

THE ECONOMIC IMPORTANCE OF SPACE TECHNOLOGY

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June 1962

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During its infancy over a century ago my profession, economics, became known as "the dismal science." The title was occasioned by Thomas Malthus and some of his colleagues who, convinced that population tends to outrun food supplies, condemned the vast majority of the world's populace to a life of bare subsistence. In the Western World, at least, this dreary view of man's fate has gone out of vogue, but it is still difficult for the economist to avoid the stigma of a kill-joy.

One trouble is that economists invariably want to look at costs; they are eternally asking whether potential benefits will cover costs, and such questions have a habit of spoiling some people's fantasy life. To one who passionately believes "man belongs wherever he wants to go," asking whether going to the moon is really worth the candle is pure heresy.

Resistance to cost-benefit comparisons, however, is, I think, only one facet of a broader problem, namely, the tendency simply to snub science in analyzing the social (including economic) consequences of space programs. Science is the keynote when it comes to the physical process which generates space technology. I think everyone who has listened during the last two days to the report on the NASA program must be impressed, as I have been, by the extent to which that effort is oriented purely to expanding our scientific knowledge. Outside of that realm, science to a very uncomfortable extent is displaced by faith. Often, wishful thinking supersedes scientific prediction.

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This paper was prepared for presentation at the Second National Conference on the Peaceful Uses of Space in Seattle, Washington, May 9, 1962.

For example, it has been said that communication satellites will enable one to call anywhere in the world for 10 cents, and that such satellites will make international communications a \$100 billion per year business. As far as evidence is concerned, such predictions are about on a par with a prediction that the sun will not rise tomorrow.

Perhaps the area where a scientific approach has been most conspicuous for its absence is in the discussions of the international problems that are raised. Questioning the effectiveness of space endeavours as a means of influencing the rest of the world is generally regarded as heretical or plain stupid or both. Meanwhile, one will search in vain for the research, body of verified theory, or analysis, which answers such questions as: Who is it in foreign nations that is impressed by our space accomplishments? How are their attitudes changed as a result? How is their behaviour and their government's behaviour changed as a consequence? How does that change in behaviour affect me as a citizen of the U.S.? How do those changes in behaviour compare with other changes that might be induced by alternative uses of the resources that are consumed in the space program?

Much has been made, for example, of the use of communication satellites in underdeveloped countries, not only for telephone and telegraph but for television as well. I don't mean to belittle communication satellites, for I believe they have a bright future, but it takes very little research or even thought to convince one that international telephone and international live television mean virtually nothing to the mass of the citizens of low income countries around the world, and will mean little for years

to come. The television point is particularly obvious. The only advantage that communication satellites offer for TV is live broadcasts. If TV is the way to educate people in underdeveloped areas, we can do that today simply by flying films to wherever we wish to use them. Indeed, that will likely be the most economical way even after communication satellites are available. The primary reason we don't use TV in Africa today is because most Africans don't have TV sets, not because we can't send live broadcasts there. Nor is there a theory of economic development which attributes special qualities to international communications as a stimulant to growth. When it comes to typical international communications in such countries, satellite systems would have to be an order of magnitude cheaper than anyone anticipates in order to be competitive with microwave relays. Finally, it is not necessary, as has often been assumed, to provide each nation with its own ground station in order to tie it into an international communications system. Radiotelephone, microwave relays, and cables can be, and already are, used for this purpose. Indeed it needs to be emphasized that citizens of Seattle also are very unlikely to have their own ground station, but that will not prevent them from using the system.

If nothing else is clear, most of you will understand by now why I feel somewhat out of tune. Having aired my personal crusade for a more scientific approach to the question of the social consequences of space programs, however, I would like to turn to the question of what we can say in a positive way about the economic implications of space technology.

I would feel much more comfortable on this occasion if I were in a position to unveil a menu of exciting applications of space technology and with confidence predict both that they soon would be realized and that they would significantly affect all our lives. Unfortunately, research and development is a very uncertain business, and confident assertions emanate only from the uninitiated, the unbridled enthusiast, or the charlatan. What at first seem very promising lines of development frequently turn out to be quite disappointing. Significant new technology often emerges from ideas that the experts agreed would never work, and technology developed for one purpose frequently turns out to be most valuable in some use which no one anticipated.

