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Future Opportunities for Space Flight Experiments

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INTRODUCTION

I'm going to try to be as realistic as I can in addressing the topic which I've been asked to discuss. These are difficult times for the space program but I'm convinced that the nation will want us to be ready to move forward once the nations' resources can be diverted from the Viet Nam situation. Three important areas in which we undoubtedly should be prepared to move forward are applications, astronomy, and life sciences. There are other areas but I'll restrict myself to those today.

"The consequences of ignorance are potentially so drastic that the investment in knowledge becomes a must." This statement, made by Dr. Homer E. Newell, Associate Administrator of NASA, in his budget testimony last year before the House Committee on Science and Astronautics, serves to underscore the importance of the opportunities for space flight experiments. Dr. Newell was referring to the subtle, yet damaging influence of man's activities combined with nature's own actions on the ultimate sources of life-giving oxygen in our atmosphere. His concern was that by the time significant changes are evident, it may already be too late to remedy the situation.

As you will note, this places the emphasis on the Earth environment and it is the word "environment" that is the key to the practical importance of much of space science. For example, understanding the lower atmosphere and its behavior is especially significant at this time when we are wrestling with problems of smog and atmospheric pollution, and with the possibilities of actually modifying weather to serve practical needs, such as enhancing water supplies, decreasing lightning hazard, protecting crops from storm damage, and perhaps, in the more distant future, even taming the hurricane and the tornado.

A major impact of space research upon geoscience is in the opening up of new, unsuspected areas in the discipline. Investigation of the Earth's magnetosphere is an entirely new aspect of geoscience, which began with James Van Allen's discovery of the radiation belts. Indeed, the term magnetosphere is new, coined to designate that region of the interplanetary medium over which the Earth's magnetic field has a dominating influence. The study of the magnetosphere is inextricably interwoven with investigations of the aurora, magnetic storms, and magnetic fluctuations, communications disturbances, and weather anomalies on the one hand, and of the interplanetary medium and solar activity on the other. With such studies we expect to learn about the detailed mechanisms by which the Sun exerts its control of the Earth's atmosphere.

The domain of geoscience has grown to include many bodies of the solar system. Comparative studies of the planets and their atmospheres, ionospheres, and magnetospheres, promise increased understanding of our own planet. The investigation of solar-terrestrial relationships can now become the study of solar-planetary relationships.

The drawing together of physics, astronomy, and the geosciences in the study of solar-terrestrial relationships and in the comparative study of the Earth, Moon, and planets represents the final impact of space research on geoscience. When Surveyor landed on the surface of the Moon, it brought about the fusion of astronomical and geoscience interests in lunar geologic investigations. And, in a similar way, studies of cosmic rays, plasmas, and magnetic fields in space, and of their relationship to the Earth's magnetosphere and atmosphere, have brought physics and geoscience into a close partnership.

APPLICATIONS

Let us now turn to a more specific consideration of one of the fields involved in the general approach outlined above: that of space applications.

Space applications are unique in that the NASA applications R&D program, leading to the development and demonstration of a particular technological capability is only the beginning of a chain of events involving continued use of the technology by other agencies to gather data (e.g., meteorlogical satellites) or to provide a service (e.g., communications satellites). Beyond the user of the space technology is a customer who benefits from the improved service resulting from the use of satellites. These distinctions become particularly important in assessing the economic benefits of space applications, and in determining the relationships of the Agencies involved.

We have already established the technology for the use of satellites for large volume point-to-point or inter-continental communications as represented by the current commercial satellite systems. These systems are bringing about healthy competition with the older conventional systems such as undersea cables as is evidenced by the recently reduced transatlantic telephone rates. However, the potential uses of satellites in the broad area of communications are many and the ultimate and complete potential is probably beyond our ability to predict, but is certainly an area in which future space flight experiment opportunities exist.

Meteorology is the second major space applications that has already resulted in an operational space system. This operational system provides daily observation of the global cloud cover, the most visible and dramatic indication of the dynamic state of the Earth's atmosphere. While short-range predictions of the weather are important to our daily activities and in the saving of lives and property, the value of weather forecasts would increase manyfold if such predictions could be extended over a longer period, perhaps as much as two weeks or more. The ingredients needed to permit such forecasts are: An adequate model of the atmosphere, sufficiently large computers, and quantitative measurements of the total atmospheric structure including such parameters as pressure, temperature, moisture content, and wind velocity at various altitudes on regular periodic schedules over the entire earth. Atmospheric models already exist as does adequate computer technology. Techniques for the acquisition of the atmospheric structure data are the only elements yet to be developed to make possible the one-to-two week forecasts of larger scale weather. Note that this too is an opportunity for further experimentation.

