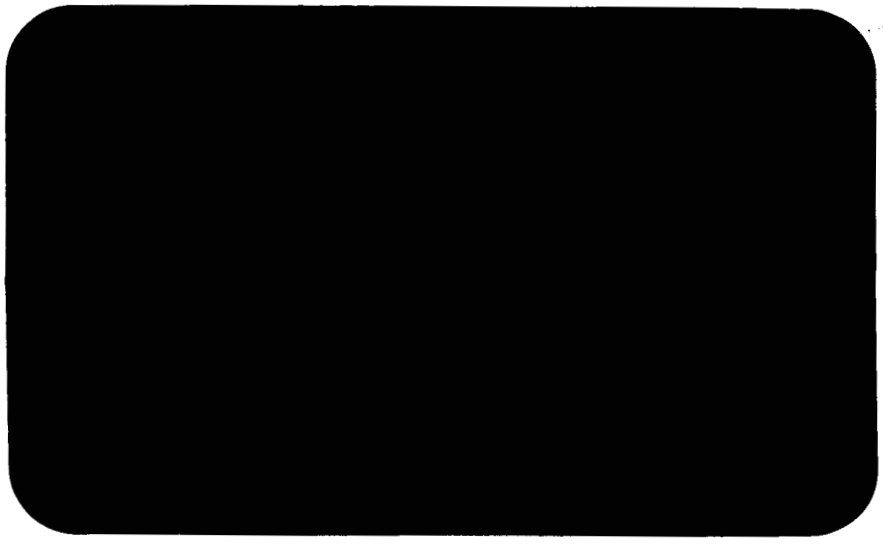

PROGRAM OF POLICY STUDIES IN SCIENCE AND TECHNOLOGY

THE GEORGE WASHINGTON UNIVERSITY

SCIENCE, TECHNOLOGY, AND THE NATIONAL POSTURE

by

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A nation's posture is the summation of many things--of many postures. Of major importance in these is the nation's preeminence in technology and science. Science is the systematic study of nature--of the universe in which we live. The product of science is knowledge and through knowledge understanding. To a major extent the science posture of a nation measures the national intellect and use of this intellect. Technology is man's application of this knowledge and understanding to man's use. The applications can be for man's betterment or his detriment and nearly always provide some of both. The long-term advantages have so far outweighed manifold the disadvantages. These advantages can be summed up in two achievements: (1) an increase in productivity per man and an increase in the variety of products man fabricates--an increase to the extent that man can enjoy the fruits of his labor, achieve comfort in his living, and do so without resorting to en masse mental and physical hardship; and (2) the elimination and lessening of the ravages of disease so that man can have a high expectancy to reach and exceed his biblical allotment of three score and ten years.

Man has always sought knowledge and has always applied this knowledge to his use. To the development of the devices for this application we assigned the term "invention"--invention of the plow, of the sail, of the wheel, of the steam engine, and of the telephone. But in more recent years because of the multi-manned effort required in invention we have adopted the term

"research and development." The two Wright brothers with the assistance of a half dozen aids "invented" the airplane, but some five thousand scientists and engineers researched towards and developed the manned Mercury spacecraft. The Apollo lunar-craft and its supporting systems will be researched and developed by some fifty thousand scientists and engineers.

The place of the individual inventor will always remain with us, but invention through multi-manned organized research and development has become and will become increasingly necessary as the tools of technology inevitably increase in complexity.

Science undertaken solely for increased understanding without regard to the use of this understanding is called basic research. Science that is a search for particular understanding to achieve a specific development is called applied research. The application of understanding or knowledge to the achievement of a particular device for man's use is called development. Roughly three per cent of our Gross National Product is currently expended on research and development (R and D) involving about a half million scientists and engineers. Three quarters of this R and D is financed by federal funds. Most of that financed by the government is conducted under contracts and grants at colleges and universities, non-profit organizations, and industry.

Essentially, if a people--a nation--conducts no research or development it makes no progress. And generation after generation the people continue in the procedures and customs of their fore-fathers. The only difference such people experience now over

that experienced centuries ago is that tourists visit them to see and photograph their stagnation of custom and living standards, and a miniscule percentage of the citizenry can and do purchase the material benefits of the research and development of other nations.

As research and development (or invention) progresses two things inevitably happen: (1) The problems to be solved become increasingly more difficult, more people and therefore more dollars are required for effective progress; and (2) the new frontiers of research and development increasingly involve those realms of nature D to which man's five senses do not respond. The first means that the people as a whole (through their duly elected representatives) must take an increasing part in deciding the level of the national R and D effort. The second means that it is increasingly difficult for the people as a whole to understand what is being done--and we have C. P. Snow's Two Cultures. Now to explain what cannot be seen, heard, tasted, smelt, or felt. To do this, research scientists had to devise instruments that would respond to these phenomena that were outside man's five senses and so could be treated only by his sixth sense--his sense of reason. By so doing, man has understood much and applied much, and we have the dramatic impact of the electronic industry--the telephone, radio, television, and, of immediate and confusing impact, automation.

Without research and development we would have a primitive agricultural society and not the highly industrialized, organized,

urban society that we have today. Is this good or bad? As far as material welfare is concerned it is good; and without material welfare the vast majority of mankind, once a primitive society is abandoned, is doomed to unrewarding, degrading, exhausting labor.

We conclude that the progression of a nation or people is paced by the research and development it conducts.

