The Challenge of Sputnik

by L. A. DuBridge

On October 4, 1957, the Russians announced that they had successfully launched an earth satellite; that a 180-pound object was circling above the earth at an average height of 300 miles or so. A month later Sputnik number two was in an orbit.

The reaction of the people of the world to these events was fabulous. To those scientists who had come to take it for granted that earth satellites would someday be launched—by both the U.S. and the U.S.S.R.—the fact that the Russians launched the first one came as a great surprise. However, it occasioned no more shock to them than having your home team lose a football game. The Russians put one over on us—fairly and squarely. O.K. —we will win the next round!

But to those who had not previously thought much about earth satellites the reaction was about as violent as though Russia had landed an atomic bomb on New York. To some it was more like the landing of a flying saucer from Mars. Astonishment, disbelief, hysteria, anger, recrimination, disillusionment, fear, and a hundred other emotional responses soon became evident. And then followed an unbelievable torrent of outraged denunciation and outrageous proposals for revenge on the Russians, for punishment of the guilty Americans.

In Europe and Asia there was confusion too, for a great idol had toppled from its pedestal; the carefully nurtured proposition that America was always first in all things technical suddenly collapsed. Europeans waited in vain for a word of explanation, of reassurance. But all they heard from America was the confusion of many voices—some of which declaimed that the end of the free world was now in sight, that Soviet superiority in all things technical, military, and even educational, was now proved; America, it was said, had lost the race for survival. Equally confused were those who treated with contempt or disdain one of the great events of man's history, who dismissed it as a mere bauble.

The Russians have capitalized on this situation by deriding our weakness and confusion, by bragging about their great triumph. They have announced that they intend to send rockets to the moon, that more animal experiments will be carried out, and that someday a manned rocket will be launched. An example of our hysteria was the headlining of a ridiculous rumor that a man had been hurled 186 miles into space in a rocket.

Now, of course, some people have been talking about space travel in this country for years—but they were dismissed as starry-eyed visionaries, or just plain nuts (as, indeed, some of them were). But when the Russian Government takes space travel seriously, Americans sit up and take notice. And now our disregarded astronauts are getting the headlines. Suddenly travel in space has become a subject of everyday conversation. People seriously expect, and some seem even to hope, that their children may someday live on the moon or on Mars.

Then on December 5 the American Vanguard launching failed—and hysteria broke loose again. I never expected to live to see the day when a leaky fuel pipe would be regarded as an international tragedy. Every engineer knows that accidents of this sort must always be expected in a new venture. Technological advances are not easy. In the early days of aviation, men found the conquest of the air to be a tough business—and scores of hardy pioneers sacrificed their equipment and even their lives to the task of making airplanes more reliable. Modern space rocketry has not claimed any lives yet—*but it will.* Large

rockets are enormously complex devices, and no amount of human ingenuity will ever make them infallible. I am sure the Russians have had accidents. The Germans certainly had many. We have had some and will have more. But we will have successes too. A leaky fuel line or a defective turbine blade can hardly be taken as signs that the whole of our science and technology has suddenly collapsed.

In any case, we find ourselves in a time of great and astonishing events—and hence, inevitably, in a time of great confusion. Many terrible questions must be asked. Are we really in great and imminent military danger? Has Russia assumed technological leadership of the world? Have they proved that a dictatorship is superior to a democracy? Must we then adopt their methods to survive? Is our educational system obsolete? Are we hopelessly outclassed, outstripped, disgraced?

These and many other questions that Sputnik has raised have no easy answers. There are too many quantities still unknown. And, even where some things are clear, the question of what we should do about them is often unclear.

The best we can do at the present stage is to bring together the facts and separate the true from the false, the known from the unknown, and the certain from the uncertain. And then we must order our questions. We must recognize that some questions, such as the one, "Are the Russians ahead of us?", have no meaning. Ahead of us in what? As of what date? Does being ahead mean they can annihilate us? Other questions are unanswerable because we cannot possibly have the information—such as, "Do the Russians intend to attack us with ballistic missiles?" No one can read their minds. But some questions are real and do have answers. We should identify those questions, then seek their answers and try to comprehend their meaning.

