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Phoebus, C. P., Capt, MC, USN

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THE NAVY LOOKS AT SPACE

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INTRODUCTION

At the present time there is probably no single area of military interest which is more alive and occupying the attention of more people, both in and outside of the military services, than Space. Much of this attention is casual and of no significance for the future, other than in a sociological sense. At the same time however, there are astonishing numbers of people in industry, in science, in government, in the armed forces, and in the press--both in this country and abroad--who are, in one way or another, contributing to our rapidly advancing knowledge of Space. In the scientific world in particular, imaginations have been triggered by the future exploitation possibilities which Space offers. All of this activity will inevitably result, eventually, in our utilization of Space for military purposes--if indeed, we are not already deriving some military benefit from our feeble attempts to date to place vehicles in Space.

In the midst of all of this activity the situation suffers from the confusion which has resulted from the pronouncements of innumerable "experts", and the many publications which have been rushed into print in order to capitalize on the rising public taste for the imagination stirring vistas which only the magic word Space can conjure.

This paper attempts to bring some measure of order out of this chaos by singling out those events, possibilities and problems which seem to have most significance and relativity to the Navy as it contemplates its future in the Space Age. As such it touches lightly on many subjects, with no attempt being made to exhaustively analyze, compile data on, or to discuss any of the topics treated. It merely represents the author's personal opinions, and gleanings through library research, of those areas of past, present, and future Navy interest which to him seemed to be representative of those things in which the Navy has or should have a stake.

It was felt that this type of an approach to the problem of Space may serve to introduce those in the Naval War College who read this paper to the subject in a more or less painless manner, and hopefully, might serve as a point of departure for anyone whose interest may be excited by any of the topics included.

THE NAVY LOOKS AT SPACE

CHAPTER I

THE NATIONAL INTEREST IN SPACE

On October 4th. 1957 the Soviet Union launched the first man-made Earth Satellite, Sputnik I. The reaction to this event throughout the world was immediate; and varied from the exultation and boasting of the Communist world, through the puzzlement and uneasiness of most of the rest of the world, to the consternation and dismay manifested at all levels among the people of the United States. This single event was unquestionably the most serious blow to its prestige ever suffered by the United States; which at the same time gave the U.S.S.R. a new stature in the eyes of the world and a new trump card to play in the Cold War. We will be a long time in regaining what we lost on that date--the date which marked the beginning of the Space Age.

In retrospect, one could have anticipated this worldwide reaction. For years men have been speculating about space, and slowly but surely groping their way through the labyrinth of ignorance, wild imaginings, fears, and myths which blocked the way. But the vast majority of mankind did not take the ideas and efforts of the few imaginitive but hard working space scientists seriously; not even when both the United States and the Soviet Union announced programs for launching artificial satellites as part of the 1957-58 International Geophysical Year scientific effort. Now however, the realization has dawned that we are actually on the eve of events to which more pure imagination has been applied, than to any of mankinds progressive plans and ideas in the past. We know now that formerly fantastic predictions for rocket flight are realistic possibilities. As Hermann Oberth, the "Grand Old Man of Rocketry" said years ago:

> Nothing in this world (or out of it) is impossible; all that is needed is to find a way of carrying out one's plans. ... After all, if someone who lived 200 years ago were to read an up to date description of New York...he would think they were the ravings of a lunatic. (18)

Most of the after-Sputnik space experts of today do not realize that nearly all of their allegedly brand new ideas about long-range rockets, satellites, space ships and the utilization of space for man have--in their basic features--been thought through already at least once before. The only difference between then and now is in the details, in the scientific and technical state of the art and in the availability of better tools to approach the final goal more realistically. Further, there are two other even more vital differences with which the pioneers struggled futilely, which are largely overcome now: public receptivity to these ideas, and the availability of money!

The ideas were formulated first by the space dreamers and idealists, who most of the time died of frustration caused by an unflinching natural fact they could not change--the fact that when they conceived their ideas--the time was neither scientifically, technically nor politically ripe for practical realization of their visions. Their problem was that they could not and did not imagine the magnitude of the task they were undertaking. They did not realize they were trying to push with insufficient means and full blast through a yet closed door into the unknown or, as we see it now, into an entirely new era for mankind--into the Space Age.

In addition to the results of Sputnik I noted above, the most notable thing that happened in the United States was a loud, nearly unanimous, and insistent public clamor that "Something must be done!" The results of that demand will form the substance of the remainder of this chapter--results on the national scene which would have been regarded as just as fantastic and unrealistic a few years ago, as were the dreams, ideas and work of the Space pioneers of pre-Sputnik days!

After the near-hysteria of late 1957 had subsided, the United States rolled up its sleeves, took a more or less good look at where we stood, and settled down to the task at hand. A Congressional Report (22) issued in early 1959 contains an amazing chronology of what happened. The year 1958 was marked by a quick succession of events which not only included the launching of more satellites by both the United States and the Soviet Union, but more particularly the organization of the United States' resources on all fronts to cope with the Space Age. At first there was the seemingly wild scramble of everyone trying to "get into the act". "Experts" of all sorts had a "field day"--in the press, on the radio, on television, in the political arena, in the Pentagon, in industry, in the hallowed halls of the universities, in "scientific" meetings, and even reaching into the White House. Books on the subject tumbled out of the presses. Hollywood found a whole new field for exercising its imaginative talents. It was plain to all that Space was the coming thing, <u>and</u> that there was money in this new field, BIG MONEY. We even took a long hard look (with hysterical trimmings) at our educational system. Yes, definitely, something had to be done!

It is probably fair to concede that Public Opinion led the way during this eventful year. But it is also necessary to point out the fact that the Military Services had each been quite active in Space matters (mostly in the field of research and development) long before it became popular elsewhere. When the Space Age suddenly arrived, the Armed Forces with their scientists and contractors were virtually the only source of know-how and money. Industry was quick to realize this and acted accordingly--a flood of salesmen with ideas and proposals, and a horde of idea-seekers, descended upon Washington. This had political repercussions which resulted in political action, and made more money available--the expected and desired effect. America was on the move in its traditional manner! But, if one ignores the substantial technical progress that resulted from all this for the moment, and looks at the events which have real long-range significance, it seems that the following stand out:

1. The Advanced Research Project Agency (ARPA) was created by the Department of Defense on 7 February 1958 and placed in charge of the Nation's outer space program, including the development of military space weapons and anti-missile missiles. Here was the first step in the direction of the large scale, long range, centralized planning and directive effort necessary for the United States to organize its resources in the Space Age. ARPA provided the necessary central control of the military effort which was needed. It's big stick was money; instead of each of the military services budgeting for its own space program, ARPA was given the money--or at least a sizeable piece of it. ARPA also had the power to review and coordinate the military space programs. While the huge expenditures of the services in the various fields of rocketry would continue, ARPA was in a position to see that Space received the bonus benefits which were secondary dividends from the missile programs.

Best of all, ARPA did not attempt to build its own empire, but instead allocated its funds to the services for expenditure in service laboratories or by service contractors--after proper justification had been presented and the individual projects had found their appropriate places in the long range program set up by ARPA.

But, however meritorious the concepts and methods of ARPA might have been, it was not enough. There were many other interests in Space outside of the Pentagon; or at least, these soon developed. Science and industry wanted to do many things in Space which could hardly be considered directly related to existing military requirements or concepts. Other governmental agencies envisioned roles for themselves in space which they wanted to explore and exploit without deference to military control. The public and Congress soon became uneasy about the alleged military domination of Space and Space thinking. The inevitable answer was soon found; a civilian Space Agency was needed.

