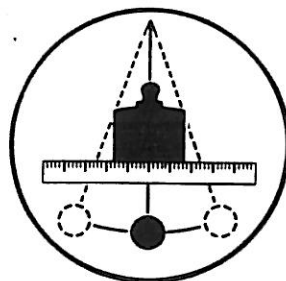


# **SOCIETAL ISSUES**

## **SCIENTIFIC VIEWPOINTS**

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# MYTHS AND REALITIES OF SPACE FLIGHT

James A. Van Allen

## Introduction

Among the many distressing and ironic aspects of the explosion-during-launch of the space shuttle *Challenger* on 28 January 1986, with its tragic loss of life, is that the principal purpose of its mission was the orbital delivery of a communications satellite. This function has been performed successfully and much less expensively for many years by unmanned launch vehicles, with minimal risk to human life.

Now, our national space program in disarray as a result of the disaster, would seem an appropriate juncture at which to rethink its basic structure in terms of the myths and realities that are associated with space flight.

## The Mythology of Space Flight

In AD 160, long before the time of Isaac Newton, the Greek satirist Lucian of Samosata wrote an account of Ulysses' ship being caught up in a whirlwind and carried on a seven-day flight to the moon. In the early seventeenth century, the great early astronomer Johannes Kepler translated the work from Greek into Latin in order to make it more widely available, and soon thereafter Kepler himself wrote a fantasy of space flight called *Somnium* (The Dream). In a letter to a friend, he wrote:

If in the end we be driven from the Earth, my book will serve as a useful guide for the emigrants and pilgrims who will be settling on the moon....<sup>1</sup>

But Kepler was careful to make clear the speculative nature of his "dream."

Since 1629, the date of Kepler's letter, many other authors have written fictional accounts of voyages from the Earth to the moon and of visits to the Earth by extraterrestrial creatures from the star Sirius and the planet Mars. Jules Verne and H. G. Wells are among the best known.

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Also, in the early 1950s, Colliers published a series of illustrated articles by rocket engineer Wernher von Braun, astronomer Fred L. Whipple, and others. These works depict huge space stations with the amenities of small towns carrying large numbers of people into orbit around the Earth. They also describe permanent, manned bases on the moon and on Mars. The authors were thoroughly familiar with physical principles, of course, and they meticulously avoided violating them. The conjectural element lay in the scale of their plans and the magnitude of the effort required to accomplish them.

Fictional space flight is now a booming component of the entertainment industry, and although, for the most part, no attention whatever is being given to either principles or practicality, the mythology of space has become a significant element of our culture.

Also closely akin to science fiction, and a prominent part of the 1986 scene, are a large number of futuristic proposals for space flight. I mention only a few by short title: solar power satellites; manufacturing in space; manned space stations in Earth orbit, on the moon, and on Mars; man's permanent presence in space (a misty-eyed concept whose rationale has never been described); manned scientific and military installations on the moon; and the mining of asteroids.

It is difficult to distinguish the proposals of prophets from those of charlatans, and I am not so foolish as to suggest that such undertakings are out-of-the-question at some remote future time, but none of them can withstand critical scrutiny in the context of the present century. Ill-considered and untimely advocacy of them, especially by prominent national figures, does the entire space effort a disservice.

In science fiction, space flight means manned space flight—that is, the flight of humans or other living creatures having at least some human characteristics. The same applies to the popular perceptions of what real space flight is mostly about.

## The Realities of Space

The many space enthusiasts who have gained such perceptions as those described above blithely ignore the fact that almost all of the truly important utilitarian and scientific achievements of our space program have been made by instrumented unmanned spacecraft controlled remotely from the Earth by radio command. Our great system of rapid, world-wide communications by means of satellite

relays in orbit around the Earth is only one of many such achievements. Others are in weather forecasting; remote sensing of the Earth's surface resources; marine and aircraft navigation; the science of the sun and of the Earth's ionosphere, magnetosphere, atmosphere, and oceans; and military reconnaissance and surveillance and technically similar applications for civil purposes.

In the realm of fundamental science, space techniques have given rise to spectacular advances in astronomy and in our efforts to gain detailed knowledge of the sun and the other elements of the solar system. And there is no end in sight.

I have selected for exemplary, but brief, consideration one of the many aspects of space exploration—planetary and solar system investigation—as a celebration of durable human achievement.