One example worth recalling is the atomic energy program. After World War II there was a good deal of excitement over using atomic energy to produce cheap electrical power and about the use of nuclear engines in a wide variety of applications -- automobiles, airplanes, etc. I think it is fair to say that the results on the whole have been quite disappointing. On the other hand, the value of using isotopes in medicine and in production quality control has been a very pleasant surprise. When the British Ministry of Supply declined to support the development of Whittle's jet engine, they gave him the patent rights with the flat statement that this engine would never be of any military value. Whittle himself thought in terms of using the engine for a mail plane, and even after Whittle had run his engine a U. S. Navy Committee reported that turbine engines would be valuable in ships but would not be useful in aircraft.

The applications of space technology that are closest to realization today are the two which have engaged the attention of my fellow members on this panel, namely, communication satellites and meteorological satellites. Studies of the economic impact of both were initiated by the National Aeronautics and Space Administration early in the game, and are continuing. Other agencies, private firms, and individuals have also undertaken independent studies of communication satellites. Despite these efforts the future of communication and meteorological satellites can be discerned only in dim outline. This does not mean their future is dark. What it does mean is we do not know enough yet to predict very accurately how big an impact they will have, or in what particular areas and ways the impact will be greatest. We can be fairly confident that some sort of communication satellite system will offer significantly lower costs in long over-water links where communications traffic is heavy -- U.S. to Europe, Hawaii to the mainland, Alaska to the mainland, and Japan to the U.S. By itself that is no mean accomplishment. Beyond that, the picture becomes decidedly hazy. What type of satellite system -- synchronous? low-altitude? passive? active? etc.? -- will be most economic? To what extent will new sources of demand like TV and data transmission materialize? What kind of ground terminal network will make sense economically? We are a long way from having definitive answers to these kinds of questions. Realistic evaluations will be possible only after experimentation forges a reasonable basis for such evaluation. In brief, as Dr. Jaffe explained so well yesterday, we have a long way to go until we have an operational system that is economically valuable. I might add in passing that Dr. Jaffe's objective appraisal of where we

are in the communication satellite business is a good example of the opposite of the "unscientific" attitude I was concerned about earlier.

The situation is even more equivocal when it comes to meteorological satellites. We are very uncertain at this point how much or in what respects weather forecasting will be improved as a result of meteorological satellites, and if we resolved that uncertainty, we still wouldn't know how to quantify objectively the value of the improved forecasts. NASA has sponsored some studies that have attempted to measure the value of improved weather information to particular industries or in particular geographic areas, but how much is it worth to travelers, to golfers, to a fisherman, to baseball fans to have improved forecasts? In the absence of a market in which weather forecasts or weather information is sold, it is nearly impossible to answer such questions.

Nor does the uncertainty end there. In the long run, better weather information could improve our understanding of the determinants of weather conditions, and thereby enable us to control or affect the weather. It takes very little imagination to see that if that situation ever is realized, the economic effect could be dramatic. On the other hand, we have no very good reason at this juncture for believing that meteorological satellites are the key that will open the door to this happy state of affairs.

If the outlook for communication and meteorological satellites is somewhat fuzzy, the economic implications of other space programs and the technology they will generate is pure conjecture. Given that uncertainty and the time available to me, it would be futile to discuss specific applications, but I would like to make several personal observations.

First, any really significant innovations are almost by definition going to be ones we now do not foresee. If we could foresee them, we would already be working on them. Second, it seems likely that any indirect economic benefits that accrue as a result of space endeavours, like the lunar landing program, will take the form of improved or new products used here on earth. Mankind is not going to be enriched either by exploiting resources on the moon or by establishing residence there. Indeed, it seems unlikely that space travel (as distinguished from space exploration) will be a good investment in any time period in which our generation has a serious interest. To put the matter a little differently, I would not buy stock in a company that was proposing to acquire a valid title to the moon for a price that was even a small fraction of what we are proposing to spend in getting there. What is likely to come out of such programs is (a) scientific knowledge which enables us to exploit resources on earth more effectively, and (b) new technology which enables us to improve products or provide new ones here on earth. The list of possibilities here is too long to enumerate, but one example is long-lived, light-weight batteries that could variously be used as power sources, perhaps even as a substitute for combustion engines in automobiles -- an application about which one of my colleagues is quite excited. Because the existence of new technology of this sort will not itself insure its use, the National Aeronautics and Space Administration has recently initiated a program to identify promising possibilities generated by the space effort and bring them to the attention of potential users. Both contractual work and in-house activities will be canvassed and screened, and the results published.

In closing I would like to return to the theme of my opening remarks. The exploration of space is a very exciting affair indeed. If glamour displaces science in guiding national policy, however, the results may be very disappointing. A communication satellite system that charges prices not very much different from present prices and that must be constantly subsidized and protected from competition, is not much of an accomplishment, and may make us the subject of ridicule rather than admiration.