The need to develop, protect, replenish, and use our natural resources wisely becomes more apparent and more urgent as the world's population continues to increase. The air is an Earth Resource as are the oceans, fresh water, glaciers, forests, minerals, tillable land, and so forth. Efficient utilization of these resources includes not only their discovery, mapping and management, but also the detection and control of pollution which is becoming an increasingly important factor. In many areas, such as the Great Lakes with which we are all familiar, this need is reaching crisis proportions. With the advent of the space age, new techniques are being discovered and developed to assist us in meeting these crises in the management of the Earth's resources. But more needs to be done!

The great potential of these Earth resources areas transcends purely NASA interests and we are working with all the appropriate and interested Government agencies and many universities and research organizations to make a truly national assessment of these areas.

Progress in the future can be expected to proceed at a much more rapid pace than in the past for the space tools of today are much more sophisticated than those of a few years ago. However, the potential importance of being able to monitor and survey and consequently, to protect our natural and cultural resources, using these tools, should not be overestimated. Further development of the role that satellites can and should play must be developed with a sense of urgency.

To quote from a more recent speech of Homer E. Newell:

> "Ten years ago scientists and engineers schooled in the traditions and skills of the pre-Space Age era, had to turn to, learning and relearning as they went, to tackle the new problems ushered in by the Space Age. Today, we see entering the scene a new generation of researchers who, during their formative years, watched the Space Age unfold. These men and women have been caught up in the excitement that space represents. They may be expected to bring their enthusiasm to bear not only upon space, but also upon the great challenges today at home on our planet earth, such as the problems of oceanography, earth resources, the cities, transportation, population, pollution, and food. They are likely to oppose any national decision to sidestep <u>any</u> of these challenges." They are imbued with an enthusiasm for what can be done today on many fronts. If you and I don't do some of these things sooner, they will take them up and do them later. History will record that they did them, and by implication, that we <u>didn't</u>."

ASTRONOMY

The NASA astronomy program builds from a basic space astronomy competence through the acquisition of survey data, and increased technological know-how through advanced scientific and technical competence to the very large astronomical space observatory of the future.

Of particular relevance to the title of this talk (Future Opportunities for Space Flight Experiments) is: What and where is a quasar? If quasars are as distant as they appear to be, we have no understanding of how they generate their enormous radiant energy. As clues to this energy source, we must learn much more about these objects. How large are they? What is their structure? Is most of the energy coming from a very small portion of the quasar, or is the energy source spreading throughout the body? Because of the turbulence in the Earth's atmosphere, even the largest terrestrial telescopes barely resolve even the nearest of these objects.

It is obvious that the source of energy is far different from that to which we are accustomed in normal stars and galaxies. We suspect that accompanying the optical and radio emission large quantities of x-rays, gamma-rays, and cosmic rays are also emitted. But, as x-rays and gamma-rays do not traverse the Earth's atmosphere, we must wait for such spacecraft as the Small Astronomical Satellite (SAS), the Orbiting Astronomical Observatory (OAO-C), the Apollo Applications Program (AAP), and perhaps even the proposed large instruments of a National Astronomical Space Observatory (NASO), before obtaining answers to this fundamental question.

If quasars are at the cosmological distance which they appear to be, the more distant ones are by far the oldest objects we can observe in the universe. For centuries astronomers have wondered whether the universe as a whole ages? A direct answer may be provided by a comparison of very distant quasars with nearby ones. We are anxiously awaiting the Astronomical Space Telescope Research Assembly (ASTRA), or perhaps OAO-D to obtain ultraviolet spectra of the nearby quasar to compare with the observations we can obtain from the distant spectra. Finally, questions have been raised as to whether the redshift which astronomers use as a distance yardstick in a valid one. Perhaps there are other yardsticks which can be used for these distant objects, but none have been found as yet. These among other unanswered questions provide the opportunities for experimentation you've asked me to discuss.

The Small Astronomical Satellites (SAS) are a series of Explorers small enough to be launched with the Scout-class vehicle which will be used to carry specialized detectors for astronomical surveys and sky mapping, primarily in the high energy region of the spectrum. The primary objective of these small satellitesis the detection and measurement with high sensitivity of x-ray sources distributed over the whole celestial sphere. At the conclusion of this program, we shall have an x-ray map of the sky. We should also have good statistics on the distribution of x-ray sources within and outside of our galaxy and of the patterns of intensity variations in these sources. Scientists are encouraged to propose experiments for these small satellites, as well as for the sounding rocket program I haven't even had time to touch on.