2. The spring of 1958 was a period of study, political activity and endless discussion which terminated with Congress passing and the President signing on 29 July 1958 the bill which created a civilian Space Agency--the National Aeronautics and Space Agency (NASA). The act which created NASA was distinguished by the unprecedented powers bestowed upon this new agency of the government. Few people realize even today how far-reaching this power is, for example the NASA: (18)

a. Has a director appointed by the President.

b. Has a board to assist the Director which draws its members from the other governmental agencies having a direct interest in Space--including <u>one</u> from the Department of Defense.

c. Was directed to absorb the National Advisory Committee for Aeronautics (NACA), its laboratories, its personnel, and its functions.

d. Has the unprecedented (yet realistic) authority to fix the compensation of its employees competitively with the rates of other employers, regardless of existing classification laws.

e. Has broad authority to administer its own programs.

f. Can conduct research in its own facilities and by contract with other organizations, wherever they may be found--in or out of government.

g. Can transfer to itself functions, activities and programs of other departments which are appropriate--with the concurrence of the heads of agencies concerned and the approval of the President.

h. Is charged with reviewing Department of Defense Space programs and related activities, with the Department of Defense to continue being responsible only for those space activities peculiar to or primarily associated with military weapons systems or military operations. ARPA is to operate the National Space program in the interim until NASA is functioning, and then concern itself only with military programs.

i. Has authority to prepare plans and organize itself.

j. Is assured of obtaining enough money to carry out its mission.

k. Is directed to coordinate its work with the National Research Council and the National Science Foundation.

It thus can readily be appreciated that the NASA has been set up as an extraordinarily powerful agency with the broad powers necessary to promote and direct the interests and efforts of the United States in the Space Age. It should be pointed out also that NASA follows the pattern first established by the Atomic Energy Commission (AEC)--with embellishments; thus gaining the advantages of a separate budget, popular support, the removal of much of our Space effort from the military spotlight, and the capacity for enormous expansion.

One might well ask, "Where does this leave ARPA and the interests of the military services?" As yet, the answer is not too clearly discernable. Since its creation, NASA has been undergoing "growing pains" as might be expected. This has been particularly evident in its search for personnel. The NACA which NASA replaced was not organized for, or entirely capable of, expanding and taking over the activities necessary for a balanced Space Program--for example, NACA had no experience in the Aviation Medicine and related Human Factors research so vital to a "man in space" program; nor did NACA often venture out of the research phase into the development and engineering phases of aeronautical progress. On the other hand, NACA had worked in close harmony with the military, with industry and with science. Perhaps the most apt simile to the NASA problem would be the AEC when it was expanding from Manhatten District Project status to that of one of our largest governmental agencies. NASA has already absorbed the Navy's Vanguard personnel and facilities, the Army's Jet Propulsion Laboratory at Cal. Tech., and is busily recruiting, organizing, and building further strength.

As for the ARPA problem, it seems clear that the Department of Defense will continue to have a major interest in Space, and will continue to supply rockets to the NASA.

On the other hand, NASA work will support military projects--just as the NACA did in the past. It would seem that the happiest solution to the problem of jurisdiction of United States Space Programs would be an ARPA-NASA relationship paralleling the existing Armed Forces Special Weapons Project (AFSWP)-AEC relationship, which has generally worked to the mutual satisfaction of the Department of Defense and the civilian interests represented by AEC. With Space opening its doors to both the military and to civilian science, it will be well worth watching this enormously important area of mutual interest. Liaison between both groups is essential; and neither should be regarded as, or allowed to develope into, a threat to each other's interests--too much is at stake!

3. The best assurance we have at present that all will progress reasonably smoothly from the United States viewpoint on space is Congress. After much politicking, numerous statements for the record, and many alarums and excursions, the House created a Select Committee on Astronautics and Space Exploration on 8 March 1958, followed on 24 July by the Senate establishment of a standing committee on Aeronautical and Space Sciences. Of these, the House Select Committee has been most active and has issued several quite remarkable reports. It's final report (22) submitted on 3 January 1959 contains the most lucid expression of how Space has grown in importance for the people of the United States that has yet been written.

As to the need for a National Space Program the Congressional sentiments can be summarized as follows:

1. We are in an age of rapid technological change wherein the strategic balance of power can shift to the nation first achieving operational usability of new scientific developments.

2. The effects of technological advance can be of compelling force even without resort to war.

3. It would be highly impractical not to face the reality that space technology, like nuclear energy, can be used for war as well as for peace.

4. The military potentialities of space technology, which the United States would prefer to see chaneled to peaceful purposes, are greater than general public discussion to date suggests.

5. The decision to undertake a space program cannot be made in the context of domestic conditions alone.

6. A key question is the relative position of the Soviet Space accomplishment as compared with that of the United States.

As to the <u>nature</u> of the Space program:

1. Inventions cannot be scheduled in advance.

2. Crash programs are the most expensive kind to undertake.

3. The early design-study phase of research is relatively cheap in money, but it may not be cheap in amount of time required.

4. To start-and-stop programs is the most expensive and dangerous way to undertake them.

5. The pace of development has been so rapid, as new devices make earlier ones obsolete, that we are pressing hard against the limits of fundamental human knowledge.

6. At the same time that the arrival of new developments is occurring more and more frequently, the complexity of many of these projects is growing so that their planning requires programing of efforts over a longer span of years.

7. Long range flexible planning should entail approval of programs which are not yet certain in every detail and a system of follow up and reappraisal leading to program revision when necessary.

As to <u>policy</u> implications for the space program:

1. Inexorable changes in society and political power will follow the development of space capabilities; failure to take account of them would virtually be to choose the path of national extinction.

2. What program the United States could achieve and what it will in fact achieve may be two very different things.

3. Budget pressures in the short run should not be the primary basis for decisions on space programs which are inherently long range, and which involve the very survival of the nation.

4. This nation should not make inadequate short-run expenditures on its space program at substantial risk to its survival a few years later.

5. The best advice obtainable (by the committee) supports the view that within a decade the peaceful application of space development to weather prediction and long range communication alone will more than pay back to the economy all the funds previously required to achieve these capabilities.

6. The greatest benefits of space development and exploration in all probability cannot even be predicted today.

7. Although engineering secrets related to national defense deserve the utmost protection, the greater part of the space program will progress more rapidly without the shackles of an undue security control.

8. Full scientific and technical cooperation among the nations of the Free World is essential to their joint survival and to the fastest growth of the American Space Program.

9. Scientific education in the United States stands in need of critical review.

Even in summary form (and without the accompanying verbiage) it would seem as though, in expressing its sentiments this vigorously, Congress showed that it had its fingers on the pulse of the national thoughts on space--and spoke the proverbial "mouthful" which the circumstances dictated.

It has become evident that every phase of modern life is somehow bound up with this new Space Age and its accompanying technology. The nation has begun to realize that national space policy, to be effective will inevitably require the greatest effort in partnership in the history of America; in fact in the history of civilization. All mankind is becoming encompassed by the unpredictable mysteries of the Space Age. It cannot be over-emphasized that the fate of the United States--indeed of the whole world is at stake. Space technology is fast becoming the heart and soul of military science, constituting as it does both the greatest threat to, and the greatest hope for, our continued existence. The military forces, science, industry, business, law and government must join in this project and engage in the bold and dynamic program which needs all of our talents if we are to meet this challenge to mankind frought with possibilities so awe inspiring, so hopeful and so overwhelming! We can be thankful that the events of 1958 have shown not only our interest in Space, but our ability to rise to its challenge.

CHAPTER II

THE DEPARTMENT OF DEFENSE AND SPACE

The momentous events that have occurred since the October day less than two years ago when Sputnik I first put a man-made object into Space have obscured the fact that various elements of the Department of Defense have long been actively engaged in work aimed at the same achievement. Unfortunately, the Soviets beat us to the punch; and thereby gained tremendous propaganda and political advantages that the United States could ill afford to sacrifice. Much has since been done to repair the damage, but how much better off we would have been if the United States had achieved the distinction of being first in Space! On the other hand, perhaps we needed this shocking blow to our ego and our prestige to initiate the chain reaction that has taken place since then and has resulted in our present Space programs. Let us hope that it will be a sustained reaction!

But, why did we lose the race in the first place? There is no single answer to this question. However, a brief look at the background may prove illuminating. The account to follow is written from the viewpoint of the author, who was one of the participants in the events described, and is offered in full realization of the fact that although this participation resulted in some perceptual advantages, it may very well suffer from bias and lack of full perspective. Nevertheless, there are a few points presented which are not commonly known.