Face the facts

First, however, let us look at a few facts. The Russians *have* launched the first two satellites. There is no doubt of that. And it is a great achievement. To launch an object into an orbit above the earth, the object must first be lifted well above the earth's atmosphere—say, 200 miles or so—then at that height it must be guided to a horizontal path, parallel to the earth's surface, aimed in the proper geographic direction, and brought up to a predetermined high speed. If an object is made to travel horizontally at 200 miles above the earth at a speed of about 18,000 miles per hour, it will circle the earth indefinitely, because the tendency of gravity to bring it down is exactly balanced by the centrifugal force tending to make it fly away from the earth entirely. A stable orbit is then followed. It may be a circular orbit or, more likely, if the speed is a bit too high or too low, an elliptical orbit getting farther from the earth at one side of its trajectory.

Some people ask: What keeps it going? What keeps it up there? In reply, let us ask what keeps the moon going around the earth? What keeps the earth going around the sun? The answer is simple. Nothing! Once an object has been started in motion, it tends to keep going forever —unless something tends to stop it. This great principle was discovered by Galileo in the 17th century, and was enunciated more precisely by Newton 50 years or so later. Every student of high school physics knows Newton's first law of motion (or does he?). Here on earth, of course, friction is always present to make things stop moving—so most people don't really believe that Newton's first law has any practical importance. But high above the atmosphere there is little or no friction, so the satellites keep on going. The Sputnik I rocket case lasted about eight weeks, the satellite itself about 12 weeks. The moon, 240,000 miles away, has been rotating in its orbit for at least four-and-a-half billion years!

Elementary physics

So, the questions which puzzle so many about satellite motions are answered by the most elementary principles of physics. And the widespread lack of understanding is sad proof of how few people have learned those simple principles.

There has been some discussion of how to bring down a satellite once it is up there. One congressman suggested we shoot them down! Other people asked how the little dog in Sputnik II was to be "let down." Again, some elementary physics must be recalled.

As I have said, once a satellite is in orbit it will stay there until something changes its motion. Friction will bring it down—very gradually at high elevations and very much faster as it comes into the atmosphere. But it is not easy to slow down a satellite suddenly so that gravity will pull it in at once. Shooting a bullet into it would damage the radio transmitter, but would not stop the motion. If you could make it collide head-on with another satellite going in the opposite direction, that would do it. But to achieve such a collision would be quite a trick. And, of course, a collision of two objects, each going 18,000 miles per hour, wouldn't have done the little doggie much good! That doggie was doomed from the beginning, and anyone who thought it could get back alive did not remember his physics.

What about a parachute? Since there is no air up there, there is nothing for the parachute to hang on to. Even if the little dog could jump out of the satellite with

Why, then, does it give us such grave concern?

his oxygen supply on, he would simply keep on sailing around the earth; he would be another satellite. There is just nothing there to slow him down enough so that gravity can overcome centrifugal force.

If a satellite could be equipped with an extra rocket motor and plenty of fuel so that the rocket blast could be fired in a direction to slow it down—that, of course, would do the trick. It takes a rocket to speed the thing up; it takes a rocket to slow it down. A rocket blast is about the only propulsion scheme we know which will work in a vacuum, above the earth's atmosphere. Maybe someday we will have satellites large enough to carry the slowing-down rocket, together with its fuel and the necessary equipment to fire it at the desired time.

