

Science and the Space Program

Technology and maintenance of peace have been enhanced at less cost to other endeavors than is often supposed.

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Over the years our national scientific space program has been the object of both enthusiasm and dissent—enthusiasm from those who welcome what they believe is the dawn of a new age for mankind, holding challenge, mystery, and opportunity; dissent from those who feel either that the problems receiving attention are secondary or that the money could be spent better in other ways.

It is challenging to review this topic at a time when the potentialities for success in the field of space exploration and research are becoming ever more clear from the technical side. It has been demonstrated quite emphatically in the last 2 or 3 years that the pattern of cooperation between the governmental and nongovernmental institutions in our country, provided by the National Aeronautics and Space Administration and the Department of Defense, has indeed made it possible to achieve a high level of reliability in the launching and control of space vehicles. Moreover, some of the successes we have already had in lunar and planetary missions make it evident that we are well on the road to being able to do what we choose with a minimum of wasted money and effort. Those of us who remember with chagrin the period less than a decade ago, when it was regarded as a miracle if a launch vehicle got off the ground, realize that the great battle to achieve reliability commensurate with the mission has essentially been won. The federal agencies have been successful in providing the techniques which the nation hoped

for. From this point on, the accomplishments will be determined much more by the money provided to the agencies by Congress and the imagination furnished by the scientific and engineering community than they will by the human or electromechanical links in the technical chain. Interestingly enough, the recent Soviet soft landing on the Moon and the Venus probes indicate that the Soviet capability is following a path much like our own.

It is my personal opinion that as a nation we are now far too deeply involved in the space program to back out of it, and that we should face the challenges and opportunities it offers with much more realism than so often seems to be the case at this time. Let me dwell on the various factors involved in our national commitment to this important field.

Psychological Factors

First are the psychological factors. I am inclined to believe that our nation will undergo a form of psychological trauma if it does not realize its potentialities in this field. Such trauma seems insured by the fact that the Soviet Union has evidently decided to challenge us in this area whether we like it or not.

About 10 years ago, Arthur Koestler, the author of *Darkness at Noon*, wrote an essay in which he pointed out that nations frequently act like individuals in the psychological sense, exhibiting collective reactions to issues and events somewhat similar to those of individual persons. He developed this theme to explain in some measure of detail the behavior of the various nations in the Atlantic community in recent decades through periods of war

and the aftermath. It seems quite clear to me, particularly since World War II, that the Soviet Union has used its own accomplishments relative to those of the United States to provide itself with a measure of its own stature, focusing particularly on those areas in which it has a reasonable opportunity to challenge us. President Kennedy recognized this when he called upon us to enter the space race in competition with the Soviet Union. I do not believe that we can turn away from this challenge without damaging our image, both that we have of ourselves and that other nations hold of us. What is perhaps even more important, I am inclined to believe that it is just as well if the overt competition between the Soviet Union and our own country takes the relatively benign form of a race in space, since the expenditure in life and material will be inconsequential compared to the losses in war. In fact it may serve as a tranquilizer to the soul of the Soviet citizen if he feels that his own country is either besting or trying us in a close and hard-fought race.

Anyone who doubts the importance the Soviet government attaches to the space race need only see copies of *Pravda* issued at the time of one of the Russian space spectaculars, for example, at the time of the soft landing of the lunar module in February, when an entire issue was devoted to the event. It was somewhat as if an entire issue of the *Washington Post* or the *New York Times* had been turned over to the Mariner trip to Mars.

My point in emphasizing psychological matters first arises from the fact that Congress tends to become lethargic in its support of the space program whenever there appears to be a lull in the international space race. Should the Russians actually decide to abandon their side of the race, I feel quite sure that our own program would taper off. The facts show, however, that the Soviet Union has no intention of abandoning the race. It follows that our intervals of lethargy will inevitably be followed by periods of intense activity in which an attempt is made to compensate for lost time and opportunity. As everyone knows, an on-and-off program seldom provides optimum use of money and manpower. What we basically need is a well-planned program and a budget that matches the planning.

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New Managerial Relationships

Let me turn to a second aspect of the space program. The program contains the essence of a vast revolution in the managerial relationships involving the governmental and private institutions in our country. As a nation we are learning through the space program to achieve new levels of accomplishment and reliability in the execution of programs of national interest.

