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ASSESSING TECHNOLOGY FOR MARINE RESOURCE DEVELOPMENT

PROCEEDINGS OF A CONFERENCE-WORKSHOP HELD BY THE MARINE TECHNOLOGY SOCIETY AT ARLINGTON, VIRGINIA ON MAY 15-17, 1972

MARINE TECHNOLOGY SOCIETY

PREPARED FOR
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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Assessing Technology for Marine Resource Development

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INTRODUCTION

ASSESSING TECHNOLOGY FOR MARINE RESOURCE DEVELOPMENT

Sponsored by

The Marine Technology Society,
Committee on Economic Potential of the Ocean
May 15 - 17, 1972
Crystal City Marriott, Arlington, Virginia

This meeting on Technology Assessment of Marine Resource Development was a pioneering effort which for the first time explored analytical techniques of technology assessment and with a view toward their application to the field of marine resource development. A forum was provided for scholars and other interested people from various walks of life including government, industries and universities.

The purpose of the symposium was to review the seriousness of economic and related socio-political problems confronting marine technology development, and the limited choices for decision makers. We examined meaningful ways of coping with some of the seemingly unresolvable questions and issues facing the great potential of ocean resources.

We chose the definition by Dr. Gabor Strasser that technology assessment is a systematic planning and forecasting process that delineates options and costs, encompassing economic as well as environmental and social considerations, that are both external and internal to the program or project in question, with special focus on technology-related "bad" as well as "good" effects.

Thus, it was felt that the wide-ranging analysis of science policy issues and the multidisciplinary approach required in technology assessment would be a particularly appropriate theme for the Economic Potential Committee of the Marine Technology Society to sponsor.

Top figures in the country in the newly-developing field of technology assessment explained the rationale and workings of these analytical methods. In technology assessment, social and environmental factors are weighed along with traditional scientific and economic considerations in examining future developments. This approach is likely to affect the way business, universities, and governments conduct their affairs in the years ahead. The U. S. Congress has moved ahead in establishing an Office of Technology Assessment to provide needed independent judgments of the total impact on society of future technological developments.

Speaking as program chairman, the excellence of this conference is almost entirely the work of Dr. Miller B. Spangler. From its earliest conception, through the planning stage, and the actual conduct of the meetings, we are indebted to Dr. Spangler.

Dr. Milton G. Johnson, Chairman
Committee on Economic Potential
of the Ocean

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SESSION I, TECHNOLOGY ASSESSMENT:
ITS PURPOSE, METHOD, AND SCOPE

Harvey Brooks
Harvard University

INTRODUCTION

It is obviously impossible to do justice to the wealth of ideas and insights regarding technology assessment which have been presented in Session I. What I shall do instead is to select for comment a few salient points which I consider especially significant. A few of these are points not stressed by the speakers, but which I feel deserve some emphasis. The presentation will be in the form of a series of propositions, with a brief commentary on each.

1. TECHNOLOGY ASSESSMENT IS HERE TO STAY.

Joseph Coates gave us a number of reasons, inherent in the nature of modern technology and the structure of modern societies, why technology assessment is bound to be an activity of growing political and economic significance. These reasons include the complexity and interdependence of human societies, the power which technology has given us to remake the environment, the growth of scientific knowledge which makes technological foresight possible, the scale and permanence of an increasing number of technological enterprises, the rising expectations of society which go with increased affluence, the political emergence of previously disenfranchised groups in society, and the popularization of anti-technology philosophies previously held only by narrow elites.

Political developments amply confirm this analysis. Congressman Davis gave us a glimpse of the importance which Congress attaches to the creation of an Office of Technology Assessment, responsive to congressional needs, but objective and nonpartisan in its orientation. Dr. Coates also gave us a view of the "sleeper" in the Environmental Protection Act with its requirement for environmental impact statements, a provision whose potential has barely begun to be realized.

2. TECHNOLOGY ASSESSMENT REPRESENTS A NEW TIME SCALE FOR SOCIAL AND TECHNICAL PLANNING.

As Charles Williams has reminded us, technology assessment has a venerable history both in government and industry. What is new about the modern version is the longer time horizon which it envisages. The discount rates used in cost-benefit analysis no longer provide a sufficient criterion for the analysis of the social impact of technology in many cases. In the past it may have been adequate to assume that the wealth created by the exploitation of technology would be more than sufficient to enable us to repair any damage from secondary effects, because the present value of the future dollar was so small. This assumes, however, that repair of damage is always technologically feasible, something we may no longer take for granted.

Mr. Williams has suggested that to test our capacity for technology assessment we should attempt to assess retrospectively the impact of decisions made 10 or 15 years ago and also begin now to follow closely the impact of decisions made now for 10 or 15 years ahead. Raymond Bauer's retrospective assessment of the impact of the railroad on American society is one of the few examples of what Williams had in mind.

In the same vein Doumani recommended to us a new view of technological progress. Our aim, he said, should not be to maximize technological progress, but rather to achieve what he called a "rationally protracted progress," a moderate enjoyment of our material capacities, like sipping a fine wine to appreciate its bouquet. Again what this implies is really a smaller discount rate in cost-benefit analysis, a greater weighting of the future relative to the present.

These ideas raise the difficult ethical issue of our responsibility to future generations, something we have never considered it necessary to take into account explicitly before. There are many who still say, "what has posterity ever done for me?" But posterity is our own children and grandchildren, and we can no longer have such great confidence in their capacity to repair our mistakes, despite the intellectual resources and wealth which we will bequeath to them.

3. TECHNOLOGY IS NEUTRAL.

What most of our speakers were suggesting, I think, is that it is unwise to take a global view of technology. We must rather look at it on a case-by-case basis, recognizing that it will be sometimes good and sometimes bad. It is, in fact, ethically neutral. As Mesthene has remarked, the actual consequences of technology are a small subset of the consequences which are possible. One reason for this is that technological invention and social invention seldom occur separately; they always accompany each other. The way technolgoy is actually used by man depends more upon the institutional evolution which accompanies it, which is by no means inevitable, than on the technology itself, a point particularly emphasized by Joseph Coates.

In his exposition of congressional attitudes Congressman Davis also underlined the point that Congress is just as interested in the positive as the negative values of technology. Even the so-called secondary consequences, or unforeseen side-effects, of technology are frequently beneficial, and as Coates told us, one of the purposes of technological assessment is to identify these positive effects at an early stage in order to do everything in our power to encourage them, as well as to discourage the secondary disbenefits.

In the early stages of a brand new technological development, people tend to be fascinated with the purely technological aspects, because it is usually only these that are readily visible when the technology is applied on only a small scale. Yet it is just in this stage that the course of institutional adaptation to technology is often set, quietly and with little notice. One purpose of technology assessment is early identification of these institutional and social factors, which are crucial to the impact of technology for good or ill as its scale of application grows.

Many of our troubles in the past have stemmed from either a generally euphoric or generally phobic attitude towards technology, with little discrimination as to detail. Indeed, the compulsive regulation or suppression of technology as frequently gets us into trouble as its uncritical and enthusiastic application. This is because it is not technology per se, but decisions about technology that have unforeseen consequences. There is just no substitute for hard thinking and wisdom in dealing with technology.