Returning satellites

As a falling missile or satellite comes into the atmosphere, a new problem arises. Because of the enormous speed, the friction of the air will generate a great deal of heat. This is the "re-entry" problem. As President Eisenhower said in his first TV science talk, this re-entry problem has been solved for a military bomb—i.e., for an object that can stand some heat and that can hit the ground at high speed, or an object that is intended to explode before striking. But we do not yet know how to bring a dog to earth gently enough, and cool enough, so that it will survive. All the energy of the many tons of fuel required to lift the rocket originally will now appear as heat on the way down. And thus a returning satellite will usually have the same fate as a meteor; it will probably be burned up—and what is left will strike the ground with a terrific impact.

This raises the question of whether, if you launched a satellite with a bomb in it, you could then drop the bomb to hit any place on earth as the satellite passes over it. The answer, of course, is *no*. If a bomb were simply ejected from the satellite—say, by a spring or a small charge of gunpowder—it, too, would become another satellite. For the bomb to drop, it would have to be propelled backward by a huge rocket charge to reduce its kinetic energy. And, even then, it would spiral toward the earth in a curious path, and the accuracy of a hit would hardly be great.

Sputnik in itself, then, is hardly a military weapon! Why, then, does Sputnik give us such grave concern?

The main reason, of course, is that a rocket and guidance system good enough to put a 1000-pound satellite into an orbit is certainly good enough to shoot a 1500-pound hydrogen bomb from Russia to the United States. The guidance accuracy might be only 50 miles. Such accuracy is not good enough to destroy an airbase, but a hit any place within 50 miles of New York or Los Angeles would be pretty bad. And the accuracy will eventually be improved.

So the Russians are clearly very good rocket engineers. This is the main thing that Sputnik proves. They have put great effort on large rockets, and they were willing to use some of their military rockets for scientific experiments of great propaganda value. That is something we were not willing to do.

Granted they are good rocket engineers, what kind of military rockets do they have? Are they any better than ours? Are they in production, or still in the experimental stage? Will they have 100 next year, or in 5 years? In any case, how big a threat to us is *one* rocket? 10? 100?

These, of course, are all unanswerable questions—and hence they are the ones that everyone speculates about. Unfortunately, the Russians have not told us precisely just what type of military rockets they have, when they will have them, or how many there will be. They have made a few proud boasts, but only the U.S. Central Intelligence Agency knows how accurate those boasts are. And CIA is not telling what it knows.

By the same token, in spite of all the press releases, the U.S. Defense Department has not told the full story of our rocket technology either. The President did say that we have over 30 types of guided missiles in development, and many of them in production. Sputnik alone does not reveal the full military strength of either country. It has revealed simply that the Russians are better rocket engineers than most of us thought. Hence, they may have now, and certainly will have someday, enough military rockets to be a serious threat to us.

U.S. missiles

But of one more thing we can be sure: The United States has not been asleep in the guided missile field either. Our Nike anti-aircraft missiles, for example, are certainly a powerful protection against the Soviet bomber. Many scientists feel that there have been too many missiles developed in this country. It might have been better to concentrate on a smaller number and not have tried to make them all so perfect. But it is a typical American habit—if there are several ways of doing a thing, we will try them all! And we will push each one to a high state of perfection. We certainly have acquired a very large and diversified missile technology in the past 10 years. And if we wish now to concentrate a large effort on one or two major projects, we could certainly get them into production fast. In fact, Caltech's Jet Propulsion Laboratory, using existing Army equipment, launched the first U.S. satellite, the Explorer, less than 12 weeks after the project was authorized.

The notion that Russian rockets could suddenly, *to-*

Has Russia now, before all the world, challenged us to an intellectual contest which we are not prepared to win?

night, destroy all American bomber bases all over the world and render us immediately defenseless is absurd. Such a feat would require the accurate and simultaneous striking of hundreds of long-range missiles—all making effective hits. To run the risk of not hitting even a few bases would be dangerous, for even a few H-bombs that we could launch can do tremendous damage. Thus our bomber force will be a serious threat to Russia for a long time to come.

But that fact should not give cause for complacency—and I know of no informed person who is complacent. As Dr. Killian, the President's new special assistant, has said, "We need a sense of *urgency without despair.*"

What, then, should we do now? What must we do later?

