The Challenge of the Space Age

Separating the sense from the nonsense about space travel

by L. A. DuBridge

Within the past few months the space age has dawned. Many people of varying degrees of competence have ventured to peer into the future and make predictions as to where we are going. Needless to say, these predictions do not all agree with one another—and yet, to some extent, to visualize the challenges of the space age we must make a choice as to which of these predictions we are going to believe.

Now who am I to try to make such a choice? I am not a rocket technologist or a space engineer. But the problem of calculating approximate satellite orbits in space is a simple problem in classical physics! The theory was all worked out by Kepler and Newton nearly 300 years ago—and no quantum mechanics or relativity or meson theory or similar erudite subjects are necessary to understand the elements of the problem.

This is a very fortunate situation. We will probably be spending a lot of money on space technology in the coming years, and it is comforting to know that we need not be at the mercy of a lot of so-called experts. If someone makes a statement about some phenomenon having to do with space travel, we can get the nearest high school or college physics teacher to tell us whether the statement is right or not. It may take an expert engineer to tell us how much some of these things are going to cost, but there do not need to be any mysteries about how things behave once they get into space.

First, I suppose everyone realizes that the earth's gravitational field does not stop at the top of the atmosphere 100 or so miles up. Rather, it extends for hundreds of thousands, even millions of miles into space, falling off in intensity inversely as the square of the distance from the earth's center. Even if we get away from the earth's field we are still in the field of the sun, which extends out a very long way indeed.

From these simple facts there follows at once a very important conclusion: There is no such thing possible as a *stationary* object in space. Everything in space is moving. An object stationary with respect to the earth, for example, would promptly fall into the earth, pulled by gravity. The only objects which can stay in space are moving objects—specifically, objects moving in such a way that the gravitational force on them is, on the average, balanced by a centrifugal reaction. Under these conditions a permanent path or orbit may be established about the attracting center—and such an orbit is always an ellipse or, in special cases, a circle, which is one kind of an ellipse. Stationary "space platforms" are a Buck Rogers myth.

There is also a precise relation between the period of the orbit—that is, the time required to travel once around it—and its average height above the earth, or more precisely, its major axis. Thus, for an orbit only 200 miles above the earth the period is always about 92 minutes; for an orbit averaging 1,000 miles above the surface, the period is 118 minutes. At about 20,000 miles the period is 24 hours; and of course at the distance of the moon, 240,000 miles, the period is the moon's period, 28 days.

The farther you are away from the earth, the slower is the speed required for a stable orbit, and the longer it takes to traverse it.

If, for example, you wish to establish an object in a very elliptical orbit which goes out as far as the moon and back, the period in that orbit (an ellipse whose major axis is about 240,000 miles) turns out to be very nearly 10 days—5 days out and 5 days back.

It has now been established that modern rocket technology has advanced to the point where it is possible to project into stable orbits about the earth objects of substantial weight—say, in the near future, up to 1,000 pounds or so. With a somewhat smaller payload the orbit could be sufficiently elliptical to reach to the vicinity of the moon.

A scientist cannot help but be excited by this prospect. Every now and then new advances in technology give science a new tool for research. The earth satellite is a tool *par excellence.* It opens up wholly new areas of scientific exploration—and America has a great opportunity to grasp these opportunities promptly and boldly.

Promising explorations

Just what scientific explorations are most promising?

To the layman who wants us to establish a colony on the moon next month, the experiments I have in mind may seem a bit less than bold. But, in contrast to some of the more fabulous schemes now being discussed, the ones I propose have the virtue of being both feasible and useful.

First, from the vantage point of an earth satellite we can learn a great deal about our own earth. We can learn more about its exact shape and size and the distances between important points. We can learn more about its gravitational anomalies, which are important in many types of geophysical explorations. Of even more practical value, we can learn more about the weather. The great meteorological patterns of storms and air currents which are so difficult to see from the surface will become much more understandable when we have observations from above the atmosphere.