4. TECHNOLOGY ASSESSMENT IS AN ITERATIVE PROCESS.

This is a point made by Coates that I would particularly like to underline. The usual outcome of a first technology assessment is merely to define more precisely our areas of ignorance and to establish priorities for the acquisition of new knowledge and for monitoring the impact of a technology as it evolves. Unless we are continually seeking this new knowledge and feeding it repeatedly back into the assessment process we cannot have an up-to-date assessment that can be reliably used as a basis for decision-making.

We can point to many historical examples where apparently reliable technology assessments were made at an early stage in the introduction of a new technology. These assessments often pointed to areas of potential risk, but existing scientific knowledge was insufficient to make us believe the risk was real. Too often we went ahead, saying there was no evidence of harm, without an active program to seek such evidence as the scale of application of the technology grew. A classic example of this was the introduction of DDT into agriculture immediately following World War II. The technology assessment was surprisingly thorough and quite adequate for the types and scale of use of DDT that were then considered likely or even plausible.

Moreover the values and expectations of society evolve, and change what is regarded as an adequate assessment. In addition to new scientific knowledge and new relative priorities between values, there are also new technological alternatives for achieving the same benefits. At one time we may decide to go ahead with the application of a technology because its benefits are obvious and great, and its costs or risks acceptable only because there is no viable alternative which would produce the same benefits at lower cost or risk. But this can change rapidly, and is the factor most likely to be ignored, because the "experts" on a particular technology may be relatively unaware of the progress with alternative or competing technologies. Hence this is another factor in the importance of continual iteration of technology assessment. Robert Ayres gave us two striking examples of economic assessments in the cases of urban rapid transit and civilian nuclear power, where failure to "look over the shoulder" at competing technologies resulted in wildly wrong assessments. Perhaps another illustration is the failure to anticipate the impact of air pollution standards and mine safety legislation on the strip mining of western coal.

5. THE SCALE OF APPLICATION IS AN ESSENTIAL FACTOR IN TECHNOLOGY ASSESSMENT.

Many technologies have what might be termed a "natural" scale of application. Until they reach this scale their benefits are obvious and highly visible, while their disbenefits are relatively unimportant. This is because benefits are usually linear in scale of use, while the disbenefits are non-linear, i.e. they increase with some power of the scale of application. For example, traffic congestion goes at least as the square of the number of vehicles; smog production increases as some high power of the concentration of automotive exhaust pollutants; the absorptive capacity of the environment begins to saturate at a certain level of contamination. Many social impacts resulting from technology have self-exciting elements. The flight to suburbia increases the attraction of the suburbs and the undesirability of the central city. A partially segregated neighborhood greatly increases the incentives for further segregation. Requirements for chemical fertilizer and for pesticides increase as the 2.5 power of crop yield, or even faster, as does the environmental contamination produced thereby. The homeostatic mechanisms of ecosystems break down quite suddenly and their limits are exceeded, much as does the physiology of the human organism in response to stress.

A concomitant phenomenon is that as a technology increases in scale of application it enjoys economies of scale which cause its design to be frozen, and further innovation becomes increasingly difficult. Thus the technological evolution which would be needed to adapt the technology to a new scale of application is inhibited by the very success of the technology. This effect is further enhanced by the institutional vested interests and habits which become established with the growing scale of application. One of the major purposes of technology assessment should be to break out of this vicious circle, to anticipate the necessary evolution of technology with scale of application before its design and accompanying social supporting systems become rigidly frozen.

All of this, of course, lends added weight to the iterative and evolutionary character of technology assessment.

6. TECHNOLOGY ASSESSMENT CANNOT PRODUCE A UNIQUE ANSWER WITHOUT REFERENCE TO SOCIAL VALUE JUDGMENTS.

The interpretation of a technology assessment in terms of recommended decisions or options involves the application of some scale of social values. The ideally neutral technology assessment is one which produces a number of alternatives and forecasts their most likely social and environmental consequences, together with the range of uncertainty in which these forecasts lie. The choice among consequences is then a political one. The test of a really good technology assessment is one that is useful even after values have changed substantially, or which will be acceptable to several conflicting interest groups having different priorities among their values. Complete neutrality is not possible in practice, because even the selection of facts and analysis for presentation in a technology assessment is inevitably influenced to some extent by unconscious value assumptions. Nevertheless, a value-free assessment is an ideal to be sought, and a criterion against which to measure the validity of an assessment.

Such a technology assessment can be presented in one of two ways. Either a number of alternative decisions may be presented, along with their probable consequences and the delineation of additional knowledge needed to reduce the uncertainty in these consequences, or a single alternative can be presented along with a very explicit setting forth of the value assumptions which underlie it and the selection of facts used to arrive at that point. Such a single alternative analysis may be more susceptible to obsolescence due to changing or conflicting values, but it can often be more thorough and understandable to the public, and useful to the decision-maker. A scientist should be under strong moral obligation not to present moral or political preferences cloaked in the guise of objective scientific judgments. The social authority of science can easily be used to lend weight to a preconceived political opinion, but such authority is a wasting asset, soon depreciated if often used.

7. THE PUBLIC MUST UNDERSTAND THAT TECHNOLOGY ASSESSMENT NEVER HAS A SINGLE ANSWER, BUT ALWAYS INVOLVES A TRADE-OFF BETWEEN BENEFITS AND RISKS AND A BALANCING OF THE PREFERENCES AND INTERESTS OF DIFFERENT SOCIAL GROUPS.

As the public becomes increasingly interested in technology assessment and wants to participate, the danger of simplistic answers and black and white conclusions becomes greater. For example, the public must understand that there is no such thing as a clean environment, only one more or less clean, and that environmental standards must depend on how much one values how clean an environment is in comparison with other goods and services. Usually an improvement in the environment benefits a different group from the one that benefits from the activity that pollutes the environment. The classic illustration I am fond of citing is the air-conditioning which improves the environment of the office worker in New York at the expense of air pollution for the postman, the policeman, or the tennis player, arising from the increased consumption of electric power.

Participatory technology assessment has limitations, for final decisions must be reached which will adversely affect some party at interest, even if the decision is to do nothing. The representation of a point of view in the decision process does not guarantee that that point of view will prevail, or even that it can be taken into account, in the final decision. Participation in the decision-making process must not be confused with the power of *de facto* veto or the capacity through procedural delay to impose *indefinitely* high costs on some of the parties to the controversy. Thus participatory assessment places a high premium on early public exposure of a problem before costly commitments are made, and in order to provide time for full exposure of the facts and arguments in the case, as well as to acquire new information to answer questions raised by some of the potential parties at interest. However, if the participants in the assessment process give overriding priority to one particular value to the exclusion of all others, with no willingness to recognize the claims of opposing values and interests, and no sense of responsibility to propose viable alternatives, the process is unlikely to converge. Thus a major objective of public education in assessment is to help the participants in the process put themselves in the shoes of other participants.

8. THE ASSESSMENT OF MARINE TECHNOLOGY PRESENTS CERTAIN UNIQUE PROBLEMS ARISING FROM THE NON-NATIONAL OR "COMMONS" NATURE OF THE OCEANS.

Although the coastal zone is usually under national control, it is almost invariably a key part of the oceanic ecosystem out of all proportion to its actual area. As such it is much more a part of the "commons" than would be a corresponding land area. This is especially true in relation to the biological resources of the oceans.