The federal government and private institutions have worked closely on a massive scale in the past, for example during wartime. In such cases the various agencies of the federal government, backed by Congress, have established programs and have called upon industrial and other organizations to meet specific requirements. Generally speaking, the requirements have centered on a mass production and have been developed through a complex process of feedback involving the supplier. For example, the attainment of quality in the mass production of traditional ordnance equipment has involved a succession of tests in service. Moreover, there has always been an opportunity, frequently essential, to adjust and modify equipment in service. In any case, the statistical limits of acceptance have been fairly broad.

The production required in the space program tends to be of a rather different type. First, only relatively few items of each prototype are manufactured. Second, the level of performance expected from each item is so much higher than in the traditional cases of the past that there is in effect a major difference in quality. Not only must many thousands of components perform in essentially perfect association with one another, but there is little opportunity for modification or adjustment while in service.

I must admit that before 1962 I had serious doubts about our ability to achieve the expected degree of reliability within the framework of existing management. Our nation had attained world fame as a mass producer of goods of reasonable quality. We all knew, however, how frequently it was necessary to have standard equipment adjusted after it had been purchased and placed in service. Most of us on buying a new car are in the position of check-out technicians. I wondered if we could ever rise to meet the new challenge of achieving essentially perfect reliability on the first try.

Perhaps it should be added that the issue of reliability had first come to my attention in the period after the war when new atomic weapons were being tested. The scientific community involved in judging the tests planned a variety of physical experiments in conjunction with each explosion, designed to determine how effective each explosion had been. In this work, it was frequently necessary to develop a piece of equipment as complicated as a cyclotron or a mass spectrograph in an exceedingly short period of time. Moreover, it was necessary that such equipment operate with high precision the first time it was used, that is, during the test of a single weapon of novel design. The groups engaged in this work managed to attain a remarkably high degree of skill in achieving such instant reliability; however, they were almost inevitably scientists using the facilities of their own laboratories. It was not necessary to call a vast national network of suppliers and sub-suppliers into coordinated action. Moreover, there was sufficient redundancy in the means of testing weapons that one could if necessary be satisfied with 75-percent reliability in any experiment. The demands placed upon space systems is far, far higher, and the pattern of production is far more complex.

The fact that in a period of only 7 years the National Aeronautics and Space Administration could succeed in developing a system of planning and production which could engender the type of performance exhibited by the Mariner probe of Mars last summer, and by the Gemini satellites last January, indicates that we are gaining a vast new capacity for reliable production. The difficulties with the recent Gemini test only underscore the points being emphasized here. I believe this new capacity will turn out to have values now completely unforeseen and will presently affect our lives in a major way.

To emphasize this point, let me remind you that until about 1949 the fatality rate in commercial airplane traffic in the United States was such that the man-years lost through death in commercial air crashes exceeded the man-years that air travel saved because of its speed relative to competing modes of travel, such as the train or commercial bus. Most individuals who traveled by commercial airplane then were either ignorant of this fact or took the chances involved as a calcu-

lated risk in order to cut corners, as I did. In the intervening time, the reliability of commercial air travel has increased by a factor somewhere near ten, and has as a result transformed our way of doing business—a revolution still far from complete. I am inclined to believe that as we learn to produce devices of ever-increasing reliability, along the lines that the NASA program makes compulsory, we will find the new techniques having a profound effect on our everyday mode of life. It seems safe to prophesy that, when this topic is examined 50 years or so from now, the cost of the space program will seem to be trivial compared to the gains to everyday living.

Spillover

The topic of spillover from space research was a matter of lively discussion several years ago and has frequently been regarded as a joke since. It seems to me that this levity is unwarranted. Really profound innovations take time to assert their influence. The automobile, the airplane, and the radio were the butts of jokes in their early phases. The benefits which the United States has gained as a result of emphasizing digital computer technology between 1945 and 1960 are not regarded as jokes by the Europeans, who now find themselves at a disadvantage in this field. No one who believes that reliability and managerial effectiveness are to be taken seriously should write off the revolutionary potentialities associated with the space program too quickly.

Military Aspects

Let me turn next to the military aspects of space. I have little doubt that the great majority of citizens in the world in or out of uniform would like to see mankind enter into a period of essentially complete disarmament. The time is long past when any nation can hope to gain through war as much as it loses, if it is competently challenged. Although one hopes that this principle will eventually be understood everywhere, the number of limited engagements now taking place in the world indicates quite clearly that the era of universal disarmament is still far off.