In June of 1954 Commander George W. Hoover, U.S. Navy, an officer in the Air Branch of the Office of Naval Research, assembled together a group of scientists and research administrators to seriously discuss the possibility and the practicability of launching a man-made satellite of the Earth into Space. Commander Hoover had long been interested in this field of science and was convinced that the "state of the art" in the necessary scientific fields was sufficiently advanced to warrant the attempt. Present at the meeting, which lasted several days, were Dr. Wernner Von Braun and several of his associates from Redstone Arsenal, such well known names as Dr. Fred Whipple of the Harvard Observatory, Mr. Alfred Mayo of Douglas Aircraft, Dr. Fred Singer of the University of Maryland, Mr. Fred Durant of the American Rocket Society, a group of Navy personnel from the Office of Naval Research and other Navy activities, and others with varying talents and interests to total about thirty. It did not take long for this group to agree that such a project was indeed feasible. As a result, Project Orbiter was born--the first satellite program in the United States to receive any type of official sanction.

It is well worth noting at this point, that a considerable portion of this initial meeting was devoted to discussion of Soviet potential in satellites, and the frank apprehension on the part of many of those present that the Soviets would achieve the first vehicle in Space. They clearly recognized the propaganda and prestige factors involved, and aside from the unquestioned scientific benefits to be expected, felt that the project was urgently justified for national prestige value if for no other reason!

Among other significant contributions which this group made was the determination of the size (21 inches) and weight of the first satellite, and the requirements for tracking and monitoring stations--both later incorporated into the Vanguard program. It was also decided to use the Army Redstone missile for the first stage of Orbiter, with Army Loki rockets for the second and third stages.

As a result of this meeting several contracts were let, and work began in earnest to ensure the early success of Project Orbiter. Commander Hoover was the project officer. He and his co-workers were confident that they could achieve their objective--an American satellite in orbit within eighteen months to two years--by the end of 1955 or early 1956. Excellent progress was made in this joint venture of the Office of Naval Research and the Army's Redstone Arsenal for almost a year. Funds for the project were limited however because they were not budgeted; so eventually it was necessary to request additional funds from the Department of Defense. The request was modest--only a few million dollars were needed to bring this project, which for the most part utilized already existing hardware, to fruition. Unfortunately however, this requirement for funds ran into a rival request for funds for the same purpose--the request of the United States Committee for the International Geophysical Year, which had also decided that a satellite was feasible but required the assistance of the Department of Defense to be accomplished.

A committee was appointed to study the problem, to review the two approaches (and others) and to decide upon the most practical program. The decision was made to separate the satellite project from military missile programs. This decision meant the demise of Project Orbiter and the birth of Project Vanguard. It also meant that the race with the Soviet Nation was not recognized and/or that we were so smug and complacent about our scientific ascendency over the Soviets that we could best them anyhow; in spite of the fact that Vanguard meant virtually starting from scratch, and because of its greater sophistication, would be much more expensive and require longer to build. In retrospect, it is difficult to see how eminent men could have been so blind! But at least we have Project Orbiter to thank for our first successful satellite--Explorer I. It was no happy accident that the Army was able to launch Explorer within two months of receiving the go-ahead signal--it was really nothing much more than Orbiter with some improvements, still utilizing the Redstone first stage originally contemplated! So much, for what might have been!

During the latter part of 1957 and the early part of 1958 while confusion reigned in the midst of wild ideas, there was much soul reaching and reevaluation of research and development programs among the three Armed Forces. The Air Force reacted most swiftly and the most positively. They, in effect, claimed space as their exclusive domain--it being in their view nothing more than an upward or outward extension of the Earth's atmosphere, entirely ignoring the fact that the vast reaches of space begin where the atmosphere ends. The most significant facet of this Air Force reorientation was seen in a changing philosophy for their long range research program which virtually resulted in the cancellation of all long range research which did not in some way support space projects. Short range or applied research and development continued wherever it was vitally necessary to support current and scheduled aircraft programs--but the vital decision to reorient towards space had been made.

In the Army, for months there was little change; most top officials feeling that the Army had no real interest in space. Furthermore, with the exception of their missile program, they seemed to have little to contribute to a

Space effort. However, it soon became apparent that Space programs and missile programs were very closely related; and that Space offered military potentials which the Army could not ignore--so the Army position changed and they entered the Space arena.

The Navy was probably in the strongest position to forge ahead into space of any of the three services initially. Unlike the Army whose entire Research and Development program was field warfare oriented, and the Air Force whose program was aviation oriented, the Navy had strong programs in both of these areas because of its aviation and Marine Corps interests, plus a broad diversified program oriented around sea warfare--on the surface and beneath it. In addition, because of its interest and investment in Project Vanguard, the Navy was well oriented in space technology. The point to be noted here is the fact that the mere diversity of its Research and Development interests and capabilities gave the Navy the strongest position of departure into the multi-faceted scientific effort which any Space program would require. It had more diversified talent than the other two services. Unfortunately however, this asset was not clearly recognized or exploited. The Navy had too many urgent requirements for its limited funds, and too many groups pressing for those funds--in addition to those rival Navy groups struggling to dominate any Navy Space Program. The result was indecision, and finally the compromise position that no single service should be given cognizance of space matters, but rather, that all should join in a National Space Program. Perhaps this was the soundest possible position, perhaps not; only time will tell.

As related in Chapter I, ARPA was created in early 1958 to guide the entire Department of Defense Space Program.

So far, ARPA has done much to reconcile the rivalries and struggles for funds and position among the Armed Services. The creation of NASA seems to have drawn the line between the military aspects of space and the more purely scientific and/or civilian interests. The question nevertheless arises as to whether these two powerful agencies may not have a stifling effect on the creative imaginations so vital to progress in space programs, when individuals or laboratories must not only surmount the red tape of their own organization, but must fit into the pre-conceived programs of ARPA and NASA, before their ideas can be explored and exploited. It is not beyond the realm of possibility that a sufficient number of military applications of space technology with both offensive and defensive implications will be found to justify the formation of a fourth military service. We will then have rounded out our complement by covering all media; land, sea, air, and space! Already there are a few far sighted individuals, or dreamers (take your choice) who foresee the time in the future when wars will be fought in space--either to gain the more or less conventional "high ground" advantage over an enemy, or because future wars will have so much destructive capability that they could not be waged on earth without jeopardizing the existence of the entire human race!

In the meanwhile the Department of Defense and ARPA are discovering new reasons for going into Space with increasing frequency, in parallel with our increasing capabilities. Foreseen within the next ten years are such advances as the following: (20:220)

A. In vehicle technology, assuming that chemical rockets will remain the backbone of our capability, it is believed that payloads will increase as follows:

1959-	Maximum	useful	payload	about	4,000 lbs.
1960-62	"	"	"	"	8,000 lbs.
1962-64	"	"	"	"	20,000 lbs.
1964-68	"	"	"	"	50,000 lbs.

These payloads will give us a man-in-space capability. It is expected that within the next few years we will have achieved, to a degree at least, the mandatory first objectives of any man-in-space program: safely orbiting and returning a manned capsule, and the determination of man's reactions to space as well as his capability of performing useful functions in space. By the end of the ten year period more sophisticated manned vehicles will have been developed, with man performing numerous essential tasks in connection with various missions--including maneuvering in space, rendezvousing with other satellites, and maneuvering in reentering the atmosphere to land at places more or less of his own choosing.

Also foreseen in the field of vehicle technology for the next decade are one or more advanced propulsion systems such as nuclear rockets, ion rockets, solar boiler rockets, or plasma jets in a limited state of development; while new sources of power such as solar batteries, solar boilers, nuclear reactors and possibly radioactive heat sources will come into use.

B. ARPA believes that such space flight capabilities will result in practical applications such as:

1. Reconnaissance--The use of satellites for strategic and even tactical reconnaissance and surveillance is obviously a military objective of prime importance.

2. Communication--The use of satellite relay stations in many kinds of long distance communications including radio and television will probably begin in a few years. They could eventually become the principal means of intercontinental communications.

3. Very-early-warning satellites may supplement or even replace earthly methods of obtaining early warning of missile attacks; as such they could become a keystone of our defense system.