At the same time the decision mechanisms applicable to such "commons" which transcend national boundaries and interests are very weak. For the most part they have to be reached by negotiation between fully sovereign states rather than by common administrative processes. Furthermore, this creates a situation which makes it easy for powerful private interests to manipulate conflicts between sovereignties to their own advantage, and to the greater detriment of the commons.

On the favorable side the oceans have a strong international scientific constituency, capable of working together to bring pressure on national decision-makers to reach agreement in the interests of the commons. While the oceans are an important resource both for food and for petroleum, and a relatively minor resource for minerals, they do not appear to be a dominating resource for any of these purposes, a fact which should encourage more restrained development, as Doumani has indicated to us.

AN OPTIMISTIC VIEW

I find myself in strong agreement with Joseph Coates' observation that the solution to technology assessment is to get on with it. Experience indicates that it can be done provided one does not demand instant perfection. The fact that makes limited assessments useful is the possibility of iteration, so that imperfection can be refined out by a learning process. Today we are just at the beginning of this process in most areas, but currently startling progress is being made in many of the disciplines that must underlie technology assessment, particularly in the environmental sciences. Despite some beliefs to the contrary I suspect that few of the things we are doing to the environment today are wholly irreversible, although they may soon become so. Thus I think we do have time for the learning process to catch up to reality and to our expectations, assuming that we recognize that continued rapid advance of basic science, especially in the environmental sciences, is an essential part of this learning process. Even if Mr. Doumani is right in calling for what I interpreted as a slower pace of advance of technology, this should not imply any slowing of the pace of science. Indeed, slowing the pace of technology will do little good for future generations unless we are able to increase our understanding of the world relative to our power to manipulate it.

THE PAST, PRESENT AND FUTURE OF TECHNOLOGY ASSESSMENT

Charles W. Williams, Jr.
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I'd like to simply share with you, under the title I have been assigned, some of the impressions and feelings that I believe are relevant to what is essentially seen as a newly emerging field. Obviously nothing is as new as it seems; neither is technology assessment. I think it's fair to say, however, that during this decade there will be an attempt to organize the approach to the assessment of technology that will be appropriately described by 1980 as a qualitatively different concept to the approaches that we have had in the past. Let me just suggest some of the past approaches that I think would qualify as technological assessment efforts; then I will describe some of the differences in the past, present, and future patterns of these developments, as I see them.

SELECTED ITEMS IN THE HISTORIC BACKDROP

I would characterize technological forecasting, at least for the purposes of my discussion this morning, as issuing more or less systematically from the efforts of the National Resources Planning Board, which would date it back to the late 1930s--around 1937 or 1938. At that time the purpose was to assess the capacity of the scientific and technological arts to help the country pull itself out of the economic depression. It has always interested me that it was that effort, insofar as I can determine, which for the first time articulated in an explicit way the concept that science is a national resource, and hence an important and critical instrument of national policy and of national goals. Both during and after World War II, an activity grew which came to be called technological forecasting. The principal objective of that activity, as it initially was engaged in, was largely to assess those aspects of the state of the art that were most susceptible to exploitation and development. It was largely a process of facilitating decision making from the standpoint of allocation of research budgets. Out of that effort evolved the interesting awareness that those who are most expert in a particular discipline are, in some senses, the most unreliable forecasters of future technological capabilities. This is largely due, of course, to the fact that many of the constraints perceived so vividly by those engaged in the actual processes of research are overcome, not within the original disciplines, but through developments in entirely different fields. There soon emerged a variety of methods which sought to make it possible to blend the expert judgment of individuals across a variety of fields. This era was still largely characterized by the orientation of facilitating the allocation of research budgets, in order to further develop the technological states of the art.

This was based on the almost unchallenged assumption that more technology and the maximum development of the state of the art should be pursued.

Another set of activities was appearing during this same period. By the late 1940s and early 1950s technological assessments in a much broader sociological context were emerging. The public debates among scientists about the hazards of atomic power dramatized an early example of a socio-economic-political-technological scenario.

Both during and after this particular period a number of people began to realize that the implications of the space program were much deeper than the scientific or engineering aspects of the program itself. So far as I know, one of the earliest studies in this area was launched by Don Michael. The central thrust of his proposition was that the assessment of the implications of the space program needed to go into its sociological, economic, and even its philosophic dimensions. Not long after that, NASA made a grant to study the social impacts of the space program, under the general direction of Ray Bauer at Harvard. In one sense, the studies arising from that program on the social implications of space technology were interesting examples of technology assessment.

The first book was a historic study of the railroad as one technology which had pervasively influenced American life, and was, so far as I know, certainly one of the best historic documentations of the dimensions of technological assessment perceived from the standpoint of hindsight.

The second book was also interesting, because that was the book that I think crystallized what has probably become or is close to becoming a movement in the social sciences--namely the thrust for social indicators. The theme of this book essentially was that one can't assess the social implications of space technology because no system of social accounting exists permitting us to understand the interfaces and interactions. It was recommended that such a system be developed.

Concurrently with this train of technological assessment there was developing what came to be called science policy research concerned with the systematic assessment and analysis of national science policies. It isn't as though this had not been going on; of course it had been. But there was a new level of consciousness about the importance of and the dimensions of science policy analysis. These early efforts to do systematic science policy research went well beyond the internal scientific projects, and even beyond the system of the sociology of science, into the interactions of science and societies. So the panoply of the things which emerged under the general classification of science policy research involved a range of activities that can now be seen as another component in the pattern of developments leading toward contemporary technology assessment.

I'd like to mention also that an interesting kind of technology assessment, not frequently called by that name, appeared in the middle 1950s, but was a sleeper on the scene until about the late 1960s. It was a little book by Rachel Carson called Silent Spring. It would be fair to say that in its day it was never seen as a serious assessment of technology at all. Yet by 1968 it could have been seen, and as a matter of fact was seen, as quite a serious work in technology assessment.

The general thrust of the technology assessment movement can also find its historic roots in such things as the development of planning, programming, budgeting, cost effectiveness, and 5-year program approach concepts in the Federal government and in large corporations.

The concern in the middle 1960s for the balancing of the social and physical sciences was still another form of technological assessment. This issue of "scientific balance" arose from divergent sources and ripened into debates in the Congress on whether or not there needed to be a National Foundation for the Social Sciences as a countervailing force to the National Science Foundation for the Physical Sciences.

Finally, the developing concern that there is a serious imbalance between the Executive and Congressional branches of government, and the concern of Congress with redressing this perceived imbalance and reasserting at least some form of its power and control is, I think, a factor in the present proposal for the Congressional Office of Technological Assessment. Undoubtedly this will become, if it is carried out, an important tool for Congress in reasserting its power. It could serve as a countervailing instrument in the balance of power between the Congressional and Executive branches.

THE PRESENT THRUST

Turning to the present, let me simply mention two classes of activities I think would be useful for us to think about at least in the context of a framework. First would be the substantive thrusts. These substantive matters are well illustrated by the scenarios that Miller Spangler has developed to guide your considerations in this conference. They are occurring in an increasing number of institutions and are gathering increased support. The National Science Foundation has launched a series of programs in this regard.

