Keynote Speaker

JAMES E. WEBB

ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PRESIDENT KENNEDY appointed James Edwin Webb Administrator of the National Aeronautics and Space Administration on Feb. 14, 1961.

An attorney and business man, Mr. Webb has served in high governmental and industry positions. He has been active in aviation and education. He is a former Director of the Bureau of the Budget and a former Under Secretary of State. He has been a Vice President of the Sperry Gyroscope Co., New York City, Chairman of the Board of Directors of the Republic Supply Co. and a Director of Kerr-McGee Oil Industries Inc.—both with headquarters in Oklahoma City, Okla.—and a Director of the McDonnell Aircraft Co., St. Louis, Mo.

Mr. Webb was graduated in 1928 from the University of North Carolina with a bachelor's degree in education. Later, he studied law at George Washington University, Washington, D. C., and was admitted to the District of Columbia bar in 1936.

In the early 1930's, Mr. Webb became a U. S. Marine Corps Reserve Officer and pilot, and he currently holds a commission as a Lieutenant Colonel in the Marine Corps Reserve.

Mr. Webb became an Assistant to the Under Secretary of the Treasury in 1946. Later that year, President Truman appointed him Director of the Bureau of the Budget, a position he held for three years. From 1949 to 1952, Mr. Webb served as Under Secretary of State in the Truman administration. From 1953 to 1958, Mr. Webb served as President of the Republic Supply Co., and became Chairman of the Board in 1958. Between 1952 and 1959, he engaged in a number of business activities, including banking, law, and the manufacturing of aircraft and accessories and oil equipment and supplies.

James E. Webb, *Administrator*
National Aeronautics and Space Administration

*Keynote Address**

THE SPACE FRONTIER

I would like to discuss with you some of the exciting adventures that we have undertaken in new realms of mapping, and how these excursions into exploring and mastering a new environment have affected our lives and led us on to new challenges and accomplishments.

It was not very many years ago that the regions between the sun, the earth, and the other planets were considered to be almost devoid of matter. Space, the name given to this region, suggested to the scientist and layman alike "empty space." Our atmosphere was and is opaque to radiations in the ultraviolet, X-ray, gamma-ray, infrared, and much of the radio portions of the spectrum. Only in the visible and shorter radio wavelengths can man look out from earth into the vast reaches of the universe.

We already know that the maps that we started with in the space program were no better than the crudest maps drawn in the sand or on birch bark in early days. In fact, we have good reason to believe that the maps available to Marco Polo when he started his long land journeys were far better than the maps we had in the early days of the space program.

Thus, in a very real sense, since the dawn of the Space Age—in less than eight years—one of our most important tasks has been that of mapping—mapping the surface of the world and its geodetic figure; mapping the world's weather, as revealed in its cloud patterns as seen from above; mapping the earth's outermost atmosphere in three dimensions, and exploring its interaction with the newly-discovered solar wind; seeing and mapping astronomical sources for the first time in ultraviolet and X-radiation from outside the earth's atmosphere; and mapping areas of our moon to an accuracy 2,000 times better than that now achievable from earth, and preparing to map areas of Mars to an accuracy as much as 100 times better than that attainable from earth.

Time does not permit covering all of these areas thoroughly, so I have chosen to give a somewhat detailed story in selected areas.

By means of satellite-borne instruments we have learned much concerning the solar wind and its interaction with the earth's magnetosphere, which is that region of interplanetary space dominated by the earth's magnetic field. The solar wind, first mapped in some detail by the Mariner II Venus probe launched in 1962 is a steady stream of charged hydrogen and helium nuclei moving outward from the sun with a velocity of about a million miles per hour and carrying with it a magnetic field. The strength of this field is roughly 1/10,000 as much as the magnetic field at the surface of the earth, and its characteristics correspond closely with those of the local magnetic field observed several days earlier at the corresponding region on the sun.

Two boundaries are produced in the interaction of this solar wind with the earth's magnetic field. Roughly 40,000 miles away from the earth toward the sun lies the boundary of the magnetosphere which was observed by the satellites Explorers XII and XIV. Fifteen thousand miles closer to the sun, Explorer XVIII found a second boundary, or shock front, which separates the region of undisturbed solar wind from the largely disordered flow produced by its inter-

* Presented at the Annual Convention of the American Society of Photogrammetry and the American Congress on Surveying and Mapping in Washington, D. C., March 31, 1965.

action with the earth's magnetic field. This phenomenon is, in many respects, analogous to that observed in a supersonic wind tunnel as the flow of gas interacts with and goes around the blunt body, with a consequent production of a shock front very similar to that observed between the earth and the sun.