4. Meteorology--The science of weather observation and prediction will almost certainly be revolutionized and vastly improved through the use of satellites.

5. Navigation--Satellites offer many advantages and new possibilities for navigation improvements for sea, air, and eventually space craft. More accurate maps and charts are also foreseen.

There probably will be other practical applications of satellites either invented or discovered. Who could deny that some of these may be far more important in military technology than anything listed here or yet thought of!

There will certainly be many scientific advances from our advancing space technology; many of these will unquestionably benefit military science--even if only by indirect means. When we look beyond earth satellites and consider what may result from exploration of the moon and the nearby planets, we may well find that our imaginations are incapable of predicting where or how military science might be led.

Before leaving the Department of Defense, it is worth noting an event of perhaps far-reaching significance that occurred recently, and which may very well point a finger in the direction of future Department of Defense thinking and activity. This was the appointment on 24 December 1958 of Doctor Herbert F. York, former Chief Scientist of ARPA to the new key post of Director of Defense Research and Engineering in the Department of Defense. This position is on the same level as the Deputy Secretary of Defense and includes cognizance of all Research and Development in the Armed Forces as well as authority over ARPA. We can assume that Dr. York will not forget about space. Could it be that this appointment has implications far beyond those which are obvious concerning the extent of Department of Defense interest in Space?

CHAPTER III

SPACE FROM THE NAVY'S MISSION VIEWPOINT

If one were to attempt to define the Navy's mission in its simplest possible terms that definition would probably reduce itself down to: The Mission of the Navy is to gain and maintain that degree of control of the waters of the earth which is required in the National Interests of the United States, in peace or in war. Many subordinate missions can be fitted into this broad mission, but probably everyone would agree that the control required includes not only the sea's surface, but the waters beneath the surface and the air above the surface. All are important; any deficiency of control in any of these media could jeopardize the desired totality of control. With this philosophy in mind, it immediately becomes apparent that the Navy <u>must</u> be interested in the space above the seas, and must play a role in the control of and exploitation of space in order to carry out its mission. It is certain that control of the space above the seas by an enemy would at least seriously threaten and perhaps render impossible the Navy's carrying out its mission--especially in view of the fact that most of the Earth's surface is covered by water and is therefore in the Navy's "domain".

This Navy interest in space is therefore inevitable, but does not mean that the Navy should claim space as its operating medium, or seek dominance of the nation's space efforts; there are too many other groups having legitimate interests in space. Space is big enough to accommodate all such interests--and then some! It does mean, however, that the Navy must conduct a searching analysis of its interests in space, and having determined what those interests are, the Navy must pursue a course designed to ensure that its interests are fully exploited and safeguarded. Such a program can never be static but must be carried on continuously; since the pace of technological advance is such that changes will become normal and fixed ideas or policies will become obsolete before they become established. We can expect no less of the Space Age.

In view of these thoughts it behooves us to briefly consider the Navy's present (circa early 1959) thinking as to its current interests in space--even while granting the fact that these interests are in most cases not exclusively those of the Navy nor denying that many of these interests are at the present time highly speculative. Such a listing of interests should certainly include: (17)(20)

1. Meteorology.

An improved knowledge of weather and better weather forecasting would be of immense value to the Navy--no matter how achieved. An earth satellite properly equipped to scan the entire world continuously could obtain information of cloud cover, cloud movements, storm formation, storm location, precipitation, wind direction, and many other measurements and observations that its unique vantage point above the atmosphere makes possible. Weather control techniques might well emerge from this new knowledge which could be of great strategic or tactical significance; for example, if it were possible to raise or lower the temperature of a given area of the earth significantly for any prolonged period of time, we would have at hand a weapon which would make an atomic bomb seem puny by comparison. However, any naval commander would be well satisfied with better weather forecasting to guide him in his operations and planning; and this, at least, seems to be well within the not too distant capabilities to be expected from weather satellites.

2. <u>Communications</u>.

Long range communication in the form of telephone, telegraph, and radio or television is now accomplished by means of land lines, cables, long and short-wave radio, and micro-wave relay stations. The total band-width of land lines, cables and low frequency radio is limited. Short-wave radio bands are crowded and unreliable because of atmospheric interference and ionospheric irregularity. Ultra-short-wave and micro-wave radio is usually limited to line-of-sight range; and long distance communications at these frequencies is commonly achieved only by means of repeater stations.

Satellites should make possible world wide communications by ultra-short-wave or micro-wave radio because the line of sight range at satellite altitudes is very great. The band width and channel capabilities at these wave lengths are sufficient for television and most other foreseeable communications needs. A few such communication satellites properly orbited around the earth could make possible vastly improved world-wide systems for relaying ground to ground, ground to satellite, and satellite to ground transmission of data, messages, voice and television. Some scientists believe that much of this capability could be achieved with large passive reflecting satellites, with no power or electronic receiving and transmitting equipment required. In any event, any and all improvements in communications will be a boom to the Navy.

3. <u>Reconnaissance</u>.

A Navy man's dream of utopia would certainly include a capability for direct observation of everything happening on the surface of the sea (and the air above it). Carrying that dream just a bit further might include satellite scanning and interrogation of a world-wide net of sonobuoys or other devices which were continually monitoring events occuring beneath the surface of the seas. The first possibility does not seem to be particularly fantastic nor technically beyond reach; in fact it seems far more likely that we first will achieve such a surface reconnaissance capability over the seas than over land-- targets being easier to identify over the relatively homogenous sea background than over the heterogenous land background, and much more difficult to conceal than over land. It is not at all unduly optimistic to foresee the time when a few satellites continuously scanning the seas will feed their intelligence to central plotting rooms where a continuous live electronic display will provide Naval Commanders with up to the minute information of the oceans' traffic. Finally, it is likely that a satisfactory missile attack warning system will not be achieved until such time as satellites are sufficiently developed to observe enemy launching sites, whether they be located ashore, afloat or in the air. With no place to hide, such reconnaissance capabilities will certainly change the whole complexion of Naval Warfare.

4. Navigation.

Though men have been traversing the seas for centuries, navigation is still far from being the precise science that is desired; particularly in bad weather, when it is most necessary. Here again artificial satellites placed in precise and predictable orbits could provide navigation fixes which are accurate and attainable under all weather conditions. Radio or radar continuous interrogation of such satellites could provide continuous fixes and would enable continuous position plots on a suitable display so that the commander could ascertain his current position at a glance.

An accompanying bonus from a precision navigation system of this sort would be the improvements possible in geographical accuracy. Even today the precise geography of much of the world is unknown, and this in turn presents formidable target acquisition problems to such weapons as the IRBM and the ICBM.

The commander of a Polaris submarine will need precise fixes on not only his own vessel's position, but on the exact bearing and distance of his target, if he is to obtain reasonable accuracy with his very expensive weapon. The combination of information obtainable from "artificial star" satellites, communication satellites and reconnaisance satellites could readily result in a sequence of events wherein a firing order might be relayed to a Polaris submarine commander, provide him with the precision data necessary to fire his missile accurately, and on the next orbit inform him of the results of his shot! Any one of these potentialities would be of immense value to the Navy.

5. The Problem of Unfriendly Satellites.

It would be short-sighted indeed to only look at the Navy's interests in its own (and other U.S.) satellites. There are already Soviet satellites in space; and there will be others. Certainly some of these will present problems to the Navy which must be considered--and some of these unfriendly satellites will require the devising of countermeasures to be employed against them. The advantages already mentioned which might accrue to the Navy, would certainly be disadvantages if turned against us. For example, a hostile satellite properly equipped and positioned might be used to jam all radio communication; or worse yet, use a high powered radar flooder to jam an entire continental air defense system. Other frightening satellite capabilities when in enemy hands can be readily imagined. In any event, it seems certain that there will be a struggle eventually to dominate space. This means that counter-satellite technology will assume a prominent place in the scheme of things--and the Navy cannot afford to ignore or neglect its vital interests in this corellary of our advance into space!