The SST is a dramatic example of the politics of such assessment, and perhaps marks a landmark decision. Although not as clear an example as one might find, I think it fair to say that it is certainly one of the most dramatic examples of where a decision was made not to push the state of the art, and thus essentially to invalidate a fundamental assumption about technological progress that had long been assumed to be sacred. The reason I say this is a signal case is because as late as 1966 or 1967 the planners of NASA had projected the space program's budget to be 15 billion dollars by 1975 or 1980 without seriously questioning that this was going to be the case. The assumptions upon which those projections were based were invalidated primarily because the value weights changed; it had nothing to do with the internal dynamics of technology itself.

The environmental impact statements now required are creating a tremendous range of technology assessments that are revealing, among other things, how expensive the process is going to be. If I remember the figures correctly, the estimate just for the technological assessment of the Alaska pipeline ran something like 9 million dollars.

Other relevant activities which may not be normally thought of as technological assessments are included under the term "evaluation research." An interesting example of such evaluation research is the problem of educating the disadvantaged. For a number of years we have advocated policies (with the support of what was characterized as the most rational or at least some of the best scientific knowledge on the subject) that would suggest that we in fact had techniques that would bring about educational equality if we would just reorganize priorities, expenditure patterns, and racial configurations. Billions of dollars and dozens of programs have been based upon these premises. Now, five or six years later, the same social scientists looking at the same and updated evidence are beginning to suggest that wasn't as good a problem-solving strategy as it originally seemed to be, even though it still might be a very desirable social policy.

I would guess that as we develop evaluation research, which is largely an evaluation of programmatic effectiveness in the context of social values and goals, we are going to find new dimensions to technology assessment. In fact a countervailing power is emerging even within the dimensions of the research community so that you've got people dealing with straightforward technological assessments and people dealing with essentially an evaluation of how effective those technologies actually are in a historic and dynamic context. If not handled carefully, these different perspectives are likely to cast such doubts upon the capacity for technological assessment as to significantly erode its credibility.

Turning from the current substantive dimensions of technology assessment, a second category of activities might be characterized as new institutional thrusts. We have here, of course, the proposed Congressional office which probably will come into existence, if not this year, within the next several years. Concepts have been developed and are gradually gaining support for new forms of institutions such as an Institute for National Alternatives, which was developed under the auspices of The Conference Board and is now being further developed by the Aspen Institute. New organizations such as the Center for the Study of Social Policy, which I represent, are also taking shape.

FUTURE DEVELOPMENTS

Now looking briefly at the future characteristics of the technological assessment role and function, what might we glean from our present understanding? Many of the things have already been said; I certainly endorse Gabor Strasser's definition of technology assessments. Perhaps, however, several things might be underlined. The systemic characteristics of technology go well beyond the assessment of the technology itself and may be characterized as a technological forecasting and sociological strategic assessment network. Let me give an example of this point. It would probably be a mistake to evaluate the probability of future marine technologies on the basis of current economics. Consider, for example, how likely it would be that alternatives to the internal combustion engines would have received serious consideration for investment before 1967. Yet, just five years later (a relatively short developmental period) the drive for quality standards is changing the economic parameters of what is regarded as economically valuable in the engineering of energy for transportation. I simply mention this to suggest that one of our lessons would be that within 5 years the economic, political and value dimensions of the technological assessment can be fundamentally changed. Such assessments are processes that never end. A continuous, dynamic, updating procedure is necessary. The process requires going beyond the internal logic of the technology or its underlying science or its direct economics, which of course must alternately interface with qualitative values.

I have some experience with trying to come to grips with the values interface; I can simply share with you that it is among the most difficult of all things to inject into the policy decision-making process. It is generally avoided by all of us because, I suppose, it's somewhat non-systematic.

Finally, I would like to suggest that whatever kind of technological forecasting capability does emerge, it is important to not forget the value of keeping historic accounts. I have been struck by the fact that we go through elaborate and rather expensive mechanisms for making decisions and choosing among a network of alternatives, normally reduced to some three or four basic pathways. (Of course, there are always more.)

The other thing that has struck me about these decisions is that once we make them we have a grossly inadequate network of accountability--I don't mean an accounting system in the traditional financial sense of the term--but we really never track that decision for a 10-year or 15-year period and evaluate it in the context of what the real analytic assumptions were at the time we made it, and how well they stood up over time. I would guess that if we were to do that, it would be a very significant contribution to the development of the methodology for improving technological assessment, and technological and sociological forecasting.

Finally, I would like to point out one other thing. Technological assessment really must be done not only in the context of the technical capabilities but of the social needs which require technical capabilities but about which we may currently have very little insight. This is, we may not have enough of a technological base to really make us think that an assessment would be adequate or would be called for; yet we've got needs in the society which require some kind of resolution but appear beyond our present capability. Solutions can only be developed with some kind of new dimension, or at least fundamentally different dimensions in the pushing of the technological foundations upon which that solution could be based.

There should be a "needs" orientation as well as a "capacity" orientation to technology assessment.

It's one thing to say we have the capacity, but is there a need? How do we approach the development of our policy strategies so that we can, in fact, aggregate that need into some kind of a market? The other approach is to ask what are our needs for which we have no resolution? What does this suggest? It would be difficult for me to understand how the National Science Foundation Research Applied to National Needs programs, for example, can progress too far without having to address that question in a very profound way. It's a very difficult question and I would certainly hope that it becomes a part of any technological assessment system which we have.

TECHNOLOGY FORECASTING: HOW GOOD IS IT?

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It is usually sound procedure -- which I shall follow in this case -- to start with ancient history. I have been asked to talk about Technology Forecasting - How Good Is It? So a good place to begin, it seems to me is, with the history of forecasting, which goes back at least to 1000 BC or so. You probably know the story of the priesthood of Mesopotamia. This group became very powerful and wealthy after discovering the secret of the annual flood cycle on the Tigris and Euphrates rivers. Like good entrepreneurs they sold that information to the peasantry. The return on their investment in Astronomy must be one of the highest ever known. In any case forecasting was off to a good start. There has been a steady demand throughout the centuries for good forecasts; the supply regrettably has been less reliable. In the old days there was some deficiency, I would say, in the incentive system for forecasters. Forecasters were frequently held responsible for their forecasts and as a consequence, being intelligent, many of them learned first how to forecast the consequences of an unsuccessful forecast and responed to that by clothing their forecasts in obscurity so that they conveyed as little hard information as possible. Verses and riddles proved helpful. It is still an interesting subject for speculation what Nostradamus, for instance, actually meant to forecast (if anything at all).

The Oracle of Delphi offers another marvelous example of cultivated ambiguity, I think. There were hundreds of instances like this but one I particularly like is a forecast made for King Croesus of Lydia, who asked the Oracle, in effect, what would be the consequences of his projected attack on the Persian Empire and the Oracle responded that "a great Empire would fall." The Oracle proved right, of course, though Croesus was the loser. So I thing the greatest single advance in the art of forecasting came when forecasters were somehow relieved of personal responsibility for the success or failure of their efforts, which is perhaps something that occurred gradually in the last century or two. Since then we have, luckily, had an opportunity to concentrate more attention on improving quality, the question of clarity having more or less resolved itself.

Now basically the only difference between technological forecasting and other kinds of forecasting is that technological forecasting is concerned with the effects of technological change. This is a relatively recent development primarily because technology is a relatively recent phenomenon: organized science. Invention goes back to the dawn of history and science goes back centuries, at least to Roger Bacon and Galileo, but technology is not science nor invention as much as a hybrid combination of the two along with engineering. In other words, technology involves the deliberate manipulation of science, initially for purposes of war and more recently for other kinds of social purposes.