Another field of great interest, because it can provide a means of detecting most of the major energy transfers occurring in the universe, is gamma-ray astronomy. Gamma-rays have the advantage of not being deflected by a magnetic field, as the ionized cosmic ray particles are, and of penetrating galactic and intergalactic matter with very little attenuation.

Observatory class spacecraft provide the accurate pointing needed for detailed studies of astronomical objects, as well as for advanced survey work in which a few observations are made of each of a large number of specific sources whose positions are already known from earlier surveys. The first of the Observatory satellite programs is the Orbiting Solar Observatory (OSO) series.

The OSO payloads for the missions to be launched in 1968, 69, and 70 during the periods of maximum solar activity have already been selected and the spacecraft and experiment hardware are in various stages of design, fabrication, test, and integration consistent with the launch dates. This points up the long lead time problem with these complex satellites. If you want to fly your experiments in the 70's - get those proposals in now.

The Apollo Applications program will represent the first major attempt to use man's capabilities in the accomplishment of astronomy experiments. Both small and large experiments will be flown. The Apollo Telescope Mount (ATM) will be the first astronomy manned payload. The objectives of the 56 day orbit are to develop and demonstrate the astronaut's capability to perform astronomical observations in space environment, to collect large amounts of significant scientific data, and to evolve, operate, and maintain astronomical instrumentation for space.

Starting with broad surveys conducted from rockets, OAO-A, Gemini and the Apollo Applications Program, we hope to progress into more detailed surveys with satellites, a high-energy stellar astronomy package, and, perhaps, the first of a series of man-maintained satellites. A very major space telescope will be required for detailed studies of very faint objects, such as distant galaxies.

In the 1970s and later we look to a different method of handling space astronomy facilities. Missions will be planned by a group of scientists. A NASA center will probably supervise the design and construction of the instrument instead of having it done by a single university. Astronomers will request the observations they need to answer the particular questions they are studying. A NASA center, through a mission control facility, whose duties are restricted to operating the space astronomy project will program the satellite to obtain the desired data. When received, the data will be distributed to interested scientists for analysis and publication of the scientific results.

Within the time available it has been possible only to hit some of the high spots of several extremely complex and varied parts of the Astronomy program. They have, however, I hope, given you some idea of the future opportunities available for experiments in the field of astronomy.

BIOSCIENCE

One of the most exciting and far-reaching aspects of the nation's space activities may be its bioscience program. This program addresses the questions, "What is the origin of life?" What is the nature of life?" and "Is life peculiar to our planet?" Thsse mysteries have stimulated the intellect of man from his earliest history.

While we now know much more than our early ancestors about systems having the quality "life" we have made little progress toward answering the more fundamental and critical questions. In fact, we may be losing ground. After all, the major problems of the world today, some of which I referred to in discussing the application program - inadequate food supply, overpopulation, disease, air and water pollution- are biological in nature - either the direct or indirect results of biological activity.

Biology has only recently emerged from a purely descriptive discipline into an analytical and quantitative science. It has not yet developed universal theories comparable to those in the physical sciences.

In general, the program is divided into two basic endeavors. The first of these is ground-based research consisting of theoretical studies and fundamental investigations to establish data baselines and to define flight experiment protocols. The other endeavor is a flight experiment program to carry out those measurements and observations requiring spaceflight with its weightlessness, removal from the Earth's geophysical influence, proximity to other bodies in the solar system, or other special space conditions.

There is evidence to indicate that the Earth at one time had a chemically reducing atmosphere which it lost during its first billion years of existence. In theory such an atmosphere exposed to sources of energy such as solar radiation and lightning could produce biochemical compounds. In 1953, Miller and Urey reported on experiments in which they produced some of the basic building blocks of living things simply by subjecting such a reducing atmosphere to electrical sparks. Since that time, a number of investigations using various sources of energy on similar systems have produced in the laboratory practically all of the major biochemical constituents of living things, including pieces of the genetic substance DNA. Since all living things, from bacteria to man, have the same general chemistry, these discoveries suggest that life would arise as an inevitable consequence of the laws of physics and chemistry wherever conditions were favorable.

The real test of this hypothesis must come from study of pre-biological as well as biological evidence that may still exist on the Moon or on other planets which may be in various stages of the atmospheric evolutionary cycle through which the Earth is going. The search for evidence of early life on Earth has been confounded by the fact that living systems reuse those chemicals that are most available (and useful), and that the lower forms of life presumed to arise first did not leave "hard tissue" skeletons likely to be found as fossils.

The Moon may very well turn out to be a well-preserved museum of solar system's past history protected by the absence of a destructive atmosphere and the consequences of the evolution of living systems. Samples of the lunar surface will be obtained and returned to Earth for detailed analysis in specially designed laboratories. The search will emphasize organic molecules of biological significance such as amino acids, fatty acids, carbohydrates etc. Microbiological studies will be made in an attempt to isolate viable organisms.