6. Science. (27)

The nation is now in the early stages of a large effort to develope a space technology. The development of such a technology and of a space exploration capability will not create a new field of science per se, but will allow science to expand into a new medium. The availability of vehicles which can remain for extended periods of time outside the atmosphere of the earth or can travel to great distances from the earth will furnish an unprecedented opportunity for research in many fields of science; just as science has been quick to take advantage of the research and observational opportunities provided by new vehicles and new technologies in the past. The recent development of rocket vehicles is based upon past scientific work. It was not undertaken for scientific purposes, but for military purposes. However, once the technology was established the techniques and vehicles were also used for scientific investigations. Most development of interest to the Navy is possible because of previous scientific and engineering work, but it is certainly not being undertaken for purely scientific purposes.

The Navy now carries out, by contract and in Navy laboratories, a diversified program of high quality scientific research. Much of this program will benefit greatly by taking advantage of space technology once the vehicles and associated communication, tracking and control systems are available. It is essential that the Navy's scientific program have access to the anticipated new facilities and vehicles just as ships, submarines, airplanes, balloons, nuclear reactors, bathyscopes and high energy accelerators are available and used now. No one can foresee future break-throughs; but that they will occur is unquestionable. One's mind can soar when he visualizes the potential of new knowledge of value to the Navy in such purely scientific fields as:

a. Cosmic radiation.

b. Measurement of the magnetic fields of the earth, the sun, the planets, the moon, and fields having their origin in space.

c. Residual atoms in space--composition and abundance.

d. Meteorites and meteoric dust.

e. Solar radiation--its whole spectrum, and its variation and correlation with terrestrial events.

f. Geodesy--configuration of the earth and its land masses.

g. Ionospheric studies.

h. Earth's air glow and aurora--direct observation.

i. Direct astronomical observations unhampered by the earth's atmosphere.

j. Mechanics of the solar system.

k. Tests of cosmological theories.

l. Life on planets.

m. Gravity free environment--its effects on man, on energy, and on materials.

The Navy is in a special position to assume leadership in the long range development of manned space vehicles --the ultimate goal of much of the Space research effort. It has a unique background of operating in the confined spaces of submarines, and is rapidly gaining experience with long submergence under nuclear power. This experience in problems of environment and control, stress physiology, psychology, and other technical factors involved in confined operations gives the Navy a head start in any program of manned space flight. Furthermore, the Navy is in the forefront of technology in all types of man-machine systems, through its programs in human engineering, instrumentation, integrated control systems, psychology and the biological sciences.

While much scientific work must be done to fill gaps in our existing technology, and equipment development must be pursued to demonstrate feasibilities within our technology, scientific studies must certainly be conducted also to solve such problems of manned and unmanned space vehicles as:

a. Re-entry into the earth's atmosphere.

b. Landing control problems.

c. Living under weightless conditions.

d. Power supply for extended flight.

e. Dangers from the external environment.

f. Psychological factors.

Even though the research, development and operational responsibilities of the National Space Program may be centralized elsewhere, what role can and should the Navy assume? As a minimum we should: (1)

1. Initiate analytical systems studies clarifying the impact of these new scientific capabilities on Navy operations;

2. Extend our basic science program into space;

3. Provide for supporting research which will assist the National effort and emphasize Naval applications; and

4. Carry out exploratory development as needed to adapt the National effort to Naval warfare applications. It is only through such a planned long range scientific program that the Navy can be assured of maintaining its rightful place in the Space Age which we are about to enter!

CHAPTER IV

THE PROBLEMS OF UTILIZING SPACE AS AN OPERATING MEDIUM.(3)(28)

So far, in this paper, the word Space has been used rather freely. But, just what are we talking about; what is Space? Space has been called many things--the void, a vacuum, the ether, etc. In fact, it is none of these things. In the first place it is rigidly governed by a complex set of natural laws. In addition, it is far from being empty. Even though the density of Space is very low, space is nevertheless quite cluttered with dust particles, meteors, charged particles, and perhaps many other things as yet unsuspected and undetected. It is certainly full of energy--cosmic radiation, light, electro-magnetic waves, gravitational fields, magnetic fields, electrical fields, and many widely spaced bodies (planets, suns, asteroids, comets) in a high state of continual motion. Probably the best word yet devised to describe the whole unending complex is Cosmos.

The requirements for any kind of flight (if we can use this word) in the cosmos are different from those we have so far encountered in our atmosphere. The means of propulsion must in the first place be independent of the atmosphere. Provision must be made for protecting people, instruments and machinery from the effects of cosmic rays, X-rays, micrometeorites, meteors, and the extreme temperatures that prevail. There must be some substitute for gravity provided for the crews of space vehicles. Space vehicles must be entirely self-sufficient, with fuel provided for traveling unprecedented distances--500,000 miles for a round trip to the moon, millions of miles to the nearer planets, a matter of light years to the closest star--and even after such journeys these vehicles must be able to reenter the Earth's atmosphere and land safely at more or less conventional speeds!

Weight in space flight is hypercritical. The extremely complex equipment must be light and occupy a minimum of space. In spite of these requirements this equipment must perform its colossal tasks under the most rigorous conditions with a reliability seldom, if ever, required of any previous man-made devices.

The standards of performance of the hardware, the scientific and engineering approaches, the combinations of technologies, and even the basic concepts are alien to our earth-bound mentality. Pumps, valves, flow meters, flexible tubing--just the plumbing of a liquid propellant rocket --must operate with exacting precision both at ordinary temperatures and at the biting minus 297°F of liquid oxygen. Propellants, sometimes at the rate of one ton per second, must flow into the combustion chambers in exacting amounts and proportions. Electronic circuitry, control systems, the plumbing, and the basic structure of the rocket itself must contend with vibrations having intensities of plus or minus 100g's and with frequencies on the order of 400-600 times a second. Ceramic, metal and plastic parts may have to withstand temperatures of thousands of degrees, the eroding effects of high velocity gases, and internal pressures that have caused many of the most carefully made rocket motors to explode.

There are problems ad nauseum. The distances around our own solar system are tremendous by earthly standards, but small in astronomical terms. The speeds needed to traverse these distances are completely incompatible with flight within our atmosphere. Yet, space vehicles will have to take off from the surface of the earth, and if manned, return to earth passing through a couple of hundred miles of atmosphere each way. Velocities in tens or hundreds of thousands of miles per hour will have to be attained for space flights, yet be capable of being reduced to hundreds of miles per hour upon reentry. Otherwise, the vehicle and its payload (living or otherwise) will burn and disintegrate in a glittering incandescent streak across the sky. Everywhere there is a need for new ideas, original approaches, and the most critical precision manufacturing requirements ever conceived.

A glance at the physical data on the principal bodies of the solar system is most sobering. In this single table (28:10) is truly revealed the stupendous task we are contemplating when we aspire to space travels within our own solar system--which is only one star system within our galaxy.

Body	Mean Distance from sun (Earths dist. equals 1.00)	Mass (Earths mass equals 1.00)	Diameter (Statute miles)	Gravitational force at solid surface (in g's)
Sun		329,000	864,000	(a)
Mercury	0.39	.05	3,100	0.3
Venus	0.72	0.82	7,500	0.91
Earth	1.0	1.0	7,920	1.0
Mars	1.52	0.11	4,150	0.38
Jupiter	5.2	317	87,000	(b)
Saturn	9.5	95	71,500	(b)
Uranus	19.2	15	32,000	(b)
Neptune	30.0	17	31,000	(b)
Pluto	39.0	0.8	?	?
Moon	1.00	0.012	2,160	0.17

Body	Intensity of sunlight at mean distance (Earths equalls 1.00)	Length of Day	Length of Year	Number of moons
Sun	---	---	---	---
Mercury	6.7	88 days	88 days	0
Venus	1.9	?	225 days	0
Earth	1.0	24 hrs	365 days	1
Mars	0.43	24.6 hrs	1.9 years	2
Jupiter	0.037	10 hrs	12 years	12
Saturn	0.011	10 hrs	29 years	9
Uranus	0.0027	11 hrs	84 years	5
Neptune	0.0011	16 hrs	165 years	2
Pluto	0.006	?	248 years	0 (?)
Moon	1.0	27 days	---	0

(a) No solid surface
(b) Location of solid surface (below thousands of miles of dense atmospheric gases covering these planets) is not known; hence, surface gravity figures are meaningless for the four giant planets.