Behind the earth, that is, in the direction away from the sun, the earth's magnetic field is swept out by the solar wind to very great distances. Instruments on Explorer XVIII have mapped this magnetospheric tail out to the limits of the satellite's orbit at 130,000 miles, which is more than halfway to the moon. Indications are that this tail extends well beyond the moon and resembles, in many respects, the tail of a comet. Other interesting phenomena have been discovered in this region behind the earth. The Van Allen trapped radiation belts are prominent features of the magnetosphere which have been extensively mapped and studied over the past seven years.

During a single penetration of the moon's tail at a point approximately halfway between the moon and the earth, Explorer XVIII also discovered that the moon possesses a wake analogous to the earth's magnetospheric tail.

OTHER SATELLITES have been busy mapping features of the earth's upper atmosphere at lower altitudes. One such satellite is the joint Canadian/United States Alouette I, which was $2\frac{1}{2}$ years old on March 29, and is still producing high-quality data on the ionosphere. Alouette has produced more than one-quarter million ionograms to date. These results have been reported in over 100 articles in scientific journals and technical reports. The significant result of this phase of the world-wide ionospheric mapping is the so-called equatorial bulge of the ionosphere over the geomagnetic equator which, in the Western Hemisphere, is some 11° south of the geographic equator.

IMPORTANT RESULTS have been achieved in determining the internal structure of our own planet with the aid of near-earth satellites. A satellite's orbit is determined by the distribution of mass within the earth. If the earth were a perfect sphere, a satellite would move in an ellipse whose plane would keep in constant orientation in space. Actually, the plane of a satellite's orbit rotates slowly in space, due to the added attraction of the earth's equatorial bulge. Studies of the orbital rotation rates of a number of satellites reveal a very precise value for the height of the equatorial bulge. These studies indicate a discrepancy between the observed value of this bulge, and the theoretical value that would exist on the assumption of hydrostatic equilibrium. It has been suggested that these results imply that the interior of the earth is not in hydrostatic equilibrium, but that the interior has a mechanical strength sufficient to maintain its shape in spite of the stresses at the base of the mantle.

Detailed analysis of these gravitational variations gives a figure of the earth in which there is a lump in the region of the western Pacific near Indonesia and the Philippines, a large depression in the Indian Ocean, and another depression in the Antarctic. Although these depressions and elevations are relatively small, they are exceedingly significant because they represent variations in the force of gravity in the regions in question. For example, the depression in the Indian Ocean is only 200 feet deep, but it signifies that the force of gravity there is, relatively, so weak that the waters of the sea are not drawn together to the depth that one would expect if the whole earth were subject to uniform gravitational force.

This information carries important implications for the history of the earth and for the processes by which the continents and other crystal formations may have been formed. Many of these will be answered by the refined geodetic measurements that are being obtained from orbiting satellites.

PART OF THE OBJECTIVE of our geodetic program is to establish a geometric world-wide reference system and to determine positions of control points to an accuracy of ten meters. All continents and islands can be inter-connected in this reference coordinate system. Our passive geodetic satellites will assist in achieving these objectives by means of optical triangulation in which the satellite will be observed from several points on earth.

ONE OF OUR EARLY ATTEMPTS to map the celestial sphere from spacecraft in wave lengths which cannot penetrate our atmosphere led to an unexpected result. The amount of ultraviolet light was found to be about as expected for average stars such as our own sun, but for hotter stars the amount of ultraviolet radiation was found to be as much as 30 times smaller than had been expected. These findings have led to a recent substantial revision downward of the temperatures for these hot stars, thus bringing their expected and measured values of ultraviolet flux into good agreement.

More recently, sounding rockets equipped with X-ray detectors have discovered and located the positions of more than half a dozen separate celestial X-ray sources to within one-half degree of arc or better. As the positions of these sources are defined more accurately, it will be possible to begin a realistic search of optical photographs to locate the sources of the X-ray emission.

All that is now known about their nature is that the X-ray source in the Crab Nebula is approximately one minute of arc in diameter, about one-sixth the visible size of that nebula.