The first demand which the Sputnik situation puts on us, of course, is to examine our military situation. Though the wild statements that the Russians have suddenly zoomed into a position of military supremacy are wrong, it is certain that there are grave dangers. Clearly, everyone now realizes that we need to accelerate our efforts to counter that Russian threat.

At the same time, it is clear that our military strength is only one aspect of our national strength. Military technology is one branch of technology; it can be no stronger than the main structure of technology itself. Rockets and radar and atomic weapons are not invented by generals and admirals; they are invented by civilian scientists and engineers working in laboratories—often in laboratories where the Government is paying the bills. These civilians draw on all available knowledge in the world of science and engineering to develop weapons and techniques which the military services require. For a nation to be successful in military technology, it must have two things:

1. Enough well-trained scientists and engineers to man the military-sponsored laboratories; and

2. An active *non*military science and technology to supply the new knowledge, and materials and new devices which military technology will require.

The shock to America is that Russia has so quickly attained these two goals. Russia, we now realize more clearly than before, is rapidly attaining a position of great technological strength. Russia is no longer the nation of illiterate peasants that many of us had supposed.

How did they get this way? How did we let the Russians get ahead of us in the satellite game? Paradoxically, it was not the shortage of engineers in this country that was responsible. It was, if anything, a shortage of psychologists! Actually, the possibility of launching a satellite had been under discussion in the United States for a long time. And the Russians had, long ago, also announced that they would launch one—date unspecified. Most people in this country regarded the satellite launching as an interesting scientific project, but it was repeatedly emphasized that it must not interfere with any military project. Hence, it could use no military hardware. So it was not pushed or given any priority. If someone could have visualized the tremendous psychological impact the first satellite would have on world opinion, and if they could have persuaded the Government of its propaganda importance, the project could easily have been accelerated. But not even the congressmen who are now shouting for blood ever told the National Science Foundation that the satellite project should be given top priority. Almost no Americans thought there was any rush. In the meantime, the Russians kept their plans secret until, suddenly, the job was done.

The first step

Our first lesson is that we must bring to the top levels of our Government better information and judgment about the potentialities of new scientific and engineering achievements, and their possible psychological effects on world opinion and their effects on the U.S. position of leadership. The appointment of Dr. J. R. Killian is a good step in the right direction—but he will need the help of many scientists, engineers, psychologists and experts in many areas of world opinion to do the full job.

Our next task is to realize the enormous advances Russia has made in science and technology in recent years.

Now that Sputnik has made us look at Russia more closely, we see very plainly—what we could have easily seen long ago—that for 30 years Russia has been systematically building an educational system that would give rigid technical training to a large number of scientists and engineers, who, under the communist system, would then be available to serve the needs of the state.

Soviet leaders foresaw, or soon learned, that you could not force people to be good scientists. There must be powerful incentives for every young person to develop any scientific talents he may have. So the Soviets turned to capitalistic methods and developed an elaborate sys-

tem of financial incentives to encourage scientific training. Young men and women are paid to go to college—if they qualify. They are paid even more to go to graduate school—if they qualify. They are paid still more when they go into active scientific or engineering work—again if they pass rigid qualifying tests. Finally, the successful scientist or engineer is paid a very high salary, gets a car, a home in the country and extra food rations. And he is showered with medals to recognize his achievements. It's all very simple capitalism—large rewards to the able and the ambitious. And in this country we have been doing just the opposite—seeing to it that scientists, engineers and teachers do *not* earn too much!

The net result is that the U.S.S.R. has attained a position of great technological strength, and by concentrating large resources of men and money on military technology—nuclear bombs, submarines, aircraft and missiles—she has attained a position of great military strength, too.

No longer is it true—if it ever was—that automatically and inevitably and forever is the U.S. technically superior to the U.S.S.R. in the military field. Whatever the exact balance may be today, the Russians are certainly moving ahead very fast.