The purposes of technology have their counterpart in the purposes of technological forecasting (Figure #1). Purpose #1 at the top of the list is "curiosity and conjecture." What kind of a world are we going to live in the future? We all want to know its technological dimension. The second one on the list is more serious: having recognized some potential problem areas involving technology (or its lacks), we're vitally interested to know how serious those problems are going to become and what the range of possible solutions are. "Propaganda" forecasting (#3) implies the recognition of an opportunity to achieve something that somebody wants to do. The most obvious example of that category were the early forecasts of space flight. Most of the people doing this forecasting were intensely interested in a particular outcome and in many cases working toward that objective. I would suggest that forecasting done by some of the people at this conference would be in the same category.

The important point to make here, going back to the question I was asked to address -- Technology Forecasting -- How good is it? -- clearly depends on for what purpose the forecasts were designed.

In the language in which these matters are discussed,you often hear terms like "normative" forecasting as opposed to "exploratory" forecasting; or you might use different terms: teleological forecasting is the term I prefer. Normative forecasting has the connotation of forecasting what "should be" (or what is "needed") which is almost a contradiction of terms, but not quite, whereas exploratory forecasting has the connotation of forecasting what "can be." This is related to the question of which comes first, the invention itself or the need for it.

We have in the literature exponents of both views. But I would say that the weight of the evidence is that, most of the time, need (or demand) precedes -- and triggers -- the development of a technology, but not always. The laser and perhaps xerography might conceivably be examples of technologies that became available before anybody understood their potential value. By and large, however, the consequence is the other way around -- you need something before it's invented. For that reason we are constantly being surprised (although we shouldn't be), by the number of times that things are invented, almost simultaneously, in different parts of the world by people who don't know each other. This happens over and over again.

Returning now to our subject -- How Good Is Forecasting? -- let me anticipate a question someone always asks by saying immediately that no single method is best and that, also, there is no single answer to the question of "How good is good enough?" But I can say something perhaps useful about the general principles with which you would attempt to match a method to a problem. Briefly, it is helpful to classify methods according to the nature of the information available. I tend to use a classification based on a hierarchy of levels of understanding or recognition. The lowest level could be described as the level of conjecture. It is perhaps a little unkind to the modern use of the Delphi method -- no relation to the Oracle of the same name -- to classify this as "conjecture" because there is much more in it than conjecture. But it is basically built upon the foundation of opinions -- specifically "expert" opinions, but the relevant expertise is usually assumed, not necessarily guaranteed or verified. After all, how would you verify an expertise on the future?

The second level of cognition or level of knowledge could be described as the level of metaphor or analogy. In this connection the so-called "growth" analogy comes to mind. This is repeatedly used in forecasting, particularly in technology forecasting. The analogy is probably obvious, so much so that there may be more to it than analogy; that is, it may in fact represent something rather fundamental. But the analogy is that technology is born, it grows, matures, and finally dies or decays (and is supplanted) very much as an organism does. In fact you can extend the analogy to talk about conception, incubation and all the rest of the biological words and still observe some correspondence with what goes on in technological development.

It is interesting that the biological growth phenomenon, if you tie it down to some specific case, for instance, bacteria growing in a bottle, tends to follow the characteristic growth functions which have been variously labeled as logistic functions or "S curves." That is, it starts growing rather slowly and then accelerates, but finally tails off again as food or space is used up.

The next level would be the level of the "quasi-model" of which perhaps a simple extrapolation would be the simplest example. The essence here is, if you have a time series which is reasonably regular, the most rational assumption about the future is that whatever has been happening in the past, will most likely go on happening unless you have some specific reason to doubt it. This is a kind of negative statement. In the absence of other knowledge, I would assume that things would continue as they have -- the sun will rise tomorrow, the population will continue to grow. Now, beyond that you can perhaps identify an empirical-phenomenological model level and I will cite at least one example of this in technological forecasting. Finally, in the physical sciences at least, you may conceivably advance well enough with the basic science to achieve an analytical "model" of which the Einstein Theory of Relativity or the Maxwell Theory of Electromagnetism, would be instances. Such a model is a comprehensive statement which covers a number of interrelated phenomena and which allows you to make very precise predictions of what will happen, given any set of initial conditions and boundary contitions. We haven't got that in technology forecasting. It looks like this really is too much to hope for. But short of that point, we do have examples of forecasts at almost every level.

What I would like to do next is comment briefly about possible pitfalls of forecasting and show some examples of these. See Figure #2. The first pitfall I wanted to mention is rather classic in that it goes back to Arthur C. Clarke; he calls it "failure of nerve," though I would be more inclined to label it as just plain conservatism. It's a characteristic of committees in particular, especially where engineers are involved. We have some spectacular examples of committees that have gone astray by piling conservative estimates on top of each other. Perhaps the best known was the blue-ribbon committee convened by the National Research Council (I believe it was 1941) that was asked to advise upon the feasibility of the newly hatched turbine engine. The men in that committee, the men -- whose names you have heard -- deliberated and concluded that a gas turbine could not work because it would involve a minimum weight to power ratio of something like 10 lbs/hp. They derived that number by doing elaborate calculations and taking conservative figures at each point. This is certainly the correct approach if you are designing a bridge, for instance. They were rather embarrassed when the first turbojet flew in England a month or two later. This is a built-in characteristic of committees -- it is the opposite of what happens in revolutions. Apparently in revolutions, the standard folklore is "never let yourself to be outflanked from the left." In engineering committees, however, it seems to be standard that you mustn't allow yourself to be outflanked from the right. Anyway, there have been a lot of examples of poor forecasts that are simply too conservative.

On the other side of that coin, for the sake of balance, I have to say there is also the possibility of being too radical. One can, in fact, be too impressed with the rapid progress of technology in recent years. If you reread the Sunday supplements of two or three decades ago, you may remember there were fearless forecasts of a helicopter in every backyard, pictures of cities with 150 story buildings linked together by ramps at various levels, and so on.

We have had serious forecasts (or at least forecasts that are taken seriously by the forecasters) of not just space travel but time travel and immortality. But such forecasts -- though one cannot be absolutely certain that they will not come true one day -- seem to fail from the other extreme of behavior: overcompensation.

Another failing -- one of the things that has gone wrong in many forecasts of the past -- is the tendency of forecasters' over-simplification of the real world. Another way of saying this is "failure to look over your shoulder." The next two figures are examples of failure to look over your shoulder to anticipated converging developments -- things coming in from left field that are going to have an impact on whatever it is you are forecasting. Figure #3 shows a number of forecasts of the demand for public transit facilities in Chicago. They failed, basically, because they did not take into account the impact of the automobile. They were still extrapolating transit use trends which had gone on for decades. When the automobile began to have a real impact, the forecasters didn't notice. They weren't looking over their shoulders. The next figure (#4) has a similar moral. In the late 40's and early 50's, the whole program of the civilian nuclear power development was predicated on the forecast that the price of coal was going to go up and up. In fact, the price had been going up and up as you see. But no sooner did we launch a major civilian nuclear power program than it went down and down and down. And that's one of the reasons it took so long for nuclear power actually to become important -- economically that is. Was this "turnaround" something that could have been forecast? What was the reason for this? The behavior of the curve can be interpreted; there were reasons. But they don't really answer the question: How could you improve the forecast? Could one reasonably have anticipated those reasons? The reasons are, in part, that the threat of nuclear power stimulated the coal industry to mechanize in a big way (also the use of steam at increasingly high pressures and temperatures in turbines for generating electricity from coal-fired boilers), with results you see.