The techniques and instruments exist for identifying the recognizable attributes of Earth life in our laboratories. The challenge of the planetary biology exploration program is to adapt these techniques and instruments for use in the automated mode on another planet. They must be miniaturized and ruggedized and must be capable of withstanding the rigors of sterilization, they must be integrated into a functioning automated laboratory. This is obviously a challenge to the talents of the nation's scientists and engineers.

Study of the effects of space environment on Earth life forms is the other main area of space bioscience activity. One of the most significant characteristics of living organisms is the capacity to maintain a uniform internal environment in the face of altered external conditions or to favorably modify the environment and to adapt genetically to improve the probability of survival. In other words, there is a pervasive and complicated interrelationship between the basic biological functions and the environment. Thus, there is no doubt that the space environment will have an effect on Earth life forms. An important objective of the Bioscience program is to determine what this effect will be so that we can assess the risks of manned space flight and devise suitable preventive measurements. There is, however, another extremely important objective in the study of space environment on living organisms. Historically the key to understanding biological functions has been research inquiring into reactions of the organisms when environmental forces are varied. If one knows how an organism senses and reacts to environmental stimuli, he knows a great deal about the mechanism and function of the organism. The space program now offers the opportunity to vary (or even completely remove) some of the geo-physical forces to which all known forms of life have been subjected continously, thus permitting environmental research never before possible. Accordingly, the bioscience research on the effects of space environment on living organisms proceeds as important effort in support of manned flight, as scientific research of great importance for its own sake, and for possible applications to medical, physiological and social problems.

Space flight research has been proposed on subjects ranging from bacteria through higher plants and animals to man himself, It will address fundamental questions common to plants and animals, such as, "How do organisms perceive gravitational strength and direction?" and "How do organisms use gravitational information to control growth, development, and normal function?"

There will be studies of cyclic phenomena, the biological clock, the circadian, or twenty-four hour, rhythms. Whether the biological rhythms continue free-running, change or disappear, will be of significance to long-term manned flight. While all of this is of interest from a pure science viewpoint, it also, has interesting potential for medical purposes.

There will be studies of radiation in portions of the frequency spectrum and high energy primary cosmic rays which cannot be duplicated at present on Earth, studies of the effects of isolation, absence of orientation cues, and of social inter-action and performance problems in small groups in a closed ecology.

Animal experimentation will be a necessary and important part of the research and will look into the effects of space environment on the central nervous system, cardiovascular system, the hemodynamic and metabolic processes and behavior. The animal experimentation will employ deep brain electrodes, long-term catheterization, deep body biotelemetry and radioisotopes.

If this country decides to go ahead with an orbiting space station, it is likely that a portion of it will be dedicated to the life sciences. Studies of various configurations are being made now. Such a space laboratory could accommodate many kinds of experiments that would benefit from the participation of a scientist-astronaut. More extensive experiments on the physiological and psychological adaptation of primates to the space environment are among the more important candidates for the manned program.

As all of you know, manned lunar landing is the major objective of the Apollo program during this decade. Analysis of the returned lunar sample program will be the central biological activity. A Lunar Receiving Laboratory is now just about ready to go into operation at the Manned Spacecraft Center in Houston and a number of grants have been let to principal investigators to develop the instrumentation, techniques and protocol for analysis of the returned samples.

There are presently scheduled two 1969 Mariner Mars Fly-bys, each of which will carry about 120 pounds of instrumentation for photography, atmospheric composition, presence of trace organic compounds in the atmosphere and surface temperature sensing.

Two Mariner Mars Orbiters are proposed for 1971. Similarly, there are proposed for 1973 two orbiters with atmospheric probes which are also survivable landers. These would use the Titan III launch vehicle.

Two Venus missions are under consideration now, an orbiter with a bouyant probe in 1972 and a Venus-Mercury fly-by in 1973.

This is by no means exhausts the possibilities for exciting and scientifically rewarding bioscience flight missions. We think and dream about the day when there will be manned planetary landers. I have little doubt that the day will come, but it lies beyond the time period of the plans I have discussed here.

In Conclusion, I think it appropriate to mention that the automated instrumentation for the environmental flights or the lunar and planetary flights offers opportunities for new achievements in bio-engineering and a new and important involvement of the aerospace research and development industry in biological research.

To conclude I want to repeat that I've only touched on the opportunities in three of the areas of importance to the space effort ------ there are others but these are the key areas and I firmly believe that we should be hard at work right now developing new ideas for the flights which will undoubtedly be made in the 1970s.