This is a sobering thought and requires sober attention. For this fact profoundly affects our foreign policy, our military posture, the nature of our defense effort and the distribution of our resources.

And if Russia can achieve these results in the military field, can she not attain similar goals in industry, in agriculture, in public health? Can she not, in short, attain in time a standard of living for her people comparable to ours? Can she not thus challenge throughout the world the superiority of a democratic system of government in providing for the welfare of its people?

That is the real challenge of Sputnik. It is not a question of how good Russia's rockets are, compared to ours. We can have good ones too. The question is whether Russia has now, before all the world, challenged us to an intellectual contest which we are not prepared to win. Can the communist system develop and use the brains of its people to a better advantage than our system?

Our intellectual resources

The challenge of Sputnik is that we must now take stock of our intellectual resources and how we are using them.

Arnold Toynbee, the historian, has advanced the proposition that the survival of nations and of civilizations depends on how they meet the challenges which they face. Blindness or complacency in the face of danger leads to collapse from without. Hysteria may lead to collapse from within. But foresight, courage and determination may conquer and challenge.

Can we, as a nation, bring these qualities to bear on the challenge we face?

Even though the challenge may not be in the form of an immediate military danger, it is clear that a rival power is surging ahead so rapidly on so many fronts that we must begin now to accelerate our pace.

How do we start? First, we must remember that back of any great new military, industrial, or technological achievement, back of any nation's material strength, lie the minds of many people. The most important resources of any nation are its intellectual resources. New developments come from new ideas. New ideas develop in the minds of men. Any single new idea, in fact, develops in the mind of a single man; the pooled ideas of many men constitute a nation's intellectual resources.

Our first task, then, is to strengthen our intellectual resources. The one great overpowering question which we need to ask is whether we are now developing and utilizing to the maximum extent, consistent with democratic principles, the full intellectual and spiritual strength of our people. If we are—we need have no fear. If we are not—we are risking grave danger.

Is America fully utilizing its intellectual resources? The answer is *no*.

Not one of us can honestly say that he is using his own intellectual resources fully. From the time we are children, until we die, most of us use only a fraction of the mental powers we have. We do not drive ourselves to use them; we do not encourage our children or friends and neighbors to use theirs. Oh, yes, we want our children to do well in school—but not too well! Johnny mustn't be different! And he mustn't be frustrated!

Instead of incentives

Instead of offering every possible incentive to intellectual achievement at all levels, in all fields, by all people, from the cradle to the grave, we offer—what? Tolerant amusement? Indifference? Or antagonism? ("Don't be an egghead!")

That is the challenge America faces now, today—that all of us (citizens, taxpayers, parents, teachers, workers) shall be aware of the importance of intellectual achievement. This challenge existed long ago, of course. But now a great question mark has been projected high in the sky for all the world to see. Are American intellectual resources going to be brought to life in a great surge of dynamic enthusiasm? Or is another more monolithic type of society going to be able to drive its people to a pace we cannot match?

I think many of our people have now become aware of the importance of raising the intellectual level of our attainments. They now seek guidance: Where shall we start? What shall we do? Unfortunately, there is no single move, or even any small group of moves, which will solve this problem.

The intellectual resources of our people are developed and nourished in many places—in our homes, our churches, our schools; in the universities, in libraries and museums; in industrial and government laboratories; in newspaper and magazine editorial rooms, and (we hope) in radio and TV broadcasting rooms.

In all of these places, higher intellectual standards

must be encouraged and achieved. Better teachers' salaries alone are not enough, but they are necessary. More classrooms and laboratories in schools and colleges are not enough, but they too are necessary. We need to insist that every course our children take in school has a good solid intellectual content and that Johnny and Mary are held to the highest standards of which they are capable, even if they get frustrated once in a while. To say that all our schools have been destroyed by the philosophy of John Dewey is unfair to many schools and is too flattering to Mr. Dewey. But it is equally wrong to say there is no room for improvement. Our task is not to return to the 19th century little red schoolhouse, but to find a new and vigorous educational climate which will fit our children of today to meet the problems of the 21st century—which most of *them*, and not many of *us*, will live to see.