The earth's magnetic field—its nature, variations and origin—also constitutes a scientific puzzle which observations a few hundred or a few thousand miles out into space will certainly help solve. To what extent is the field connected with electric currents in the ionosphere? What is the precise nature and extent of the ionosphere itself? How will radio waves behave when bounced off the top of the ionosphere? What happens as they pass through it? To what extent and in what way is the ionosphere affected by radiations from the sun—by solar flares and other eruptions, for example? Can these effects be related to radio propagation on the earth?—to the weather?—to high altitude jet stream winds?

Again, a whole book could be written about what the astronomers would like to do with a telescope which is above the atmosphere and which could see the heavens for the first time unaffected by the disturbances, the distortions, the absorption and the stray radiations of our blanket of air. The problems of stabilizing a telescope on a satellite in order to get good pictures are not easy. And the problems of transmitting pictures of good quality back to earth, presumably through some type of radio-photo technique, are even more difficult.

But these are problems which can be solved in time, and there is much to be done even with relatively crude techniques. Man has never been able to measure directly the ultraviolet light from the sun, for example, since it is all absorbed at very high levels in the atmosphere. Even crude pictures of the sun taken in ultraviolet light would be of great interest, and would help us understand some of the complex processes going on in sunspots and solar flares.

And then there are the cosmic ray problems, such as those being examined in the first U.S. satellites, Explorers I and II. The effects which primary cosmic rays produce in our atmosphere are so complex that these secondary phenomena delayed for 20 years our understanding of the true nature of the primary cosmic rays themselves. To observe these primaries for the first time on a continuous basis, completely unencumbered by the multiplicity of secondary phenomena which occur when they strike the air, will advance enormously our knowledge of their nature and origin—and this may help us unravel some of the deep puzzles about the origin and evolution of the universe, of our galaxy and our solar system.

I have said that experiments and observations such as these and many more are technically feasible. Many of them are feasible right now with satellites weighing only from 50 to a few hundred pounds. But there are a number of technical difficulties which will be with us for a long time. One, of course, is the unreliability of the rockets which launch these objects. These rockets are bound to be big and expensive devices, and it is important that we do not lose half of our experiments through technical failures of the rockets themselves. It will be some time before even a 50 percent overall reliability can be achieved, I am told. And 90 percent is still in the future.

Providing an energy source

An even more troublesome problem is that of providing an energy source to power the various satellite experiments and to transmit the intelligence by radio back to earth. Thanks to the development of extremely sensitive receiving techniques, we can use radio signals from a satellite transmitted with a power of only 1/100 of a watt—provided the distance from the earth does not exceed a few hundred miles. Even the 20-pound payload of Explorer I has enough batteries to power such a transmitter for two months or so. But the Explorer I satellite itself will stay in orbit for many years—and it is exasperating to have all those valuable instruments, gotten up there at such great expense, remain completely useless all that time. And as we project objects farther out into space and put more complex equipment aboard, we will need not only longer life, but also much more power.

To detect a radio transmitter which is near the moon, for example, may require a power not of .01 watt but of 10 watts—1,000 times as much. We don't need to transmit signals all the time; we can develop more efficient batteries; we can put more batteries in the larger vehicles and use solar batteries. But the fact remains that the limit to how much information we can obtain from scientific satellites will be set primarily by the strength of the energy source they can carry along. Even solar batteries cannot provide large amounts of power in moderate-size units—and, of course, they cease to operate when the satellite enters the earth's shadow.

If the problem of energy sources looks pretty difficult for satellites requiring only a couple of watts for a few weeks, think of the colossal problems facing us when we try to plan more extensive and complex space expeditions. The great hero of the space age will be the man who invents an extremely compact device for storing quite large amounts of energy. None is now in sight.

So far I have said nothing about satellites which carry human beings. The reason is simple. For most scientific explorations in space the presence of man involves quite unwarranted complications and expense not justified by what he can contribute to the success of the venture. True, a man makes a pretty good servo system; he could keep a telescope pointed at the right star, for instance. He could also supply a little bit of energy—by turning a crank connected with a dynamo to charge up a battery, possibly. But in return for this he demands a colossal price. He not only requires that we take along air and water and food and other things to keep him alive and comfortable, *but he also requires fantastically expensive* provisions to bring him back alive.

