
James A. Van Allen

On the Future of Space Science and Applications



"Maybe it is a closed universe."

My views on the future of space science and applications are based on some forty-six years of active participation in the field of space science, continuing at the present time. As you will see, they differ markedly from those of our current president and his immediate predecessor in the White House.

Recently I have read David DeVorkin's book entitled *Race to the Stratosphere: Manned Scientific Ballooning in America*. The author's point of departure is the 1931 balloon flight of the Belgian aeronaut Auguste Piccard to an altitude of nearly sixteen kilometers. This flight generated widespread public interest in Europe and elsewhere and was hailed as opening up a vast frontier of human adventure and exploration. The sheer romance and public visibility of high-altitude ballooning were Piccard's central motivations. But he felt it necessary to exalt his aspirations by wrapping them in the cloak of scientific objectives.

However, his own attempts to achieve such objectives were feeble and inconclusive, being severely compromised by his necessary preoccupation with his life-support system and the mechanics of the flight.

Manned ballooning to high altitudes enjoyed a brief revival in America after World War II. But it became overwhelmingly evident that automated equipment on

unmanned balloons provides a greatly superior technique for scientific measurements within the atmosphere. At the present time, scores of unmanned balloon flights are made each year for scientific and practical purposes, but manned ballooning survives only as an adventurous sport practiced at relatively low altitudes.

Most of the modern history of scientific ballooning falls within my direct personal knowledge, as does the entire history of space flight. On many occasions I have compared the two histories. The theme of historical parallelism is developed by DeVorkin in a richly detailed and persuasive way.

With the benefit of more than three decades of our collective experience in space flight, it is now clear that (a) the conduct of scientific and applicational missions in space by human crews is of very limited value and that (b) justification for future manned space missions must rest on other considerations—those of a general cultural nature such as inspiration, high adventure under exotic and perilous circumstances, human record-setting, and the like. It would be refreshing to hear a prominent political leader make such statements, assess the motives for manned space missions in the context of their significance and cost, and not obfuscate the issue with false analogies and unsupported claims.

The post-World War II epoch was characterized in the United States by intense Cold War rivalry with the Soviet Union and by a notably optimistic and expansionistic public mood. But as of 1992, following the collapse of the Soviet Union, our citizenry is much more preoccupied with societal, financial, and environmental distress and with political strife on the international scene. Hence, I consider it futile to attempt to replay the Apollo paradigm during the 1990s. Rather, we should restructure our plans to match our extensive experience and the political realities of the current epoch.

Any attempt to visualize the future of the U.S. space program must consider the relative roles of manned and unmanned spacecraft. The route of easy virtue is to declare in favor of a "balanced" program. But such a simple declaration is, of course, meaningless. It becomes

meaningful and discussable only if one specifies a quantitative ratio of the respective efforts and explains the rational basis for such a ratio. Otherwise, advocacy of a balanced program is what my father would have called a platitudinous pomposity.

The issue of balance is a fundamental one. It will not go away; it cannot be waved aside. It is a chronically acute one. I will now offer my own assessment of this issue.

Space Science. A proper description of the scientific advances that have been achieved by space techniques is far too voluminous for a short article. Many basic geophysical and astronomical discoveries are made each year, and the total volume of original work is truly staggering. Let me list a few examples.

Knowledge of the composition, structure, and dynamics of the Earth's atmosphere, ionosphere, and magnetosphere has been greatly expanded and clarified. Corresponding, but less comprehensive, studies of seven other planets of the solar system have been conducted on deep-space missions. The results of these planetary studies have intrinsic interest and add depth to our attempts to better understand the Earth system.

The full electromagnetic spectrum of solar emissions, from gamma rays to radio waves, has been observed, as have the sporadic solar emission of energetic particles and solar influences on the intensity and composition of cosmic rays out to great distances from the Sun. A much-improved understanding of the dynamics of the alternately quiescent and disturbed Sun and the consequences on the Earth has been achieved.

Knowledge of distant astronomical objects, the interstellar medium, and the origin of the universe has been extended greatly by space-based observations in the gamma-ray, x-ray, ultraviolet, infrared, and radio segments of the electromagnetic spectrum and by improved angular resolution. This work is continuing at an accelerated pace.

Oceanography, geodesy, and geology have also profited importantly by space-based techniques. Such advances together with those in atmospheric science undergird long-term forecasts of the future of the Earth as a habitat for life.

In the realm of biological science, the most significant findings have come from the Viking landers on Mars. Their remote-controlled assays of surface samples revealed an essentially complete absence of any biological material. These findings do not conclusively preclude the presence of biological material elsewhere on Mars or on some other nonterrestrial body in the solar system but do make such a possibility much less likely.

Nearly all of the great advances in space science have been achieved by unmanned automated spacecraft, controlled and monitored by teams of scientists and engineers from the comfort of resourceful terrestrial laboratories.