The first successful flight to another planet was made by Mariner II, whose flyby of Venus occurred on 14 December 1962. From Mariner II we learned that Venus is an unmagnetized planet; we measured its temperature and certain of its atmospheric characteristics. We also determined comprehensively, for the first time, the properties of the interplanetary medium, or solar wind, and observed many sporadic emissions of energetic solar particles.

Also, as of this date, the United States and the Soviet Union have carried out massive and sophisticated programs of close-up investigations of Mercury, Venus, Mars, Jupiter, Saturn, and Uranus and scrutinized many satellites of the last four named planets and the rings of the latter three.

The Pioneer Venus Orbiter continues its very fruitful investigation of Venus, begun in 1978, and, following their first *in situ* explorations of the Jupiter and Saturn systems, Pioneers 10 and 11 are exploring the outer reaches of the solar system. These spacecraft have been in flight for more than fourteen and thirteen years, respectively, and continue to provide new and exciting data. Currently, Pioneer 10 is more than five and one-half billion kilometers from the sun, far beyond the outermost known planet of the solar system. It is still transmitting data by radio on a daily basis—surely it is one of man's greatest technical and scientific achievements.

Pioneers 10 and 11 and Voyagers 1 and 2 will continue their missions until, eventually, they escape from the solar system, but first (in 1989) Voyager 2 will encounter Neptune.

During the past two decades, lunar and planetary investigations by the United States and the Soviet Union have included close flyby, orbiter, and both hard- and soft-lander missions. Both our Apollo spacecraft and the Soviet Union's unmanned, commandable spacecraft have brought samples of lunar surface material back to earth for laboratory study.

We have greatly increased our detailed knowledge of the origin and evolution of our solar system and of its physical and chemical workings. While a full account of these findings is far too voluminous for this brief account, I think it fair to claim that the past twenty-four years of solar system investigation have constituted one of the most important epochs of human history. Each planet and each satellite is a new world of marvelous and distinctive prop-

erties and phenomena. Each is worthy of much more detailed scientific study.

Within a broad humanistic context, the most important products of this work, as with the entire field of astronomy, are of a general intellectual nature—namely, the enhancement of our understanding of mankind's place in the universe.

Here I quote William Fowler, one of the two 1983 Nobel laureates in physics, concerning his studies of the sources of the sun's energy output on which all life depends:

What we're doing is mainly a cultural and intellectual contribution to the sum total of human knowledge and that's why we do it. If there turn out to be potential applications, that's fine and dandy, but we think that it's important for the human race to know where sunlight comes from.<sup>2</sup>

Among other aspects of the body of evidence we have found is the realization that the Earth harbors the only living organisms within the solar system. This finding is not yet wholly conclusive, but there is progressively less basis for doubting it.

A complementary realization is that the ecology of the Earth is a fragile one and that the Earth, too, may become unsuitable for human habitation at some future time because of a combination of natural and man-made causes. Such a possibility is illuminated by studies of Venus, often called the Earth's sister planet because of its similar size, mass, and distance from the sun. The surface of Venus is hotter than the melting temperature of lead, and its dense atmosphere consists of carbon dioxide, nitrogen, carbon monoxide, sulfuric acid, and other gases deadly to any known form of life.

I am not forecasting the near-term extinction of life on Earth, but I am noting that comparative studies of the planets by remotely controlled spacecraft are already providing guidance for the wise conduct of human activities. Yet, in the summer of 1981 and in the face of all of the great successes and future promise of solar system exploration, the federal government decided, in effect, to terminate the entire enterprise by eliminating support for existing solar system missions, cancelling missions already in an advanced stage of development, indefinitely postponing all prospective missions, and deferring the orderly planning of future missions.

Among the most prominent targets on NASA's hit list was the U.S. member of the two-spacecraft international program for investigating, for the first time, the polar regions of the sun and the interplanetary medium at high solar latitudes. Another was the U.S. plan to fly an instrumented spacecraft past comet Halley in March 1986 and subsequently rendezvous with and fly alongside comet Tempel II. But there were dozens of other cancellations and massive delays in well-founded scientific and applicational programs, from which recovery has been difficult and protracted.