I NEED HARDLY RECALL to this audience the excitement of the first close-up TV pictures of the moon taken by Ranger VII last year. These pictures were taken in an area of the Sea of Clouds, which has as a result of these observations been named Mare Cognitum, or the Sea That Has Become Known. These pictures revealed for the first time objects of a three-foot size, a thousand times smaller than anything that had been photographed previously through the largest groundbased telescopes. Of great importance to the space program, these pictures indicate that the surface features of the moon will not hinder man's landing. In February, Ranger VIII provided over 7,000 pictures of the area of the Sea of Tranquility, and it was just one week ago that Ranger IX impacted in the northern portion of the lunar crater Alphonsus after transmitting additional thousands of pictures of this more varied lunar terrain, many of which were seen in real time over the commercial TV networks.

From the pictures sent back by Ranger IX we have gained additional information on the processes that have occurred and are occurring on the moon. A study of the faulting, cracks, and sympathetic cracking of the lunar material, and any features that tend to expose the cross-sectional structure of the lunar surface give us a chance to make better deductions about the composition, structure, and strength of the lunar surface. It is recognized that pictures of the lunar surface in general provide basic information about the topography of the surface.

Mariner IV has been on its way to Mars since November 28, 1964. If all continues to go well it will fly by Mars on July 14 of this year. Cameras on board the spacecraft will take 21 pictures of the planet from as close as 5,600 miles. These photographs will be 50 to 100 times better than any taken from the earth, and will approach the resolution achieved by ground-based photographs of the moon.

All of this must be of professional interest to many people—to scientists, to engineers and to map-makers. But as a nation we must understand that the mapping of space that we have been doing is the first stage in the mastery of a new environment. And as a nation looking to all of the factors that affect our security and well being, we must understand that the most profound consequences always flow from the mastery of a new environment. This is doubly true when mastery of a new environment is based on a new technology, as in space.

WE CANNOT YET FORESEE all the consequences of man's entry into space. But the record of history is clear that the mastery by one nation of a new environment, or of a major new technology, or the combination of the two as we now see in space, has always in the past had the most profound effects on all nations and on all the peoples of the earth.

The discovery of the New World by use of a new ocean technology, exemplified by Columbus, set in motion powerful forces that altered forever the life of Western Europe, and ultimately, that of all nations on earth. There were strong effects on the complex power relations among the nations. There were direct military consequences, including warfare for the possession of new lands.

Tremendous new impulses were given to trade and communications, to the mobilizing of ships and supplies, and to the organizing of colonies to exploit the resources of the new lands. Over-all, the increments of wealth and the expanded view of the world became primary factors shaping the history of Europe after 1492. And the impetus there and in the new lands, of which America was one, lasted 400 years.

In fact in America, in 1893, Frederick Jackson Turner was already heralding the closing of our Western Frontier and interpreting in "The Significances of the Frontier in American History," its meaning. But Turner was premature. He did not foresee that in the next decade the Wright Brothers would begin the mastery of yet another new environment at Kitty Hawk, North Carolina.

There were some, such as the noted scientist, Simon Newcomb, who in the same year 1903 could not foresee the opening of this frontier when he wrote, "may not our mechanicians be ultimately forced to admit that aerial flight is one of the great class of problems with which man can never hope to cope and give up all attempts to grapple with it?"

But the Wright Brotheres persisted and demonstrated that their technology development could open the atmospheric environment for use by man.

THE FIRST HALF of this century has shown that the environment of the air differs radically from the environment of the oceans that had to be crossed by Europeans to get to the lands of the New World, and also from the land frontiers opened in the New World. But this half century has also shown that the *consequences* of the mastery of the environment of the earth's atmosphere were just as significant, and we know today that aviation adds a vital component to both our national and personal life.

Military air power has become a major new element in warfare; Winston Churchill's death reminded us of how much hung in the balance as the technological balance of air power was tested in the Battle of Britain in 1940; and our own ability to build thousands of airplanes a year was later decisive in World War II. Commmercial air travel has become a basic part of the world's economy. In the United States the research, development and manufacture of aircraft has been a strong force in our technological advance in many fields and today the aerospace industry is the largest industrial group in the nation, employing over a million people and generating sales of over $20 billion a year.