Man against instruments

No set of *instruments* demands such a ridiculously expensive luxury. Instruments are content to coast around in space, unused and unattended for years, and then to come back to earth, if at all, in a fiery cataclysm. But not a man! He wants to get back to earth, and he wants to get back not only unburnt but essentially unjarred as well.

I assure you this is not easy, and we are a long way from having the facilities to do it in any practical way. Consider a satellite vehicle rotating in an orbit some 200 to 400 miles above the earth. Its speed will have to be in the neighborhood of 18,000 miles per hour, or 5 miles per second. Suppose this vehicle is large enough to carry a man, and the man now wants to return to earth. How does he do it? Obviously, jumping out of the vehicle with a parachute and an oxygen tank won't do it. There is no air to affect the parachute, so our man would become another satellite floating alive around the earth at 18,000 miles per hour—alive, that is, until his oxygen gave out.

No—he'd better stay in his vehicle. He will then find he needs a sizable rocket motor and a good deal of unused fuel so he can reduce his speed and lower himself gently into the atmosphere, where his parachute may be used. This is no mean trick, and it will require a large amount of rocket propellant—all of which will have had to be a part of the payload with which he was launched in the first place. So the initial payload will have to be, not a few hundred pounds, but many thousand pounds—and, of course, the size of our launching rocket has increased proportionately.

But let us interrupt our discussion of the scientific uses of space satellites at this point and ask what other uses such vehicles have. We think at once of possible military uses and then of the use for space travel, or space adventure. Whether the human being is of any use for scientific observations or not, human beings are going to insist someday on taking journeys out into space. The spirit of human adventure cannot be suppressed, no matter what it costs. Granted adequate resources and adequate time for technological development of the necessary equipment, men can certainly be projected into orbits around the earth someday, and eventually into orbits which go far from the earth. There is nothing about space travel which man can't stand—except perhaps the expense. Provided he is housed in a suitable container supplied with oxygen, water, food, and suitable temperature controls, there is nothing in space that will hurt him. On long journeys he is more likely to die of boredom than anything else.

Landing on the moon

But when we talk about landing a man on the moon or Mars or some other planet, and then getting him off again and back home safely, we are talking about a new order of magnitude of difficulty and cost. To land safely on the moon will take the same sort of rocket equipment that would be required to lower him back to the earth. The gravitational force on the moon is smaller, so that will help, but also there is no atmosphere on the moon to support a parachute. Hence the entire vehicle will have to be lowered gently to the moon's surface using the rocket blast alone—like the landing of a vertical-take-off jet plane. Then there will have to be enough fuel for the vehicle to take off again, get projected into an earth-bound orbit, and there will still have to be enough fuel left over to lower the vehicle gently into the earth's atmosphere.

During all this time the man has had no access to any supplies of oxygen, water, food and energy other than what he carried with him on take-off. And the entire round-trip in the best orbits for the purpose would consume not less than 10 days. I will leave it to some rocket experts to calculate what payload would have to be lifted from the earth for such a journey—and how many millions of pounds of initial thrust it would take to do it. There is nothing impossible about it, you understand. It will just take a lot of money and a long time. Whether it is worth it or not depends on our concept of the values to be achieved.

Clearly, a man landing on the moon and coming back could bring valuable scientific information, such as samples of the moon's surface (if he didn't get roasted or frozen while on the moon's surface, which boils water in the daytime and freezes carbon dioxide into dry ice at night). His visual and photographic observations would be of great scientific interest. I think, however, that most responsible scientists (not counting the Space Cadets) would feel that we could collect plenty of scientific data about the moon during the next few years by cheaper methods.

What about the military value of space travel?

Obviously, military *ballistic missiles* which will hit accurately any point on the earth from bases in the United States, with payloads of 1,500 pounds or more, are very important military weapons. Nothing should impede our efforts to develop and manufacture them and continue to try to make them cheaper, more reliable and more effective. That, in itself, is a big job which will take a lot of talent and money during the coming years. That is the challenging job which American industry and American technology must not lose sight of.

