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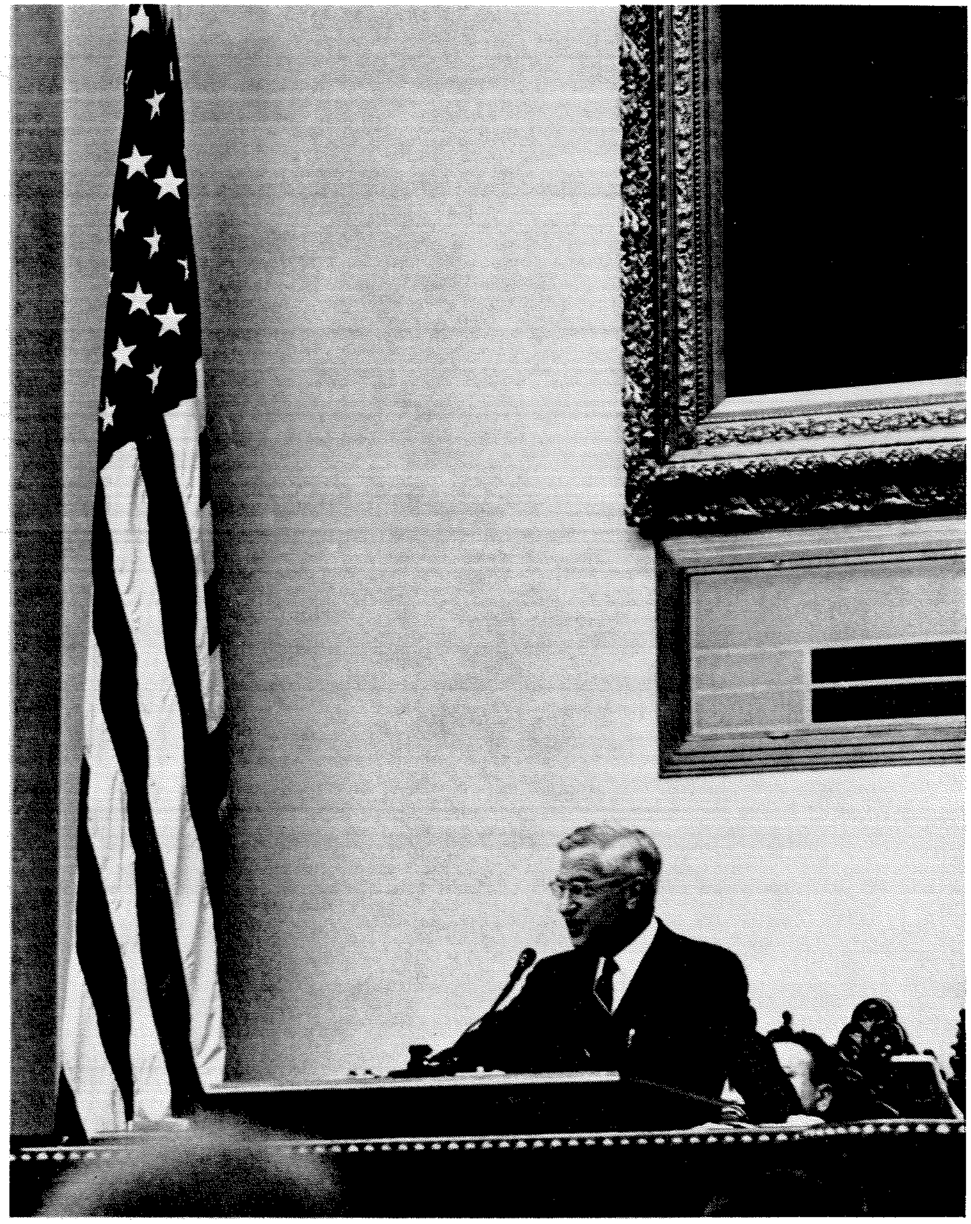


President DuBridge speaking to the joint session of the Senate and the Assembly of the State of California in Sacramento, May 3, 1963.

California and the Space Age

by L. A. DuBridge

This age of space dawned in October 1957 when the first Russian Sputnik went into an orbit around the earth. All Americans were distressed that this first space event occurred under Russian and not under American auspices. And yet American technology was not as far behind as some supposed, for it was only four months later (which is a very short time, as such things go) that the American Explorer I successfully went into an earth orbit.