WHILE THE PERVASIVE INFLUENCE of what Walter Prescott Webb has called **"The Great Frontier"** was opened and pioneered by technology related to the earth's oceans, reached beyond Turner's concepts and lasted 400 years, we must look squarely at the fact that the aviation frontier, opened by the technology related to the earth's atmosphere, held a dominant position with pervasive influence for little more than 50 years. Now we are fast developing the **technology of space** and opening to pioneering those vast reaches of the universe about which man has dreamed so long, as his mind moved out from the desire to "fly like a bird" to a yearning to seek life, and the meaning of life, on neighboring planets in our solar system.

How long will the space frontier prove to be a dominant or widely pervasive force? Who can tell, but we already know the U.S.S.R. and the United States' efforts to conquer and use it have become both symbols and indicators of technological power in every nation.

The ocean technology led on to new lands and new wealth, but the aviation technology led only back to already-known places or power-related to such places here on earth. Space technology is more like ocean technology—leading not to new and unknown lands, but to new and unknown reaches and bodies in our solar system and beyond, and, of course, the problems of surveying and mapping each of these involves quite, quite different problems and processes.

Writing just 49 years after the Wright Brothers flight of 1903, Webb characterized man's relation to nature on the frontier as against civilization's framework in these words: "The outstanding qualities of wild and gigantic nature are its impersonality and impassiveness. Nature broods over man, but it never intervenes for or against him. It gives no orders, issues no proclamations, has no prisons, no privileges; it knows nothing of vengeance or mercy. Before nature, all men are free and equal."

IN THE CONTEXT of the present cares of the world, it is important to recognize the "impersonality and impassiveness" of nature. What has constantly separated one generation from another and what will continue to determine the superiority of one society over another will be technology, which is the use that each society makes of the impassive and impersonal possibilities offered by nature and natural forces as science unfolds the wraps and knowledge emerges.

Noting that American democracy and Western civilization had been shaped by these forces of nature in the 400 years of the frontier, Webb went on to say in 1951, "Western civilization today stands facing a closed frontier, and in this sense it forces a unique situation in modern times . . . I should like to make it clear that mankind is . . . searching for a new frontier which we once had and did not prize . . . but now that we have lost it, we have a great pain in the heart, and we are always trying to get it back again." He paraphrased Isaiah Bowman by saying that science "is not likely soon to find a new world, or make the one we have, much bigger, than it is."

True, after 1957, Walter Prescott Webb sent a message to his fellow Texan President Johnson, expressing a concern that he had settled on the closing of man's frontier too soon.

It is, of course, true, that science has not made our world "bigger than it is" but science combined with technology has made it possible for us to better understand the size of the world we have and has made it possible for us to reach into the vastness of the space around our world.

THE NEW SPACE FRONTIER is not a clear line that can be drawn at distinct locations in our solar system or beyond. It is indeed, as we view it now, infinite. At any given time, it may be measured by our capability to view its distant reaches. Although we cannot yet explore as far as we can see in space, we have opened this new frontier to the same human desires and challenges that encouraged this country's westward expansion and established its democratic institutions.

And so it is that historians are reopening their books to write again of man's efforts to understand and open up a vast new region based on a new technology, and they must continue to write of the effect of this on man himself.

Sputnik itself carried with great force the message of Soviet achievement in science and technology, and this message had substantial effects in the field of international affairs. Two things were clearly indicated: First, that the new technology of rocket power had given man the opportunity to enter the space environment, and second, that the Soviet Union intended to make maximum use of the opportunities they acquired by being the leading nation in rocket technology. This gave the Soviet Union an image of greater strength than the economic and military data alone could justify. Given the nature of space, and of modern weaponry and communications, the world knows that it cannot assume that effective military use of this environment will not be developed, or that man, at some point, will not be required to fill a military function in space. We have little room for choice. The capability of man in space must be probed far enough to determine his full usefulness and his role.

The mastery and occupation of a new environment has usually resulted in the development of related resources. The prime resource of space now discernible is knowledge: of the earth's atmosphere, of the sun, of the planets, perhaps of the origin of life itself. I have already indicated how we are making great scientific advances in the first exploratory steps into space. In the modern world, basic knowledge, applied through technology, is a source of national power. This fact will increase in importance.

A GREAT AND COMPLEX EFFORT in research and development has been undertaken in the manufacture of launch vehicles and spacecraft, bringing significant advances in virtually every area of technology, from power sources to materials. New concepts in organization, in reliability and in systems development are emerging. The result is the beginning of wide ranging technological advances.