Then the opposite failure is the failure of insufficient simplification. That is over-specificity, being too concerned with details that you may not need. It is often a failure (again of engineers) to get very fascinated with techniques, with specifics. One example would be Jules Verne. Jules Verne was a very good forecaster from one point of view. At least he did successfully forecast some technologies that have come to pass (among others that did not). We don't know how serious he was in making those forecasts, but the detailed descriptions of his rocket to the moon -- actually a missile -- was entirely erroneous. The same could be said for many other especially fictional forecasts, as well as many other more serious kinds of forecasts in the past half century. The lesson to be drawn from it is: don't go to any greater level of detail with regard to "how" a thing is to be accomplished than you can get away with.

The next figure (#5) makes this point more explicitly. It is a forecast of computer trends -- that is a trend line with curve describing computer capabilities from 1945 to 1970. The units on the chart are all labeled on the left-hand margin. I am using this chart to illustrate the point that it doesn't pay to get too concerned with details. These computers, you will notice, cover a range of different technologies going from the CRT type of memory with vacuum tubes, at the further end of the curve, down at the lower left-hand corner and through the age of transistors to the integrated circuit, magnetic cores and so on. Several generations of totally different technology have passed, yet that curve has grown rather steadily at the rate of about 2 1/2 magnitudes per decade, and the most advanced computers appear on or near the envelope, as you would expect. If you characterize performance as I have here, the capacity for other types of tasks -- say matrix inversion -- is not necessarily well represented. There are other measures you could invent which will reflect other capabilities, though any simple measure would sooner or later begin to fail to represent what is going on as computer technology evolves. They are beginning to fail now because the advances in computer technology are more and more concerned with linking together remote terminals and sophisticated internal munipulation of the data within the core. You can't measure such capabilities in such a simpleminded way. So you invent, as time goes on, more and more complicated measures to measure the capability. But the measures themselves are rather independent of the specifics of technology which is, I think, an important point to understand.

Let me now attempt, quickly, to illustrate the different "levels of understanding" and their correspondence with different types of forecasts. Remember, I listed five kinds of forecasts, beginning with the level of conjecture. The next figure (#6) illustrates a use of organized conjecture. These are the results of a Delphi study. A word of explanation here: the Delphi study has nothing do do with the Oracle. It is a survey carried out (in principle) anonymously as in a series of questions to a "panel" in which the panel members do not interact. The survey is usually done by mail. The results are collected and collated and certain statistical measures are recorded, notably the first quartile, the median and the third quartile of the responses from panelists.

Next, this is redistributed to the respondents who are asked whether they want to change their responses, having seen the results of the other respondents in this statistical form. There are also opportunities to raise questions to clarify ambiguities, explain positions (anonymously) etc. Over two or three iterations it is found that these distributions tend to coverage, which is regarded as something promising. But it doesn't really improve the quality of the information base. It does perhaps improve the understanding of what the participants have of what the question really meant, for instance, or what other peoples' arguments might be. Skipping now to the level of "quasi-model", the next figure (#7) is an illustration of a trend correlation. This is essentially the same level of knowledge as an extrapolation, but in this case you notice that one kind of technology tends to follow another, with a relatively fixed relationship. Here you see that civilian aircraft tended to follow behind military aircraft by some years in their development. So if you can forecast for one you have at least a first order forecast of the other. Still at the same level, the next figure (#8) is a little more elaborate. The envelope curve represents the maximum energy from various kinds of particle accelerators over the last three or four decades. You can see the classic S-curve phenomena, which I described a few minutes ago, nicely illustrated here. Each curve refers to a specific configuration or "species" of accelerators and there are about 7 or 8 shown there. For each configuration there was a period of rapidly increasing performance (the early beginnings are not necessarily shown) and then a saturation. Yet the envelope curve -- that is the curve that touches the tops of the performance curves for the specific configurations -- rises much more rapidly than its component elements. This is often a useful technique for obtaining an integrated overview of the combined effects of a succession of different specific competing technologies contributing to a generalized function. In this case the function was accelerating the particles. Figure #9 shows another slightly less exotic example. Here you see the same phenomenon of superposition of successive "S" curves (only the upper parts of the curves are shown) corresponding to the substitution of successive technologies

Let me now pass on to the highest, immediately attainable level of our hierarchy, the level of empirical-phenomenological models. I will conclude with a brief discussion of the "substitution model." Here what has happened is that the notion that technology follows a "growth" curve has now been rather elaborated and incorporated into a broader economic context. In fact, the idea is that two technologies "compete" with each other much as biological organisms do. You can postulate that the rate of replacement of one by the other is related to the amount that remains to be replaced. From that postulate, if you formulate it a little more carefully, you can derive a rather simple differential equation. When the differential equation is solved you end up with (Surprise!) a function which is equivalent to an S curve. Now here is an example of historical data for 2 cases, one is natural fibers and the other is synthetic fibers (Figure #10). The projection there is now made by eye, or by a straight line extrapolation (which for many years was the most sophisticated form of projections we had). It's done by solving a differential equation and fitting the data to that. Now let me show you what happens when you do this in another form, in the next two Figures #11 and #12. In Figure #11 we've superimposed a number of substitutions, and transformed the variables on the lefthand margin, where it is given in terms of f/1-f, f being the fraction substituted. A function that plots as a straight line here would resemble an S curve if you plotted in terms of f instead, as shown in Figure #12. You can see that the data points fall remarkably close to the theoretical curves in each case. The model has flaws, but as an early attempt, it is rather encouraging.

FIGURE 1

PURPOSES OF FORECASTING

1. Curiosity and Conjecture. What kind of world? Social Dynamics
2. Problems (self-denying?)
   - Population and poverty
   - Pollution
   - Proliferation
   - 1984
3. Promises and Propaganda (self-reinforcing?)
   - Space
   - Health
4. Policy choices: Benefits and Costs
   (a) Hedging or insurance--how much?
   - Deterrence vs. defense
   - CD vs. arms control
   - Natural disasters

   (b) Where to invest: forward discounts and opportunity costs
   - Nuclear vs. fossil fuel power; satellites vs. coaxial cables
   - Public Facilities (roads, canals, dams, etc.)
   - Stocks, bonds, real estate or gold?
5. Plans and Programs: Optimum (Critical) Path Scheduling
   (a) To a technical capability (objective)
   - Military, space
   - Communications, electric power
   - Transportation (highways, SST)

   (b) To a social or economic goal
   - Education
   - Housing
   - Employment
   - Industrial competitiveness

SOURCE: Robert U. Ayres.