The prospective U.S. termination of support for solar system exploration, scientific investigation, and advanced applications of space technology was greeted with shocked

disbelief by the scientific community of our own and other countries. In most walks of life it is axiomatic that success breeds success, but the federal government appears to regard the success of an undertaking as cause for its premature termination and failure as a cause for its expansion—this in the context of the current national debate on intensified efforts in manned flight. Meanwhile, the Soviet Union, the European Space Agency, Japan, and other individual countries are proceeding with high integrity of purpose.

The obvious villain in these distressing developments is our overriding national commitment to the development of the manned Space Transportation System, of which the shuttle is visualized as only the first step. I reach this conclusion reluctantly because of my high professional regard for the individuals who are engaged in this difficult technical undertaking. Nonetheless, I believe many of my colleagues concur.

In fairness, I will mention the other main elements of our national predicament.

In the euphoria of the post-Apollo epoch, national planning for space activities assumed that there would be a progressively increasing level of support such that the continuation of vigorous programs of manned flight and of advanced scientific and applicational missions would be possible. I am among those who believe that the United States can afford such a threefold undertaking, with properly balanced emphasis on its three basic components. But given the prevailing economic and political climate of the United States, the 1972 assumption of progressive, real growth in our space activities is unrealistic.

Furthermore, scientific and applicational missions have, under the same false assumption, been made progressively more sophisticated and much more expensive. The most conspicuous current examples are the Space Telescope and the Galileo mission to Jupiter, both of which are missions of great scientific promise, but they are only part of the total picture.

The combination of all these factors has led to our present distressed state.

I come now to the question that is facing a large segment of the scientific community.

Do planetary and solar system exploration, astronomical research, and other fields of space science and space applications have a future in the United States?

I continue to hope so, but it will not be easy to regain our momentum. To be sure, recent developments have been mildly encouraging. Continuing support for the ongoing missions of the Pioneer Venus Orbiter, Pioneer 10, Pioneer 11, Voyager 1, and Voyager 2 is promised, though at an austere level. The planned, but much delayed, Galileo probe-orbiter mission to Jupiter is still alive and now scheduled, with perhaps unjustified optimism, for a mid-1987 launch, using the shuttle as the first stage and the wide-body Centaur as the high-speed upper stage of the launching system. The existing ISEE-3 spacecraft was maneuvered in flight so that it flew through the coma of comet Giacobini-Zinner in September 1985. This mission was a considerable retreat from our earlier plan to fly through comet Halley and rendezvous with comet Tempel II, but it was nonetheless a worthy mission to a new type of

astronomical object. Detailed work on a scaled down version of the long planned, and then cancelled, Venus Orbiting Imaging Radar spacecraft (now called Magellan) is under way. Preliminary work on a new Mars mission has been authorized, and planning for other scientific missions is being encouraged. Support for the reduction, analysis, and interpretation of existing space data is being maintained somewhat above the disaster level that was in prospect several years ago. Meanwhile the Space Science Board of the National Academy of Sciences and other advisory groups are making a heroic effort to devise missions that are both scientifically significant and relatively low in cost. These include advanced missions to Mars, Saturn, and the moon and to comets and asteroids.

Despite these favorable developments, however, many of us are uneasy about the President's belated endorsement of space exploration because its central emphasis is on the development of a system of permanently manned space stations during the next decade. Such an undertaking may be justified politically, but it is otherwise poorly founded and excessively futuristic. Meanwhile, I expect that many of the much more worthy undertakings in space will languish for lack of support. Hence, the broad predicament of space science and space applications remains and may, in fact, be worsened during the coming years if the space station program is pursued as directed by the President two years ago.

## Conclusion

My own view is that this predicament is the result of the clash between the mythology of manned space flight and the real achievements of space technology in practical applications to human welfare and the expansion of human knowledge.

Fervent advocates of the view that it is mankind's manifest destiny to populate space inflict a plethora of false analogies on anyone who contests this belief. At the mere mention of Christopher Columbus' name, they expect the opposition to wither and slink away. I find it possible to resist such an expectation. An off-hand, thoughtless reference to Columbus is merely incompetent, but one made with full knowledge of the facts is deceitful and fraudulent. Let me explain. Our instrumented spacecraft have now ranged over the entire solar system. As an example, the surface of Mars has been studied comprehensively by a succession of U.S. and Soviet spacecraft, most notably the two Viking orbiter and soft-lander missions. If a similar survey of America had been available in the late fifteenth century, the mission of Columbus' fleet to the West Indies would have been unequivocally desirable. But the application of the Columbus analogy to support advocacy of a manned mission to Mars is massively deceitful. Mars is not *terra incognita*. We have already explored it and found it to be far more desolate and sterile than the heart of the Sahara desert. Many matters of deep scientific interest about Mars remain, of course, but these matters can be addressed systematically, safely, and relatively inexpensively by automated, commandable spacecraft, surface rovers, and sample return-to-Earth missions.