To meet the challenges of the year 2000 A.D., our nation will need to attain an enormous new surge of intellectual vigor.

How can we hope to achieve this when those engaged in intellectual pursuits find themselves at the bottom rung of the economic ladder? I do not claim it is wrong that a movie actress should earn 100 times as much as a professor because her bust and waist measurements have the correct ratio. But I do worry about the future of a society where the best brains are held in low esteem. I know that, to a teacher, other things are more important than salary. But, just to prove to our young people that a life of intellectual endeavor is important to our nation, let's increase our teachers' salaries—at least a little.

A little emphasis

Then, too, how can we have a vigorous intellectual climate when so few high school students get any adequate exposure to mathematics and science? Yes, I know people will insist that we must not have overemphasis on science. And I agree. But, before we complain about *over*emphasis, let's have a little emphasis. The fact is that science and mathematics, in many schools throughout the country, have been all but ostracized as legitimate subjects of study. They are too hard, or too technical, or "too remote from life." Bad counseling, bad administration, and bad teaching have all helped in this decline—and I think now is a good time to reverse the trend. It's time to give every youngster a chance to test his mettle on some good tough subjects—mathematics, language, economics, science—so he can find out where his talents lie and choose his future interests accordingly.

Today we are confronted with the political issue of what role the Federal Government should play in rejuvenating the vigor of our educational system. There are those who believe in no federal activity at all; others believe in very large federal subventions. Actually, I believe the recently proposed administration program is about right. It is large enough to underline the federal interest in education; it is small enough to avoid federal control. It will, by no means, solve all problems, but it will stimulate states and local communities to get busy on a few. It emphasizes the importance of the student and the teacher and seeks to help both.

The Federal Government can take leadership in other aspects of an intellectual reawakening. It can encourage improved higher education and graduate study; it can stimulate and support research and scholarship in many fields; it can make more efficient and effective use of manpower in its own activities.

But, in America it is the people themselves—not the Government—that determine their future. They set the intellectual standards; they create the intellectual climate; they determine relative values of intellectual and nonintellectual pursuits; they support the educational system; they are responsible for their own children; they pay the bills. They will determine whether or not America responds adequately to the challenge we face. I hope the American people will now get busy!

A triple responsibility

Finally, I should like to suggest that the universities of America must play a critical role in responding to this challenge. They have, in fact, a triple responsibilty.

They have a responsibility, first, to assist the Government in immediate technological problems. They carry on research and development in many fields related to national defense and national welfare.

Second, they have a responsibility in seeking new knowledge. It is the new scientific understanding gained today which is the foundation of our strength of tomorrow. The nation's relatively few centers of basic research in the country are precious assets indeed. It is essential that they be kept strong and made ever stronger. The universities are dedicated to the task of maintaining centers where the best minds in the country can effectively attack the deepest and most profound problems in every scholarly field.

Finally, the universities have a responsibility in educating men—men who will be leaders in pure and applied science, in education, in business, in politics. The research men, the university teachers, the leaders in industrial technology must be men of high ability, superbly trained. If it is an intellectual challenge that this nation faces, our success in meeting it will be determined by our success in producing great intellectual leaders.

A former officer of a Rockefeller Foundation Board used to say that the most important task in American higher education was to "make the peaks higher." Where high quality is found—make it still higher. Where strong leadership is developing—make it still stronger. Where outstanding men are found, help them work to the full limit of their talents. As the grandeur of a mountain range is determined by the height of its highest peaks, so we must give most devoted attention to those institutions at the pinnacles of scientific and educational achievement.

Every citizen in the nation can join in this endeavor.