Obviously, also, the rocket techniques which will carry sizable warheads on trajectories of 5,000 miles or so on earth are also automatically adequate, with but moderate changes, to launch earth satellites of a few hundred pounds weight, more or less, into orbits around the earth—and even out to the moon or beyond.

Military satellites

What military value will such satellites have?

First, they will make fine reconnaissance vehicles. With suitable optical and telemetering equipment, they will provide interesting pictures of most of the earth's surface every few days, if the orbit is properly chosen. Let's hope we can load enough batteries aboard so we won't have to send up a new vehicle every two weeks or so because the old one's batteries have run down.

Second, our military satellite will be good for weather observations—and military men always seem to be interested in the weather.

That, as far as I can see, is about the end of the story on the military value of earth satellites. Probably some communication techniques will be worked out; possibly someone can figure a way to use satellites for radar antennæ. But as weapon delivery systems they are clearly not very interesting. You can't drop a bomb from a satellite; it just won't drop! And to project a bomb to earth accurately is most difficult. You may not have to treat the bomb quite so gently as a man, but you do have to land it at exactly the right place. Besides, the ballistic missiles we already have, which started all the excitement in the first place, are quite adequate weapon carriers—a lot more accurate, cheaper, more reliable, more flexible, and more instantly available for use than any satellite could be.

Thus, the military value of developing very large rockets (of a million pounds thrust or more) solely for the purpose of launching very large satellites would appear to be very small in the immediately foreseeable future.

What about a military base on the moon?

There have been some extraordinary statements made on this question in recent months. Here is a typical one from a Sunday newspaper supplement, in an article by a Washington correspondent: "A base on the moon with elaborate equipment and highly-trained men *(What are the men breathing, I wonder?)* would be an observation post surpassing anything military strategists have dreamed of in history." *(I am not familiar with military strategists' dreams—but I do know that from the moon only one side of the earth faces you at a time, and for a good fraction of each month that face will be in total darkness. Much of it will probably be covered by clouds anyway—and anyone who thinks he can see manmade objects from 240,000 miles away is a bit optimistic.)*

But the quote goes on: "It (the base on the moon) could launch weapons of great destruction *(the very same weapons we've got right here on earth now, I'll bet you)* with terrible accuracy *(terrible is right)* on any target on earth. It could also be done without the slightest fear of retaliation. *(Retaliation against what? Nobody on the moon could stop the enemy from wiping out New York, Washington and Los Angeles.)* For us, reaching the moon first is a defense necessity."

That's what the man said! It is my firm opinion that this is utter nonsense. It is nonsense for many reasons. I will mention only three:

1. Why transport a hydrogen warhead, together with all men and equipment for establishing and maintaining a base, 240,000 miles to the moon, just to shoot it 240,000 miles back to earth, when the target is only 5,000 miles away in the first place. I can think of no gain that is worth the colossal cost.

2. If you did launch a bomb from the moon to a target on the earth, using, of course, an orbit that required the minimum amount of fuel, the warhead would take five days to reach the earth. The war might be over by then! An ICBM can reach any target on earth in 20 minutes.

3. As to retaliation, if we have rockets good enough to land men and equipment on the moon, the enemy will surely have rockets good enough to put a hydrogen bomb (a much smaller payload) at the same spot. Either people will land on the moon for peaceful purposes by mutual agreement—or else we will surely launch the nuclear war here on earth which we are all trying to avoid. I'll willingly fight a war to keep the Communists off our shores—but I am not interested in getting blown up to decide who shall have a military base on the moon.

The challenge

As I see it then, the challenge of the space age is whether we use the great new technologies of space travel for peaceful and scientific purposes—conducting a bold and exciting program of research and exploration—or will we be led into wild programs of Buck Rogers stunts and pseudo-military expeditions? The decision is going to be made soon, and it is high time that the best people in America—including the best people in industry—do some good hard thinking about it.