That Explorer I, as you know, was designed and fabricated at the Jet Propulsion Laboratory of the California Institute of Technology in Pasadena. The large booster which projected the capsule into orbit was, of course, fabricated at what was then the U. S. Army Ordnance missile development facility in Huntsville, Alabama.

Thus, California entered the space race at its very outset, and its space activities have been growing at an extraordinary – some might even say at an alarming – rate ever since.

Explorer I was not as heavy as was Sputnik I, but it carried a far more precious load of scientific instruments; it made far more extensive scientific observations; and, indeed, in that very first flight, it uncovered the first evidence for the existence of the cloud of charged particles trapped in the earth's magnetic field, hundreds to thousands of miles above the surface, now known as the "Van Allen Belt."

Since those early days of the space age, the United States has launched 128 successful capsules which either circled the earth or went off into other parts of the solar system. The Russians have launched 34. It has continued to be true that the Russian vehicles were heavier than the American. It has also continued to be true that the American vehicles were more efficiently equipped with scientific instruments and have yielded a vastly greater quantity of scientific data about the earth, the moon, the planet Venus, and the characteristics of the so-called "empty space" that lies beyond the earth's atmosphere. In the launching of every one of these American spacecraft California scientists and engineers and California industry have had some part – often a predominant part.

Scientific achievements

There are a host of scientific achievements which have come as a result of these American space projects. We have explored the earth's magnetic and gravitational fields. We have obtained valuable information on world weather phenomena. We have more fully explored the characteristics of the Van Allen Belt. We have sampled the radiations, the matter, and the gravitational and magnetic fields which exist in deep space. We have detected and measured the so-called "solar wind" – the flood of charged atoms which emerge continually from the sun itself, adding to the cosmic rays which strike the earth and influencing the earth's magnetic field.

We have measured the temperature of the atmosphere and of the surface of Venus and have determined that the planet Venus rotates only slowly about its own axis, possibly keeping always the same face pointed toward the sun, as the moon keeps the same face pointed toward the earth. We have determined that Venus possesses a zero, or at least a very small, magnetic field.

We have observed the face of the sun from space vehicles, getting information on radiations which cannot get through the earth's atmosphere to our surface observatories. We have launched communication satellites, and opened a whole new era in worldwide communication technology. We have achieved many other advances in science and technology, much too numerous to mention here. It is not too much to say that a real scientific and technological revolution has taken place in these few short years.

And yet we have made but a bare beginning in exploiting our opportunities for space exploration. We shall soon be sending spacecraft to land on the moon and tell us about its physical and chemical composition. We shall launch a vehicle to pass in the vicinity of the planet Mars. We shall send additional spacecraft to Mars and to Venus, and eventually we hope to land instruments on both of those planets. All these spacecraft aimed at distant objects will, during their hundreds of millions of miles of travel, gather new information about the sun and about the solar system. We shall someday launch astronomical telescopes into orbits far above the earth's atmosphere where, for the first time, man will be able to see the universe unimpeded by the murky, the wiggly, and the partially opaque blanket of air which shrouds the earth's surface.

We shall soon outrun the capabilities for instruments alone to make all the scientific and technical observations which are desired, and we shall then send men into space to enhance the value of our observations and our explorations.

Never before in human history has such an exciting and such a far-reaching scientific and technical enterprise been possible. Never before have man's horizons been broadened so far and so fast. And yet it was only a short 25 years ago that anyone who suggested that man would soon be able to embark on an era of space exploration would have been thought to be either demented or possibly a science fiction writer, or a comic-strip artist.

Dreams of the future

And yet here we are, already immersed in the five-year-old space age, already dreaming even grander dreams with each passing year; dreams now, however, which are based on fact, not on fancy.

What, then, is the major purpose of these dreams? What is the purpose of the huge national effort we are putting into the task of making these dreams come true?

You will find many answers to these questions.

Some will say, "We must catch up with the Soviets," which is to say we must prove that we can build just as big and powerful rocket boosters as they. Well, someday we *will* have bigger boosters, vastly more powerful than the ones we now have. But a big booster is surely not an end in itself; what do we wish to do with it? It's what's up front that counts. Our present boosters are quite adequate for military purposes; that is what they were originally designed for. They can carry powerful nuclear warheads to any spot on earth. Our military striking power thus will not be enhanced in any critical way by larger boosters. Maybe the Russians had to have big ones because they did not, at the time, have such compact nuclear warheads as we did. And so we have just made a virtue out of their necessity.