It is difficult to avoid mentioning the poignant juxta-

position of the *Challenger* disaster and the brilliantly successful encounter of the scientific spacecraft Voyager 2 with the planet Uranus during the same week of late January. Voyager 2 was launched by a Titan Centaur on 20 August 1977 and proceeded outward to extremely fruitful flybys of Jupiter (July 1979) and Saturn (August 1981). Its close encounter with Uranus yielded the discovery of its magnetic field and radiation belts (previously totally unknown) and marked advances in knowledge of its atmosphere and its extensive system of satellites and rings. During the close encounter, fresh discoveries were pouring out of the investigators' workrooms at a dizzying pace. Anyone who thinks unmanned spacecraft are dull or void of intensive human participation should have been present, as I was, at the Jet Propulsion Laboratory in late January.

To appreciate these achievements, one should note that Uranus, despite having a diameter four times the Earth's, is invisible to the unaided eye of a terrestrial observer and was therefore unknown to early astronomers. It was discovered by Sir William Herschel with a small telescope in 1781, though he thought initially that it was a comet. At the time of the Voyager 2 encounter, Uranus was about three billion kilometers from the Earth. During the flight history of Voyager 2, some hundreds of thousands of well-considered radio commands have been sent to the spacecraft. These commands have been acknowledged and executed by the spacecraft's systems. Preprogrammed commands were placed in the on-board memory before and during the Uranus encounter.

As I have indicated, I am quite unable to support the declaration that the manifest destiny of mankind is to live and work in space. Nonetheless, I join many others in admiration for the men and women who willingly risk their lives in space, and I am thrilled by scenes of their floating around inside a spacecraft or in protective suits outside. I get the same type of thrill from watching quarterback Joe Theismann of the Washington Redskins make a successful forward pass under very adverse and threatening circumstances. But I do not think the federal government has the obligation to provide that type of entertainment at a cost of \$200 million per shuttle flight. I agree that human resourcefulness, judgment, and flexibility are of great value in guiding a taxicab through New York City traffic, but in space exploration, these qualities are much more effectively exercised by personnel in monitoring and command stations on the Earth. Indeed, with only minor further development, space shuttle missions can be "flown" from the Earth with no human occupants in the spacecraft.

I conclude by proposing the following measures for the optimal exploitation of the great potential of space during the years immediately ahead.

- Suspend manned flights indefinitely, pending clear justification for their resumption.
- Postpone development of the space station.
- Resume the production of previously well-developed expendable launch vehicles: Scout, Delta, Atlas, Centaur, and Titan.

- Upgrade their performances progressively.

- Intensify advanced applicational and scientific work.

- Recast the structure and public image of NASA to those of an agency devoted to developing space applications of widespread human importance and making major advances in human understanding of the universe.

I offer these suggestions because I am deeply distressed by the dissipation and misdirection of our technical and human resources on enterprises that appeal to persons of a science fiction mindset but that are otherwise ill-considered and fruitless.

## Notes

<sup>1</sup>*McGraw-Hill Encyclopedia of Space* (McGraw-Hill, New York, 1967), p. 16.

<sup>2</sup>W. Fowler, interview quoted in *Caltech Bulletin* (1984).

## To What End

On prolix days

I, diseased by infinity

trundle fractions to their limit,

add a half to one, then a third, a fourth,

a fifth...

the pesky, counterintuitive divergence of it all

I sunder line segments

into smaller ones,

carving out in each interval

a crisp crevasse of nothingness

for another, in-between to fall,

wedged secure by its neighbors only

until my next partition stroke.

There is no lasting togetherness for numbers.

In extension and intrusion

I look for the frozen moment

of reaching the end

(which is not an end)

to which all may be added,

and all is unchanged.

On such days I play

in endless poker games

where the stakes rise exponentially,

follow the horizons on every sphere,

and walk down railroad tracks

to prevent them from meeting.

But infinities are only theoretical

and terminate

in the limit

of the solitary

I.