FIGURE 2

PITFALLS

1. Lack of imagination and/or "nerve" (A.C. Clarke)
   Natural bias of committees of eminent experts
2. Excessive Optimism: Anything is possible for harnessed technology
   "Gee Whiz" Forecasters; Russians; Pope Paul
3. Failure to anticipate convergence, changes in competition
   nuclear power vs. fossil fuel
   electric car?
4. Too narrow a view, concentration on specific configurations
   Most early forecasts (Wells, Verne, Plessner, Norway, Haldane)
5. Incorrect calculation or scientific error:
   Simon Newcomb and airplane
   J. W. Campbell and rocket
   JBS Haldane and purple algae
6. Intrinsic Uncertainties and Historical Accidents: What if ...?
   Fleming (Squibb?)
   Steam vs. ICE (Doble and WWI)
   Dewar and Kammerlingh-Onnes

SOURCE: Robert U. Ayres.

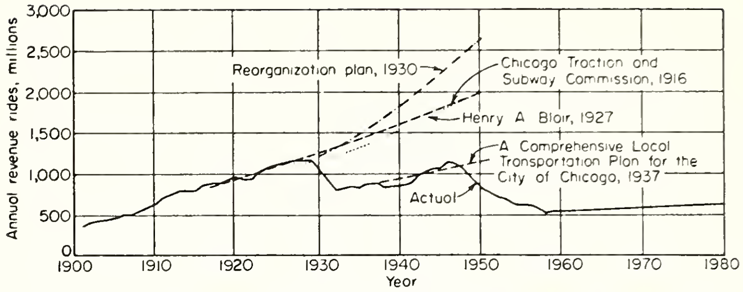


Figure 3: *Actual use of transit facilities from 1901 to 1960 and estimated to 1980 compared with various projections of estimated use (Chicago).*

SOURCE: Chicago Area Transportation Study, Final Report, vol. III, April, 1962.

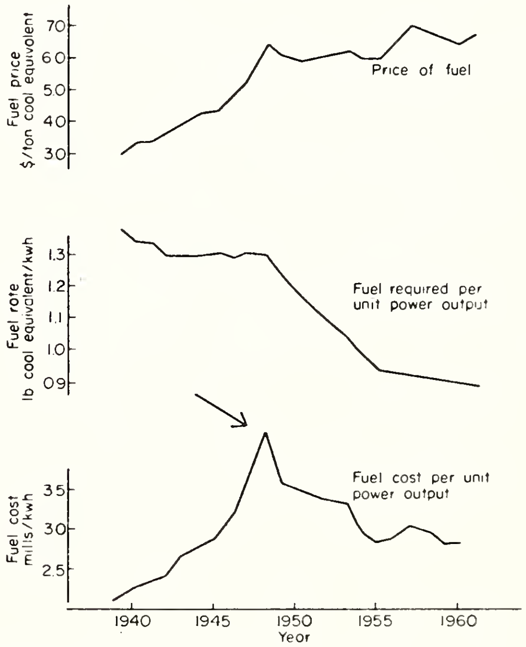
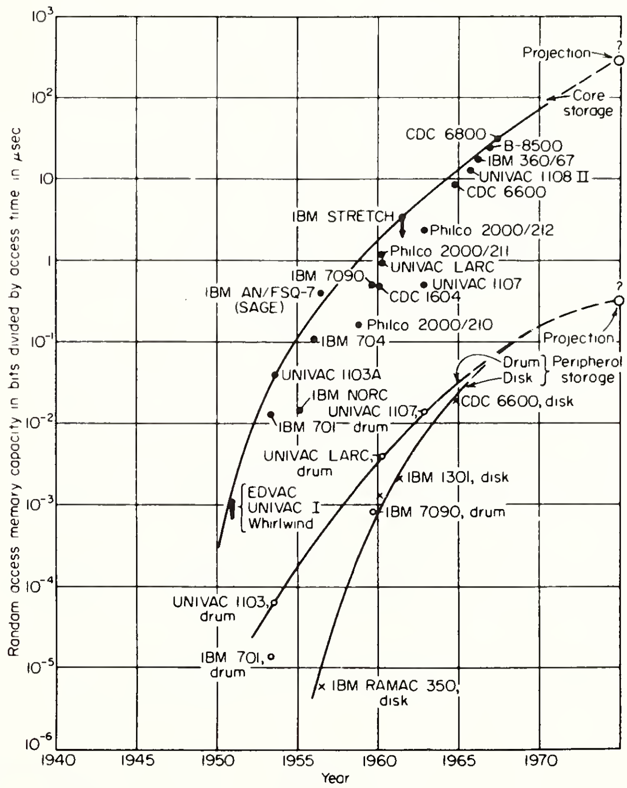


Figure 4: *Fuel trends for conventional steam power plants. Note the unexpected reversal of the rising trend of fuel costs. This was the factor that kept conventional power from being replaced by nuclear power in the late fifties.*

SOURCE: J.F. Hogerton et al., Atomic Energy Deskbook, Reinhold Book Corp., N.Y., 1963.