The new frontiers of research and development are not arbitrarily chosen by man. They are dictated by what man has already accomplished. One can liken man's industrial and inventive progress to a continually enlarging circle. The ever enlarging area inside the circle represents what he now understands and what he has successfully researched and developed. The continually lengthening circumference represents the new frontier he faces. To keep a balance he must traverse the whole of the circumference representing the unknown. When a breakthrough occurs--as with the invention of the wheel, Sir Isaac Newton's exploitation of the concept of force, Maxwell's derivation of his famous equations, Einstein's concept of relativity, the development of the atom bomb, or man's first flight into space--salients do appear, salients that can throw progress out of balance. But the base of the salient is soon widened and the balance of circularity reestablished. At the time the breakthrough is made, its overall effect on enlarging man's understanding and the applications of this understanding cannot be foreseen, but the challenge it presents for a broad advance in research and development is clear and unmistakable.

Three breakthroughs of major importance to applied research and to development occurred in the two decades from 1940 to 1960: first, the achievement at Chicago of a controlled nuclear chain reaction on December 2, 1942; second, the invention of the transistor, announced by the Bell Telephone Laboratories in 1948; and, third, the successful Russian launching of the Sputnik spacecraft on October 4, 1958.

The first breakthrough brought World War II to an abrupt end without the necessity of a Normandy D-Day operation on the coast of Japan. Nuclear power plants for government and industry are now commonplace for particular operations--most notably the Polaris submarine. And the use of radioactive isotopes as tracers in the organic and inorganic sciences and technologies is widespread.

The second, the transistor, has made "miniaturization" feasible in the field of electronics, and as a result we have our whole new computer industry, automation, and miniaturization. These two breakthroughs--achievement of the controlled nuclear chain reaction and of the transistor effect--have had vast and virtually immediate effects on the world at large--its peace and its industrial progress. It is important to emphasize the fact that the nation in which the breakthrough occurred had only a short time advantage in either the power struggle or the industrial struggle between nations and people. Soon every nation with a wide research and development base was using the new understanding to develop the resulting devices.

The third frontier opened in these two decades of war and postwar--man's flight into space--has not as yet had the payoffs of the other two, but the payoffs in the applied fields are becoming evident first in the field of weather reporting, second in the field of communications, and third in the field of surveillance. The first two are for man's immediate betterment, and the third, as a means of preserving the peace, for insuring that man can enjoy these betterments.

Should we as a nation continue our efforts--our application of man hours and materials--in this basic research, applied research, and development in space? The fact cannot be avoided that such a program is inherently expensive. The cost of placing a geiger counter in earth orbit is many tens of times the cost of placing the same geiger counter deep in the earth's bowels in a diamond mine in Africa.

As we progress in our space research and development, the effectiveness of the program per dollar spent will increase, because our flight failures will decrease. Essentially, this will mean that for the same cost we will be able to explore more deeply and more extensively into space, with both manned and unmanned craft. These are the as yet intangible opportunities to further our national posture that flight into space gives us.

In June a year ago, Barbara Ward, the British economist, speaking in Williamsburg, focused attention on the opportunities

of our nation. She said:

> I would like to suggest...the possibility that once a certain level of scientific, technological, and industrial advance has been secured, one of the chief ways in which we secure the materials we need for accomplishing our purpose is simply by deciding to achieve them.
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> ...the reason is that the scientific revolution has unleashed such capacity for expansion, such powers of production, such ability to augment productivity, that imagination is now the chief limiting factor on what we can and cannot produce.[1]

Our success in space exemplified this as no other national program has. In October of 1958 all that was needed to achieve our subsequent space triumphs was the will to do so. And, by so willing, and so doing, we have accomplished things that a half a dozen years ago were hardly dreamed of. Would we as a nation be better off if we had not accomplished these successes--accomplished them through an effort that currently consumes the mental and manual labor of one per cent of our work force? What have we achieved? We have done things of great magnitude that have shown our ability as a nation to use untapped resources to accomplish dramatic portents of the future. We have shot a craft to seek its own orbit of the sun. We have sent a craft to look closely at Venus. Our astronauts have examined the earth in a manner heretofore not possible. We have looked at the sun, the planets,

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[1]"Spirit of '76--Why Not Now," delivered at the 187th Anniversary of the Virginia Resolution for Independence and the Virginia Declaration of Rights, Williamsburg, Virginia, June, 1963.

the galaxies from above the veil of the earth's atmosphere. The costs in dollars have been high. What the returns to our betterment will be we do not yet know, and will not know for some time. But we have had the audacity to stretch greatly toward the future.

At a much lesser cost, we have done things in space that are giving us immediate returns--we have examined and reported on the weather; we have televised programs across the Atlantic; we have observed the earth from space; and we have demonstrated, in the words of Senator Gore, that:

> ...with malice toward none, science [through flight in space] has decreed that we are to live in an increasingly open world, like it or not...[2]

One need only look at the progress Japan made in the latter years of the nineteenth and the initial third of the twentieth century, Germany's progress from 1920 to 1940, and Russia's progress in this second third of the twentieth century to see the effect of a strong program in science and technology on national posture and preeminence.

In regard to our program in space we must use our intellect to interpret the effects of science and technology on our past progress and that of other nations. As a nation we must show the faith for our future progress that was previously required

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[2]Speech delivered to the United Nations, December 3, 1962.

by only a few men--Eli Whitney, the Wright Brothers, Henry Ford. For more and more the great discoveries of the mind and the great opportunities for national betterment will require public support and therefore public understanding before they can be brought to fruition. The gains are too great to be ignored, the costs too great for individual development, and the profits too uncertain for backing by private capital. We as a nation must grasp the fundamentals of these facts and not be confused or dumbfounded by the changes they require.