Any nation which has occupied as

critical a role on the world stage as our own would obviously commit suicide if it attempted unilateral disarmament. It is true that as the Soviet Union gains wisdom through first-hand experience with atomic weapons and the means of delivery, and as its standard of living rises, the hope that it will accept some form of bilateral agreement on disarmament emerges as a reasonable possibility. Until the ambitions and potentialities of Communist China are clearly understood, however, I seriously doubt that such bilateral discussions can achieve very much more than limited good will. If the Chinese are unwilling to permit the North Vietnamese to discuss terms of peace in South Vietnam, who can believe it likely that they would be willing to discuss more general terms for global peace in the immediate future? For at least a generation ahead it will be as important as it ever has been in our national history to comprehend the full military implications of technological innovations.

The best one can hope for in the present atmosphere is to achieve a military stalemate in which no major nation has the temerity to take the step which will lead to a major world conflagration. The technology of aerospace, viewed in its broadest and most complete sense, clearly is of major military importance. As a nation we cannot afford to be inferior to any other in any significant aspect of it.

I will admit that individual missions, such as those to Mars and Venus, probably have negligible military implication in any immediate sense. On the other hand, no one is wise enough to predict that all aspects of the present scientific space program will remain permanently benign. It took more than 40 years for Becquerel's discovery of natural radioactivity to have military consequences. The protection of the Free World requires that we remain in the forefront of nations concerned with the technology needed for exploration of space. In our continual pursuit of peace, we can hope that such programs will eventually enjoy the type of international cooperation familiar in the exploration of Antarctica.

One might reasonably ask if the aspects of space research of interest for future military potentialities could not

better be carried out exclusively within the framework of the Department of Defense. Without laboring the point, I think it is safe to say that military agencies should not be expected to carry out all the really general investigations needed to assure their own position in the more distant future. The Department of Defense is heavily burdened with the highly important mission of making sure that our defenses are adequate both today and next year. Since our armor is never completely secure at any given time, those who make crucial decisions in that agency must inevitably balance expenditures for the future against those for the obvious needs of today. They cannot be criticized very severely for giving highest priority to the latter. At the same time, however, one must admit that a field as important as space research needs the independent attention of an organization such as NASA.

Scientific Programs

Let me turn finally to the purely scientific programs associated with space research. For a decade it has been very popular in segments of the scientific community to deride the scientific space program, acting on the one hand as if the knowledge to be gained is of completely negligible value, or, on the other, as if one would automatically be in a position to place 5-or-so billion dollars at the disposal of other scientific or social activities if the scientific space program were abandoned.

It apparently must be emphasized again and again that the funds involved in the truly scientific aspects of the space program represent a relatively small add-on to a much larger base of expenditure made necessary for other purposes such as national prestige, technological innovation, and defense. Congress could not and does not regard the expenditures for space science in the same category as those by the National Science Foundation. The most those scientists who attack the space program can hope to achieve is to have the budget for space science cut by perhaps 20 percent, and thereby guarantee that the scientifically most exciting aspects of the work are eliminated. It is hardly necessary to add

that our national system of making decisions guarantees that such cuts will not produce comparable add-ons to other budgets significant for science.

It is my personal opinion that the scientific community would pursue the interests of science far more effectively if it recognized that we have a unique opportunity to make the space program scientifically valuable by lending support to those components of it which do have a significant bearing on scientific knowledge. I believe that the knowledge we can gain of the solar system through the space program represents a major contribution to our heritage of knowledge, fully as important as the knowledge of the earth we have gained in the last 500 years through the exploration which began with Henry the Navigator's systematic explorations of the coast of Africa. Beyond this, the opportunities for stellar and galactic astronomy coming within reach through observation platforms outside the earth's atmosphere obviously are challenging.

When future generations of mankind contemplate scientific knowledge made possible by the space program they may well wonder what manner of men the doubters were. I must confess that the photographs of the cratered surface of Mars we all saw last summer gave me a feeling that could not have been very different from that which I would have had a century ago on learning for the first time of the source of the Nile in Lake Victoria. I experienced a somewhat similar thrill on learning of the stellar x-ray sources.

Science is unusually viable in our nation at the present time because of our affluence, because of the openness of our society, which is particularly conducive to the type of speculation and exchange highly vital for science, and because we have spent several centuries, first painfully and falteringly and finally with assurance, in building a scientific establishment which is now admired by all other nations in the world. Granted that we do have a space program for reasons which may be in themselves peripheral to science, the enlightenment of mankind requires that our nation support those aspects of the program which will be, as in the past, the source of uniquely valuable scientific information obtainable in no other way.