The recent National Academy of Sciences seven-volume report, *Space Science in the Twenty First Century—Imperatives for the Decade 1995–2015*, summarizes the rich agenda of our aspirations for the near future. Aside from studies of human physiology and psychology under prolonged free-fall (or weightless) conditions, very little need for manned space vehicles emerged.

Space science throughout the world is supported almost entirely by governments, i.e., by tax-paying citizens. A tough-minded politician is therefore entitled to question the appropriateness of any proposed level of effort.

One form of answer, of course, is to cite the long history of pure science in laying the foundations for innumerable technical developments and their contributions to human welfare and, further, to cite specific examples.

Also, I have no difficulty in defending the intellectual quality of astronomical science, for example. But I would not like what I might see in a mirror were I to claim or imply that knowledge of the magnetic moment of Saturn is of any immediate practical importance. Nor do I attempt to do so. In such matters, I think that our best move is to fall back on the general public perception of "worthwhileness." Worthwhileness is a collective judgment representing a kind of equilibrium between advocates and skeptics. So it is with space science.

It is well known that scientists have a virtually unlimited capacity for planning new programs. The challenges of space research are noteworthy for spawning expansive thinking. I have often remarked that I can think of a one-billion-dollar space project before breakfast any day of the week or of a two-billion-dollar project before breakfast on Sunday. This is easy to do. Yet we must not delude ourselves by what has been called a triumph of hope over experience in formulating our programs.

Space Applications. "Space applications" is a short term for the use of space-flight technology to provide direct human benefits of a utilitarian nature. Such applications are sometimes called "spin-offs." But I personally deplore the use of this latter term, which implies that they are incidental and without conscious intent. On the contrary, space applications are the result of purposeful and highly competent effort directed toward clear needs.

In some cases, they are derived from fresh knowledge gained by space scientists, but more often they have a much broader scientific and technological base. Some have commercial potential; others lie primarily in the realm of governmental services.

The most prominent of space applications is the use of satellite relays for rapid domestic and international telecommunications. This is the only application of space technology that has achieved true commercial status in the nongovernmental marketplace. Communication satellites serve an immense variety of civilian and military purposes and are a pervasive element of modern civilization. Their use continues to grow, but they now have formidable competition in high-traffic point-to-point communication by way of optical-fiber cables, especially transoceanic ones.

Another prominent space application is represented by satellites for the continuous monitoring of the Earth's weather on a global basis and for monitoring solar emissions. Special applications of meteorological satellites in surveying the ozone content of the upper atmosphere and the distribution of other minor but important components of the atmosphere are of increasing importance in assessing both natural and anthropogenic fluctuations and trends. (CONTINUED ON PAGE 44)

(CONTINUED FROM PAGE 41) A further major application of remote sensing from space is typified by Landsat and Spot satellites for the sophisticated, multi-spectral survey of the surface and near-surface features of the Earth and its oceans on a global basis. Again, such satellites have both civilian and military purposes. There is significant commercial potential for their observations, but most continue to fall into the broad area of governmental services, and there is no reasonable expectation that this situation will change markedly in the near future.

Networks of satellites provide the basis for navigation on land, at sea, and in the air with unprecedented accuracy, and they also have important applications to geodesy and geology.

My roster of examples of space applications is, of course, incomplete, but it does illustrate modern developments. It is a matter of regret that their importance in everyday life is so little appreciated by the general public, including the news media, industry, and commerce, which, ironically, are increasingly dependent on them in their daily operations.

All important applications of space technology utilize unmanned, commandable spacecraft, most of which have useful lifetimes of many years. There is little or no justification for claiming that human crews in space have had or will have importance in the field of space applications.

Concerning the Space Flight of Human Crews. I now turn to some remarks on the future role of human crews in space from the perspective of our collective experience over the past three decades.

In common with millions of others, I shared in the vicarious thrill of the first Apollo landing on the Moon, on 20 July 1969, now nearly twenty-three years ago.

Significant scientific results were obtained by the Apollo and Skylab programs, but at no time has manned flight been truly essential to any important scientific or utilitarian purpose despite the fact that, in the United States, it has consumed more than two-thirds of the resources of our civilian space program.

It can be and has been argued that the United States can afford expenditures of such magnitude purely for lofty cultural goals and high adventure. But in the face of our massive societal distress, I judge that typical taxpayers and their representatives in the Congress do not have a manned mission to Mars among their national priorities. Worse yet, presidential rhetoric emphasizing such remote possibilities does a great disservice to the many worthy, much less costly, and readily achievable scientific and utilitarian objectives of a thoughtful program of space exploration with unmanned spacecraft. The latter objectives, as mentioned earlier, include environmental monitoring of the Earth on a global basis and important contributions to assuring the health and welfare of future generations of its human inhabitants. **NE**

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