To even consider going beyond our own solar system becomes quite incomprehensible when we realize that there are some $2X10^{11}$ stars (suns) in our galaxy, with one to ten billion of these possibly having planetary systems. Out of this vast number there surely must be some systems with earth-like planets; and on some of these, life similar to our own may have evolved.

> With our present state of knowledge, however, even communication with such planetary systems is a matter of speculation only. When we recall that our galaxy is some 100,000 light years in diameter, the sun being an insignificant star some 30,000 light years from the galactic center, circling in an orbit of its own every 200 million years as the galaxy rotates, we realize that even trying to visualize the tremendous scale of the universe beyond the solar system is difficult, let alone trying to attempt physical exploration and communication. Nor is the interstellar space of our galaxy the end, for beyond are the millions of other gallaxies all apparently rushing away from one another at fantastic speeds; and the limits of the telescopically observable universe extend at least two billion light years from us in all directions. (28:18)

Space presents problems, more problems, and problems almost without number. This brief paper does not permit anything like adequate consideration of any of these conundrums; however, brief mention can be made of some of them for illustrative purposes at least. So far we have taken a glimpse at the space environment. Others would include:

1. Trajectories and Orbits.

Before a space vehicle is launched it must be determined where we want the vehicle to go. All kinds of possible trajectories (point to point), and orbits (repetitive paths around another body), can be conceived. We may desire to orbit the earth, the moon, the sun, or a specified planet; or we may merely desire to reach an extraterrestrial body. In any case precision is desired: and this in turn requires exacting knowledge in many fields of science. Approximations may satisfy us at present, but eventually precision will be mandatory. Predictable flight paths and adequate orientation control are far from satisfactorily attainable to date.

2. Propellants and Propulsion Systems.

The only presently known way to meet space flight velocity requirements is through the use of the rocket in one of its various forms. There eventually may be developed other means of propulsion for space vehicles once they are actually in space; but to get there in the first place would seem to require rocket power for the foreseeable future. As far as chemical rockets are concerned, their performance depends upon two factors; the specific impulse (amount of propellant needed to accomplish a given task) and the fixed weight of the engine (including tankage, power supply and structure). Chemical propellants now in use deliver a relatively low specific impulse--around 250 seconds; and while improvements will certainly occur, specific impulses above 400 seconds (even from some as-yet-undiscovered super-fuel) are unlikely. Nuclear rocket engines are potentially more promising, perhaps yielding specific impulses up to 1,000 seconds; however temperature limitations of wall materials are handicaps at present.

No prospects are apparent for "anti-gravity" devices because the negation or reversal of the gravitational attraction of matter would violate basic physical laws as we now know them. The notion of anti-gravity now stands in a state similar to that of the perpetual motion machine. (28:40)

3. Internal Power Sources.

All space vehicles will require some source of electrical power for operation of communication equipment, environmental control, instrumentation, etc. Some may even need power for electrical propulsion systems. Current satellites have low power requirements; but, inevitably, power requirements will increase as space vehicles become more sophisticated. For example, a television broadcast from the moon, or an instrumentation link to Mars would require not watts, but kilowatts of power. In addition power requirements must be keyed to peak loads--not average loads, such as during occasional operation of a radio transmitter. Voltage will also be a problem; since different pieces of equipment will have different requirements; and if both direct and alternating currents are required there will be a transformer problem. For these reasons alone, not to mention the durability requirements, it seems likely that the presently used batteries of various sorts will eventually be replaced by solar power converters and/or nuclear power (already under development).

4. Guidance.

Space vehicles will require guidance if they are ever to serve really useful functions. This guidance may be external, internal (manned vehicles), or a combination of both. In any event we shall have to learn to exactly measure vehicle position and velocity, compute the control actions necessary to alter position and velocity, and to deliver the proper adjustment commands to the control system of the vehicle. The accuracy of guidance required--whether in the initial, mid-course or terminal phase of flight is extremely critical. For example, the following table gives the miss distances calculated for one foot per second error in the magnitude of velocity at thrust cutoff: (28:70)

Miss Distances

Destination	Nautical Miles
Point on earth (5,500 mi. ICBM)	1
Moon	20-100
Mercury	40,000
Venus	25,000
Mars	20,000
Jupiter	65,000
Saturn	200,000
Uranus	700,000

!!!!!

It is apparent, that guidance will be of extreme importance in the military applications of space technology. If we are to have reliable navigation, reconnaissance, and communication satellites it is mandatory that they be precisely positioned. If two satellites are to rendezvous--to build or supply a space station, or to intercept and destroy an enemy satellite--guidance is a primary requirement. If we are to ever achieve a colony on the Moon or a nearby planet, precision guidance is a must!

5. Communication.

Although there have already been spectacular achievements in communication with our present primitive space vehicles, there still remain important and difficult research and development areas in communications which are challenging, to say the least. The space environment alone presents difficulties which complicate the picture. The vast distances involved are unique to space. Reliability requirements for long unattended operations, plus the probable lack of adequate spare parts in a manned vehicle, calls for quality control never before contemplated. Finally, data processing, storage, coding, and retrieval is a whole field of technology which we have just begun to understand and use advantageously. Yet, without adequate data handling and communication of that data back to earth, we will fall far short of realizing the maximum from our expensive "toys".

6. Landing and Recovery.

A whole treatise could be written on these problem areas alone. For our present purposes only a few pertinent observations need be made. First, our experiences with these problems to date have been generally unsatisfactory. In addition to the difficulties encountered through aerodynamic heating when re-entering the atmosphere, we have been notably unsuccessful in most instances in our efforts to find and recover even our missile nose cones which have been fired into only the lower fringes of space for brief periods. Secondly, until the landing and recovery problem is solved, we will not reap the full benefits of scientific knowledge which could be gained from our satellites. Think what could be gained from the recovery of photographic film, for example. Thirdly, manned space flight will inevitably be deferred until landing and recovery techniques are assured. At this point, our space medicine men would be delighted to recover even the badly charred remains of one small mouse. There is quite a gap to be closed before we put our first man into space! Let us hope that the forthcoming X-15 manned flights will provide some clues to the solution of these vexing problems.

7. Cost Factors and Ground Facilities.

If there is one thing certain about the cost of space programs, it is the fact that the dollars involved are commensurate with the astronomical distances in space! Already the missile (and space) industry is the largest in the United States; with the future unlikely to bring about anything but an increase in the size of this new giant. It must be recognized that space flight programs will be expensive, even when using many primary components already perfected as part of the military missile program. At present, the carry-over from weapons system programs is our chief asset in astronautics. But there are many hidden costs in our space programs--super-priority effort, construction and testing of prototype items, the lack of applicability of mass production techniques, ground support equipment and facilities, scarce but highly trained personnel requirements, research and development into new areas of science and technology, operation of test ranges and tracking stations--and many others.

The launching of rockets with payloads up to 100,000 pounds or more are being discussed. The propellants for such vehicles may be millions of pounds of dangerous highly energetic chemicals, raising some rather considerable safety problems and requiring a great deal of space around launch sites. This brings up the interesting possibility (to the Navy especially) of constructing artificial islands off shore as relatively inexpensive launching sites for hazardous systems. Sea ranges are also advantageous for testing purposes; and here again is a new Naval problem, for who else will man the tracking, monitoring, guidance and recovery vessels required on these vast sea ranges? But it all costs money.

In conclusion we must reiterate--problems, more problems, and problems without number!

CHAPTER V

MAN IN SPACE

Throughout all of human history man has lived, loved, dreamed, played, fought, and died right here on Earth. And, in a restless sort of way, he has been content. With a few rare exceptions, he has never even contemplated the possibility of an alternative. Now, quietly and in the logical course of events, yet suddenly in the profoundness of its implications, he has another, and startling, second choice. Space beckons, with all of its vast potential. In the next few decades there is no aspect of human thought or activity that will not be affected by this incipient second phase of man's chronicle.

