics, Space Systems Division in San Diego, California. He speaks and writes frequently for popular and technical audiences on his favorite topic—the human exploration of the Moon and Mars.

Phobos
prospector
assays surface of
the Mars moon



Artwork: Paul Dimare

civilizations throughout the past, historian Arnold Toynbee identified the critical factor as national response to challenge. Based on this analysis, former NASA Administrator Thomas Paine asserts that "When a purposefully developed technology base opens access to vast new territories, the exploration imperative drives statesmen of vision and decisive leadership to sponsor bold voyages of discovery—or suffer national decline . . . America's future surely will be determined by our response to the challenge of space."

Expansion into space, increased perspectives and humanity's ultimate destiny, may be intimately related. Ray Leonard states that "governments need to realize that behind the din of mobs shouting for . . . handouts, are men and women who, if they but had the tools and ships, would go out into the silvery sea of stars and cast their nets of science and technology to catch the resources of the galaxy to feed those who remain at home."

Expressed in a more transcendental style, NASA's Jesco Von Puttkamer believes that large space projects can stimulate the reintegration of "culture and technology, body and soul, matter and spirit, knowledge and reason, science and religion for continued evolutionary development in unbounded growth." In a bio-

the years
following
President
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