We do need bigger boosters for our more ambitious space ventures, however. Yet we have, as I have said, done pretty well with those we have. They are adequate to send spacecraft to Venus and Mars. The fact that the weight of these capsules is smaller than the ones the Soviets launch only means we must be more clever in designing light and compact instruments. And that's what we have done. We need not be ashamed of what our spacecraft have achieved. And isn't that the final test?

But to return to the goal of our space program: There are some who say its only goal is to put Americans on the moon before any Russians land there. Well, that is an announced national policy. We are working strenuously to that end, and it will be several years before we know whether we shall succeed – whether we shall in fact be the first.

Our scientific goal

But *why* do we send men to the moon; why do we send so many instruments into space? As I have already pointed out, the goal is really a scientific one. We are seeking to *learn* more. We want to explore the moon, with instruments and with men. We want to find out what it is like, what it is made of. We think that a close look at the moon may tell us about its origin, and thus about the origin of the earth and the solar system.

There is recent evidence that the moon has something to do with the earth's weather. When the moon is "new" (that is, when it is between the earth and the sun), there is less rainfall than when the moon is full (that is, on the side away from the sun). Why is this? Does the new moon shield the earth from charged particles or dust streams emanating from the sun, and do such things affect our weather? We don't know. But it would be a good thing to find out.

But the moon is only our first step into space. Our space program will not cease when men first arrive there. We must send many expeditions to the moon. We must send instruments, and later men, to circle the planets Venus and Mars – perhaps, someday, to land on the surface.

Why?

Just to beat the Soviets?

Surely there is something deeper. Surely here, too, our aim is scientific exploration – to seek new knowledge. Mars and Venus are deep mysteries to us. We can never find out too much about them until we get there.

Think, for example, of the one staggering discovery that remains to be made: Is there, or is there not, some form of life on Mars? If not, why not? If there is life, what is it like? Is it like earthly life? Does it employ the same chemistry as does life here? Is the pattern of genetics, reproduction, and evolution the same as on earth? These are deep and profound and immensely interesting questions. Civilized men cannot be content until they are answered.

But even Venus and Mars are hardly a step from our door, as cosmic distances go. What about going still further? Yes, someday, Jupiter and Saturn and the other planets that rotate about our sun will be our goals too. They are much farther away, but the technology for reaching them is clearly in sight.

Will we visit other stars?

And what about beyond our solar system? What about visiting other stars, like our sun, which might have planets rotating around them?

On this point the news is not so good. Even the *nearest* large star, Alpha Centauri, is so far away that even if we could escape from the colossal gravitational pull of our sun (a tremendous task) and could then speed our capsule up again to, say, 20 miles per second (another stupendous task), we would still find it would take 40,000 years to reach Alpha Centauri. It would take a million years to reach other nearby stars, three-quarters of a billion years to reach the center of our Milky Way, 40 billion years to reach the next nearest galaxy of stars – and 40 trillion years to get to the most distant galaxies the Palomar telescope can see.

Reaching out to other parts of the universe will have to be deferred for a while – deferred forever, perhaps, for man's lifetime is just too short.

But we can, nevertheless, learn much more about the distant universe from our space capsules. Once we can get fine telescopes above our atmosphere, the distant reaches of the universe will come into sharper focus, and we can't even imagine all the new things we will learn.

So there are the goals of our civilian space program: to learn more about the earth, about the moon and the planets, about the empty space that lies between them, and to get a clearer view of the rest of the universe.

Does this justify the huge sums of money we are spending?

That, of course, depends on your point of view. Clearly, no great modern nation can stay out of the space age entirely; clearly, America cannot help but assume leadership in this great and new human enterprise. Whether our level of spending is too large or too small, I will not attempt to judge. But the space age is here, our nation is committed to a substantial program – and, whether Congress should appropriate 4.5, 5, or even 5.7 billion dollars for the space agency next year, we still face the fact that space exploration is to produce a tremendous impact upon our national life and upon the minds of men and women all over the world.

California's place in the space age

But let us turn our attention again to California's place in the space age. Why is it that this state occupies such a predominant place in this picture? Why do the expenditures in California for space work loom larger, by a factor of three, than for any other state in the union? Why is such a large fraction of the nation's efforts in the development and fabrication of large rockets, in the development and manufacture of intricate electronics, guidance and communication equipment, and in scientific instrumentation to be found in California?