Why should man go into space? The best answers seem to be, "Because it's there"; or, "Why should we not do it"? And there are other reasons perhaps even more pragmatic; such as fear--fear that the Russians might beat us to it and thus gain a military ascendacy which we would be powerless to resist; or perhaps there is one of even more vital long term importance--the quest for knowledge. All of these reasons, the spirit of adventure, military necessity, and scientific curiosity compel man to seek escape from the confines of the Earth. Perhaps the prophecy of the 19th. Century Russian space flight pioneer, Konstantine E. Tsiolkovski will become true: "The Earth is the cradle of the mind, but one cannot live forever in a cradle"! (3)

In contemplating the problem posed by attempting to put a man into space however, it becomes immediately clear that there is no real reason whatsoever for putting him there other than to make maximum use of man's unique capabilities. The automation possible through modern technology is not a complete or satisfying answer to Space flight. The answer seems to lie in a clever combination of fully automatic equipment and the reasoning power of man. Only if we let the automatic equipment do what it can do better and let man do what he can do best, can we find the correct answer to space flight. Space will be conquered by man, not by unattended automatic machines.

This premise immediately dictates the necessity for designing man-carrying space vehicles around the man and his requirements rather than having to modify and distort man to fulfill the needs of the vehicles. It is evident that any stop-gap procedures necessary in trying to adapt man into an environment or situation not designed to meet his requirements is inadequate. Man's requirement in space will vary with the type of vehicle considered, the mission to be performed, and the time of continuous operation. Of these variables, the most significant is the "time in space" factor which dictates the breadth of the aeromedical problem involved in any of the other variables.

In accordance with American National philosophy and policy, it is unthinkable for us to contemplate putting a man into a space vehicle unless we can assure ourselves (and him) that there is a reasonable likelihood that he will survive the experience; i.e., we must be sure that we can get him back. It therefore becomes evident that the first and most important problem to be solved in putting a man into space is the solution of the recovery problem. When a satisfactory solution to this problem (which involves primarily the combined stresses of deceleration and heat) is attained, then we can consider the other aspects of manned-space flight which revolve around the ever important determination of how long he is to stay in space. This does not mean that the recovery problem must be solved prior to pursuing work on the other problems, however.

To emphasize the time parameter mentioned above, it should be pointed out that a space vehicle is uniquely different from any other vehicle designed for man in that it must provide and carry with it all of the environment and materials needed for man's existence and performance of a mission. There is no air surrounding a space vehicle. There is no water surrounding a space vehicle. There is literally nothing in space of a material nature which can be in anyway used to sustain life in man. In many ways this problem becomes one of logistics. The logistics of a space vehicle which makes a few orbits around the earth and returns in the course of a few hours do not appear to be formidable or beyond present-day capabilities. It is probable that the logistic problems are soluble up to a flight of a week or two if the development of proper techniques is pursued vigorously. Beyond this point, however, when one contemplates the logistics of keeping a man in space for many weeks or months, the problems involved will require extensive long-range research and development before adequate solutions are obtained. Such a program can only be accomplished through the following logical steps:

1. A clear definition of the problem;

2. A complete statement of the requirements for habitability, operation, and maintenance;

3. The initiation of a balanced inter-disciplinary research program designed to meet these requirements <u>without compromise</u>.

Any other approach can only result in a continuation of the present effort to adapt man to a stressful environment rather than tailoring the environment to <u>man's</u> requirement.

The major problems and research areas in space medicine are as follows:

1. <u>The Provision of an Adequate Gaseous Atmosphere to Support Man's Respiratory Requirements.</u> This means that he must have available a continuous supply of oxygen fed to him under adequate pressure for him to utilize it; and at the same time provide means of removing the carbon dioxide and other noxious or toxic gases which he produces. It will probably also be necessary to provide nitrogen (or possibly helium) to this gaseous environment in order to properly dilute the oxygen and carbon dioxide, and to prevent oxygen poisoning. This balanced atmosphere must be continually maintained. For short flights this can probably be taken care of by carrying along the entire amount of oxygen needed for the flight, and the provision of some chemical or mechanical means for removing carbon dioxide from the air. Longer flights will require a self-contained regenerative system which will produce adequate amounts of oxygen and remove the carbon dioxide. A photosynthetic gas exchanger at present seems to be the most reasonable approach to the solution of this long-range problem.

2. <u>The Second Problem is that of Acceleration and Deceleration.</u> It is believed that man can be properly positioned and protected against the acceleration force which may be encountered in launching a space vehicle. The deceleration problem which will only be encountered during reentry is probably more formidable because it is during this phase that it will be most desirable to use man's performance capabilities to the utmost. His performance under high decelerative forces must not be appreciably impaired. The acceleration phase, on the other hand, can probably be accomplished through automatic means in which man will have to exercise only a minimal control function.

3. Nutrition Requirements. For a short space flight, the nutritional requirement of man is rather simple. It is comparable to that existing at present in airplanes and can be solved through the same means. On longer flights, however, the problem becomes formidable by reason of the bulk and weight of the food and water required. A normal individual in an average environment has a water turnover of about two and one-half liters per day, which represents an irreducible minimum water consumption in one form or another of five pounds per man per day. It could become a matter of extreme importance to devise a system for recycling water through the spaceman not only to conserve water, but to avoid the discomfort of continuous existence in an atmosphere saturated with water vapor which is lost through perspiration and respiration. The food requirement on a continual basis amounts to at least 2,500 calories per day which is on the order of a dry weight of pure carbohydrate, protein and fat of about one pound per day. This is tolerable for only short periods because of the palatability factor which might easily bring the daily weight requirement for food up to well over two pounds per day. This basic food requirement does not include dietary supplements such as minerals, vitamins, etc.

4. Environmental Temperature. This presents a problem which, in theory sounds easy but in practice may be quite difficult of solution. If one accepts the extreme temperatures encountered during launch and reentry, the environmental temperature problem resolves itself down to that of maintaining an ambient temperature within the space vehicle at the optimal level of 65°F. plus or minus 10°. Maintaining this temperature will be necessary for optimal performance of the occupant over any prolonged period of time.

5. <u>The Psychological Aspects</u>. Individuals vary widely in their ability to tolerate the stress of confinement. What is easily tolerable for a matter of hours becomes borderline in a very few days and becomes intolerable over a period of weeks or months. The environment provided must be tolerable for the time period of the flight involved. It must provide for relaxation, exercise, and recreation, as well as for continuous performance of tasks. It must provide for sleep. It is likely that, for all flights lasting more than a few hours, provision must be made for several individuals in the crew rather than for a single individual. There is comfort in numbers as well as increased performance capability. A single individual cannot for more than a few days <u>continually</u> perform a useful function. It is therefore mandatory that other crew members be provided for.

6. <u>Personnel</u>. It seems evident that the number of people who will be involved in space travel for the foreseeable future will be very small. More important, however, is the necessity for most careful selection of prospective spacemen both from the physical, motivational and psychological viewpoint. Training to best fit them for withstanding the stresses to which they will be exposed will be required. Simulation of their new environment, acclimatization to that environment and finally conditioning for the flight will be needed. This conditioning might very well involve not merely training and simulation techniques, but special dietary preparation and the use of selected drugs.

7. <u>Waste Disposal</u>. While it is perfectly possible for the problem of waste disposal to be ignored in flights of short duration; this is not true of those extending for more than six hours. Man cannot function adequately without provision being made for the elimination of human excreta. A means for recycling these wastes and deriving some useful

benefit from these substances has yet to be devised. Yet, if this is not done, it means that eventually all of the food and water provided for the occupant will eventually become waste; and even if this were tolerable, the problem of disposing of it in a satisfactory manner is formidable.

8. Weightlessness. It is believed that the no-gravity state is a condition which can be tolerated by man for brief periods of time. Again, the unknown variable is time--for how long can this be tolerated? What are the effects upon circulation, digestion, orientation, performance and equilibrium? In any event, weightlessness is an unnatural state for man, and must be eliminated from his environment if he is to perform as a man. There are several possible techniques for approaching this problem; the best of which seem to be the provision of an artificial gravity medium through centrifugation. It is quite likely that the presence of only a fraction of terrestrial g force may be all that is required, and that man may in many respects be able to perform his tasks far better in a fractional g environment than he does normally.