As an example, consider the field of materials on which practically all technology is dependent. The Space Age demands faster and more powerful vehicles and engines that are light, strong, and resistant to heat. More and more materials are being produced which meet such demands.

Engines are producing controlled power at operating temperatures 1,500°F. over the melting point of steel. New solid lubricants have been developed which are usable up to 2,000°F. for short periods of time.

The advanced technology of combining fibers with other materials has resulted in developing new materials with hitherto unattainable combinations of characteristics. We can produce such composite materials which weigh less but have twice the strength and five times the rigidity of those in present use. We have developed practical applications for steels twice as strong as those in use twenty years ago.

The materials research program in NASA extends into a wide variety of areas which will benefit segments of American industry other than those devoted to aeronautics and space. Take, for example, the research program on improving paints for controlling high and low temperatures. Research on paint pigments aimed at reflecting the sun's heat away from fuel tanks of spacecraft will find application in paints for such industrial applications as fuel and gas storage and refrigeration plants, and even for helping to keep our homes and buildings cooler.

Even such a well established field of technology as the lubrication of rotating machinery is being profoundly influenced by our scientific research program. Conventional lubricants cannot withstand the harsh environmental demands of space, whether they be heat, cold, vacuum, or radiation. Ingenious schemes for providing reliable lubrication are being studied. In some cases a fluid already in the system is the "oil"—whether it be liquid hydrogen fuel at 423 degrees below zero, boiling metal for a space power turbine at 2,000 degrees, or concentrated acid oxidizer for a rocket. In others, lubrication is provided by an appropriately slippery solid which is bonded to the sliding surfaces. In still others, the structure of the bearing is such that it provides a reservoir of solid lubricant from within itself. Such nonconventional schemes will have impact on the design of new and advanced industrial machinery.

The mastery of space has required a great and complex effort in research and development, and in the manufacture of launch vehicles and spacecraft. The harsh conditions of space are requiring significant advances in virtually every area of technology, from energy sources to materials. New concepts in organization, in reliability, and in systems development are emerging.

MASTERY OF THE NEW ENVIRONMENT of space demands our best. It taxes our technical and organizational capacities to the limit. It opens to us a vast new area to explore and to use. And in acquiring the new knowledge and the new technology that we must have to reach farther and farther into space for longer and longer periods of time, as a nation we acquire new capabilities for economic, social and political decision and action—new capabilities essential to the maintenance of our position of world leadership and to our national security. It is not unimportant to the over-all economic, social and political power of this Nation, and the image held of it by friend and foe around the world, that the National Aeronautics and Space Administration, created a short seven years ago and spanning the Administrations of Presidents Eisenhower, Kennedy, and Johnson, has succeeded in doing all the things required to mobilize the broad capabilities of over a hundred and fifty universities, twenty thousand industrial prime and subcontractors, and almost 400,000 men and women and to focus them sharply on the work required to establish a position of leadership in space, as well as to maintain our leading role in aeronautics. In the years ahead this capacity, focused on one of the greatest adventures which has ever stirred the imagination and ingenuity of the world promises also to sustain our power over our own destiny, to increase our capacity for that freedom necessary to pursue our own goals, and to play our part in the big decisions that will determine the future environment within which other nations can work out their own destiny.

★ ★ ★

(*Continued from page 488*)

It was not deemed necessary to recanvass the various Highway Departments to update the report on Operations and Methods made to the annual meeting last year. Attention in this area is also called to the publication of the Highway Research Board, "Highway Research News," No. 6, June, 1963, which summarized the responses to a questionnaire made by forty-seven State and Federal Highway Agencies. It should be noted that first-order machines and numerical methods for extending control and executing cadastral surveys are now being used by several Highway Departments, also that production of orthophotos by a computer controlled single projector method has been successfully tried by at least one Department.

State Highway Department Research in progress can be followed by reference to a yearly publication of the U. S. Department of Commerce, Bureau of Public Roads, titled, "Highway Research and Development Studies Using Federal Aid Research and Planning Funds." A number of projects involving photogrammetry, electronic surveying and photo-interpretation are noted being conducted generally by Universities or State Forces.

Finally a considerable effort to solicit papers was made by the committee with only moderate success.

Since difficulty was encountered in scheduling a panel at the annual meeting, most papers are being held for presentation at an appropriate time.

—*Lloyd O. Herd*, Chairman