The story, of course, goes back many years to the early days of the airplane when the first flight enthusiasts found that, because of its weather, California offered an excellent location for building and testing airplanes. Pioneers such as Donald Douglas saw here the opportunity to initiate an aircraft industrial development.

Those early aircraft were pretty fragile contraptions by modern standards, and they were fragile, undependable, and inefficient because, in those days, there was no real science of aeronautics. We did not really understand the principles which made it possible for heavier-than-air craft to fly through the atmosphere. In about 1927 a group of scientists and engineers perceived that further developments in the technology of flight could be carried forward only if the science of aeronautics were first explored. And so, with the help of the Guggenheim Foundation, the first university laboratory of aeronautical science was established at Caltech in Pasadena in 1929, stimulated by that farsighted scientist and educator, my predecessor, Dr. Robert A. Millikan.

Within a few short years the scientific work of that laboratory had uncovered quantities of new data on the nature of air-flow around such things as aircraft wings, had pinpointed the factors which underlie the lift and drag phenomena; and, more important, that laboratory was educating engineers broadly trained in the basic science and technology of flight.

These engineers joined the staffs of the growing aircraft industrial companies, and soon California-made airplanes were the finest in the world. Many additional aircraft companies began operations in southern California to be near the scientific and engineering developments which were revolutionizing aircraft design, and which eventually made possible the modern, highly efficient, high-speed jet aircraft, and also the modern rocket.

Here was one of the first startling examples of the way in which a relatively small educational institution, devoted to advanced education and scientific research, contributed so heavily to the economy of a great state.

But there were many more examples to come. At Stanford University a great research laboratory in the field of electronics was in the making in the 1930's. Scientific discoveries in this area led to technological developments which revolutionized communication, navigation, air defense, and led eventually to the modern era of automation. It is no accident that one of the great centers of the electronic industry in the country is to be found within a few miles of Stanford University in Palo Alto, California.

The Jet Propulsion Laboratory

As a third example, in this same Guggenheim Aeronautical Laboratory at Caltech there was emerging in 1940 the idea that jet propulsion had now become a practical technological possibility. A small test laboratory was set up near the mountains, in what was then an uninhabited part of Pasadena, to make tests on jet propulsion devices. During the war that laboratory developed to vast proportions as a center for the development of large rocket engines – and it is now the Jet Propulsion Laboratory, operated under the National Aeronautics and Space Administration by the California Institute of Technology, employing 4,000 people, and being responsible for the expenditure of some 200 million dollars annually. The science and technology developed in that laboratory spread to the aircraft and rocket industries.

The present great Aerojet-General Corporation, with plants in southern California and also one near Sacramento, began as a small manufacturing concern to supply to the government the first jet propulsion devices developed at the Jet Propulsion Laboratory, initially used to serve as booster engines for aircraft taking off from short runways —the so-called JATO equipment. Aerojet-General is now one of the large industries of California. Dozens of other California companies began in a similar way as manufacturing agencies for electronic, aircraft, or rocket manufacturing to put into production new ideas developed in university laboratories.

Developing nuclear warheads

Another great boost to the missile and space industry of the nation was the development of nuclear warheads for military rockets. As everyone knows, the University of California at Berkeley was already, by 1940, one of the great nuclear science centers in the world. Because of the University's leadership in this field, it was asked by the Manhattan District during World War II to set up and manage the Los Alamos Scientific Laboratory in New Mexico which has been the center for all developments of nuclear warheads for bombs and rockets. The great laboratory at Livermore was later set up to supplement the work of Los Alamos. It was out of these laboratories that the first compact hydrogen-burning or thermonuclear warheads were first developed which made it feasible to mount these powerful warheads on ballistic missiles. The Atlas missile manufactured by Convair, with headquarters in San Diego, was the first such military intercontinental missile to be developed, and the Atlas has also been an essential element in our space exploration projects.

Thus, in California, through the collaborative efforts of universities and industry, *all* of the essential technical foundations of our space program were brought into being – flight science, jet propulsion, electronic science, and military missiles. No area in the country could bring together so rapidly and so effectively these four basic requirements for our entry into the space age. And no state had acquired the great resources of highly educated and highly skilled manpower as could be found right here.