9. Radiation Effects. In view of the fact that a space vehicle will provide an impermeable shield around its occupants, this fact in itself will provide shielding against many possible harmful radiations; certainly against ultraviolet, infra-red and soft X-rays. This, however, is not true of cosmic radiation, neutrons and gamma rays. The hazards of these forms of radiation are, as yet, incompletely evaluated. It would appear, however, that this will resolve itself down to a dosage problem and this, in turn, is coupled with our old friend the time problem. Certainly, man can withstand small amounts of these forms of radiation for short periods of time. The intensity of the field, and the time, will determine the ultimate effects on man. Shielding of

an adequate nature as we know it on earth does not seem practicable in the space vehicle against these forms of radiation, because of the mass of material required.

The above-mentioned areas present the more commonly accepted problems attendent upon manned-space flight. There are certainly many others which have been mentioned in the past, and there is the likelihood that as our technology in this whole area of space flight advances, we will become aware of other problems as yet unknown. It would appear, if we hope to get a man into space in the reasonably near future (or ever), that we must pursue a vigorous program of research in the bio-medical problems of space flight. While a great many of these problems can be approached, and have been approached, over a period of years in laboratories on the ground, it is becoming increasingly evident that we must take advantage of every satellite vehicle now in existence or proposed for the future, in order to carry out appropriate bio-medical and psychological experimentation. It is only through a complete understanding of the problems involved, and the slow progression from exploratory experimentation and the development of an adequate environment to meet man's requirements, that the goal of putting man into space can be achieved. It won't be easy!

We gain much by putting man into space. (6)

Man has a perceptual constancy. He is able to recognize patterns and objects despite changes in size, orientation, hue, and contrast. He is sensitive to a wide variety of inputs such as vision, hearing, touch, vibration, pressure, linear and angular accelerations. He is able to deal with low probability alternatives and unexpected events. It is factually not feasible to anticipate and program all possible alternative situations into automatic systems. Man takes advantage of time, redundency, and sequencial dependencies and thus profits from his experiences. He shows originality in discovering and putting to use data and intelligence gathered incidental to the mission. He is flexible, can improvise, reprogram and even change performance tolerances. He has preservation instincts for himself, the vehicle, and for the mission. He can tolerate temporary overloads without disruption, and can select and filter inputs. He is capable of inductive reasoning, of setting up and verifying generalizing hypotheses. He can find and identify signals in a wide variety of noise patterns and spectra. He is harder to jam than automatic equipment. All of this, and much more, is man!

In order to go where we wish in space we have to maneuver; and through the reasoning power of the crew we have that ability. If we were flying in space with tremendous speed and a trajectory fixed at burn-out, we would be bound to a definite fixed track, with no room for error. But flying time in space is long. We do not have to make flight path corrections suddenly, using full force. There is time, after the necessary calculations have been made, to do it with small forces over a long period of time. Visual outside information, with the exception of stellar navigation data, will be of no help. The task of a crew in a space ship will be to monitor, to supervise, to readjust, to over-ride, and to repair equipment and instruments. Through the judgement and reasoning power of the crew, necessary corrections to the flight path can be instigated.

They will have to act with alertness, speed and accuracy. They will have to obtain and interpret information concerning vehicle operation, cabin environment, personnel functioning, and anticipate difficulties by advance planning and action. They will have to check, test, and observe all scientific instruments. Finally, in coming back, they probably will have to land the ship safely on Earth.

To accomplish all of this when we take man into space we must do away with the sardine-can approach, with men crowded into, and immobilized, in a tiny sealed capsule. We must give him space enough to live comfortably for quite some time. The human crew can increase the effectiveness of future space systems by providing unique capabilities which cannot be replaced by automatic mechanisms. This effectiveness can be attained by providing a satisfactory environment to insure crew safety and performance. Man can provide those high qualities of intelligence, initiative, ingenuity, judgement and decision-making which are vital to the future conquest of Space. And please don't forget that none of our other assets can compete with man in being mass produced, cheaply, and by unskilled labor!

SUMMARY

The important thing regarding space is not *what* men are thinking of; but the fact that they *are* thinking. This paper has attempted to sketch for the uninitiated some of the thinking that has taken place, some of the events that have occurred in the past, some of the problems, and some of the future possibilities and trends which might serve as guideposts for the future. But any such effort must clearly recognize the fact that we have so far entered upon only the most elementary stages of thinking about, and action directed towards, the conquest of space. It can be safely asserted that the whole of todays younger generation (at least) will be eye-witnesses of the first epoch making advance of man into space. When? In two years or twenty years, or maybe in fifty, depending upon the money and resources that are put into the project.

In the lifetime of all of us we have witnessed technological advances which would have been dismissed as the most bizerre sort of dreaming even a very few years before the break-throughs occurred. The pace is constantly accelerating and not likely to slow down or reverse itself. We seem to be entering another era in which quantum break-throughs are not only possible, but, probable. Fortunately, the United States as a Nation seems to have grasped at least part of the significance of what has occurred, what is occurring, and (both hopefully and fearfully) of what is likely to occur in the future. We have made a reasonable start in organizing ourselves to cope with the situation at a national level. We are busily engaged in working on a broad spectrum of military efforts to regain our lost leadership back from the Soviets at the Department of Defense level.

The Navy, which was initially in an enviable position to forge ahead rapidly into the new medium of space, seems to have forgotten some of the lessons of naval strategy and tactics--as well as the lessons of history. It long ago learned to suit its capabilities to its operating medium--whether that medium was on the surface of land or sea, beneath the surface of the sea, or in the air above land or sea. And the Navy learned that denying the enemy access to these operating media was a sure way to achieve ultimate victory--if it were done in time. In the case of space it seems not to have been realized that here is another medium which we can ill afford to ignore, minimize, or permit a potential enemy to gain ascendency in; while we remain tied, to "conventional" operating media. Time's a wasting!

As far as the scientific opportunities offered by space for exploitation are concerned, horizons are unlimited. The consequences of failure to meet the challenge can be catastrophic; but the promises of achievement are great. In many areas of science space offers an opportunity which must be realized. For example, weightlessness will prevail there--with all of its singular effects. All of our scientific and technical knowledge is based on the existence of the force of gravity. While many phenomena will occur whether gravity is present or not, many would certainly display new phenomena in its absence. It is most interesting to imagine a scientific and technical world without gravity; but we certainly cannot afford to <u>not</u> know of the consequences. Nor can we risk not knowing of the experiments and observations that can be carried out uniquity in Space such as: low temperature research wherein fantastically low temperatures can be maintained as long as desired and to any degree--not for the brief periods possible on earth; astronomical studies conducted in a medium free of the interference of the earth and its atmosphere; and the studies of all sorts of rays, particles and forces which certainly exist in a "purer" state, and perhaps in greater variety, than we have been able to discover in or from our earth-bound environment.

The greatest adventure of them all certainly lies in man's invasion of space. In addition to the challenges offered by the attempt to put man into space, we will require man's presence in space to exploit to the full degree the potentials offered by space for the benefit, or the detriment, of mankind. The opportunities offered for peace, for war, or for science will require the infinitely sound judgement and the capability, which only can be achieved by man's presence in space; if the inherent promise of the Space Age is to be fully exploited.

While space hardly seems at present to offer much to appeal to the esthetic sense of man, perhaps even this aspect of our existence will be profoundly effected by future events. In support of this thesis is one of the few spatial invasions of the world of literature which has come to the author's attention; and yet seems to contain the proper spirit of the times with which to conclude this glimpse into what the future may hold in store for all of us:

> Whither away, oh care worn world.
> What is to be thy fate?
> A dead and forgotten planet.
> On its eternal journey throughout space?
> Or the revered home of galactic civilization
> Fulfilling thy intended destiny!
> The hour of decision is at hand
> And the road is clearly marked.
> What is the answer, fellow man? (4:71)

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