A cogent illustration of how important economic and industrial impacts follow these centers of education and research is the study of what happens to the very large research and development budget now operated by the government. Last year some 12 billion dollars of government funds were spent for research and development in the fields of space, electronics, and defense, as well as for basic scientific and engineering investigations. Needless to say, a research and development contract can only go to those institutions and to those companies that have the brains, the know-how, and the access to new ideas. Of this large research and development budget, 41 percent was spent in the State of California. Next in line was the State of New York with 12 percent, less than one-third of California's share, and Massachusetts stood third with 5.7 percent.

It is no accident that these three states carry on 59 percent of the dollar value of the government's vast research and development program for these are also the three states in which some of the greatest universities in the world are located. Research money follows the brains, and the brains are developed in university centers. It is just as simple as that.

Revolution in education

Over two years ago, in a speech delivered to a Caltech audience, the great industrialist Alfred P. Sloan, Jr., formerly Chairman of the Board of the General Motors Corporation and now the Chairman of the Sloan Foundation, expressed this situation very clearly. He said:

> "I believe a revolution has taken place as to the status of education among the activities of our society. . . . In the new concept education is evolving as a problem of major social and economic significance in the deliberations of our society . . .
>
> "The business impact on education and the impact of education on business stand out crystal clear. . . . in fact, education becomes a competitive necessity in business."

I have already pointed out the way in which great universities and their great research centers are essential elements in modern industrial development. But it goes far beyond that. Professional schools in law, medicine, agriculture, and business also play an essential role, for a great and prosperous state requires men and women of many talents. Our liberal arts colleges add another major element, for educated citizens in all walks of life are essential to a civilized and well governed and prosperous community.

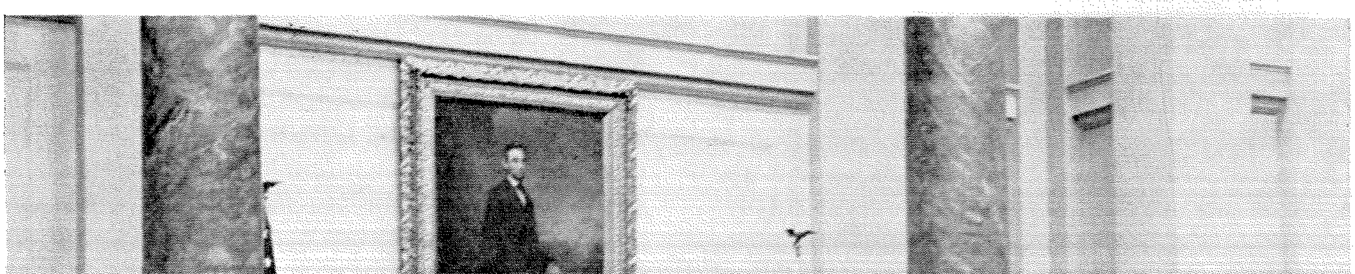
And whence come the young people who *enter* our colleges and universities? From our primary and secondary schools, of course. So they must be fine too. And I can assure you of this: our best high schools in California *are* pretty fine, and are getting better every year. The freshmen who are entering Caltech and Stanford and Berkeley and Occidental and Pomona and other colleges are much better prepared for college than they were a few years ago. They have had better courses in mathematics, in science, in English and history and foreign languages than they had ten, or even five, years ago. We have much further to go to make all our public schools even finer, but they are now on the march.

Yes, California has built a fine educational system. And, as I have said, these efforts are now paying off economically. For our fine educational system has been a major factor in the state's industrial and technological development. Our investment in education is paying off a hundred-fold.

But I know you would not want me to leave you with the impression that the purpose of our educational system is *only* to contribute to economic and industrial development. Far from it. The purpose of education is to serve the needs of our young people, to enable them to develop and use their talents, to live richer and more fruitful lives, to be better citizens. In 1787 the Congress of the United States passed the Northwest Ordinance, leading to the development of the western states. That document said:

> "Religion, morality, and knowledge, being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged."

The State of California has followed that injunction. It has not been an easy task. Education is a large, complex, and costly enterprise. To encourage it properly requires wisdom, understanding, and farsighted judgment – and also money. But I hope I have helped to confirm your opinion that the building of a fine educational system is the most important task you have achieved – and the most important objective for the future, if we wish to maintain in California the finest environment in the nation in which fine people can live happy and fruitful lives.



California state legislators accord President DuBridge a standing ovation at the conclusion of his speech.