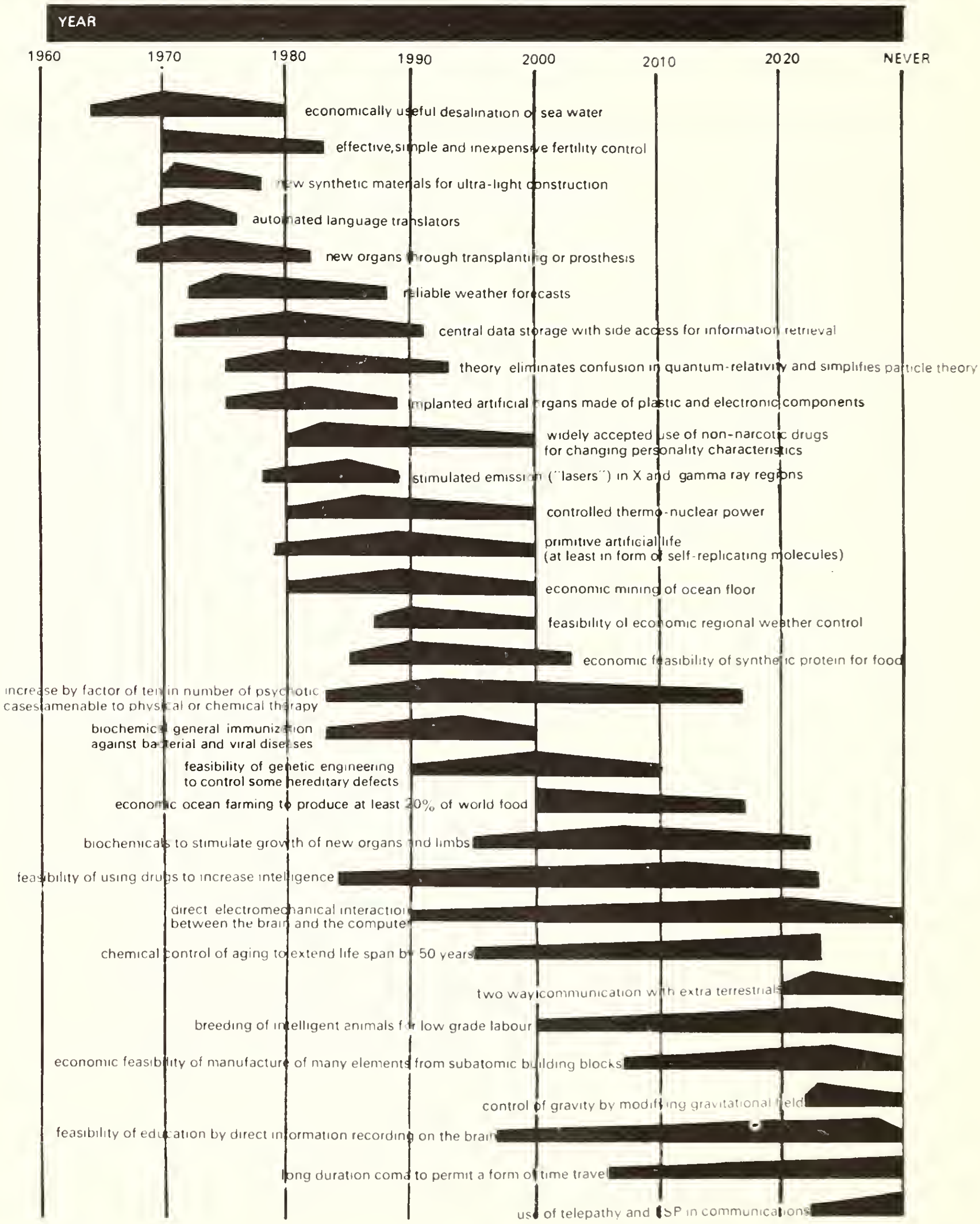
FIGURE 5



Random access memory capacity (bits) divided by access time

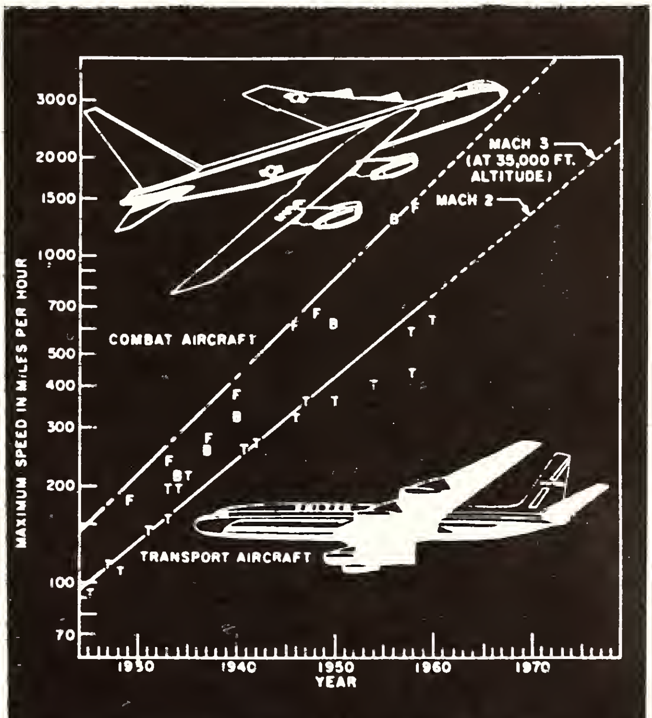
SOURCE: Robert U. Ayres, Technological Forecasting and Long-Range Planning, McGraw-Hill Book Co., 1969.

FIGURE 6



SOURCE: T. Gordon and O. Helmer. "Report on a Long Range Study." Report P-2982, Rand, September 1964.

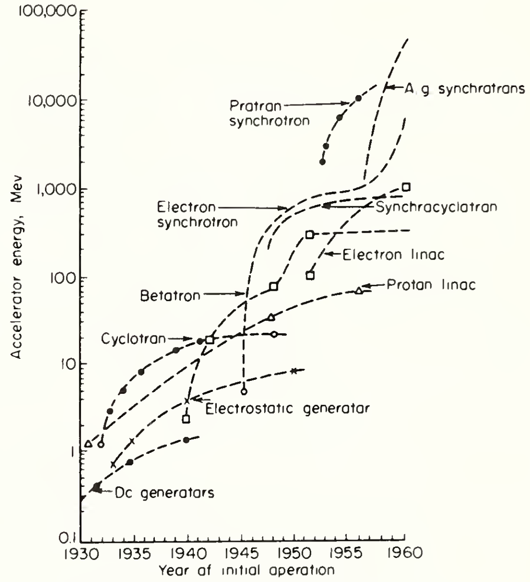
FIGURE 7



Comparative Speed Trends of Combat and Transport Aircraft

SOURCE: RALPH LENZ, JR. <u>Technological Forecasting;</u> 2nd Edition, Aeronautical Systems Div. AFSC, ASD-TDR-62-414, Wright Patterson AFB, Ohio. June 1962 (AD 408-085).

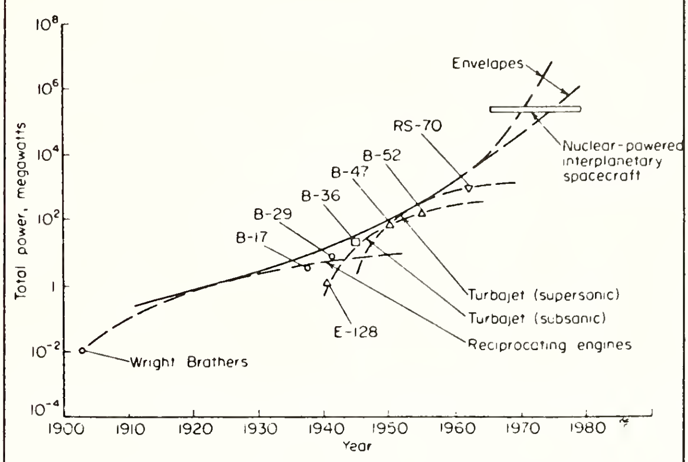
FIGURE 8



The rate of increase of operating energy in particle accelerators.

SOURCE: M. Stanley Livingston, reprinted in Gerald Holton, "Scientific Research and Scholarship Notes toward the Design of Proper Scales," Daedalus, 1962.

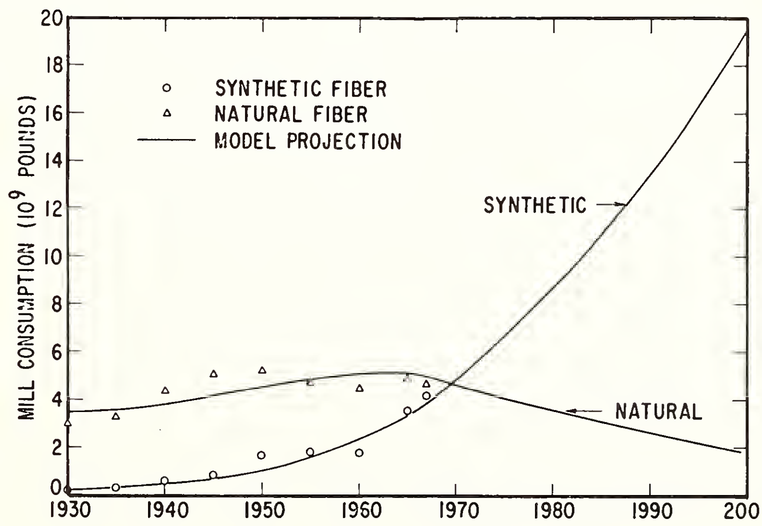
FIGURE 9



Aircraft power trend.

SOURCE: D.G. Samaras, "Nuclear Space Propulsion: A Historic Necessity," Nuclear Energy, p. 352, September, 1962.

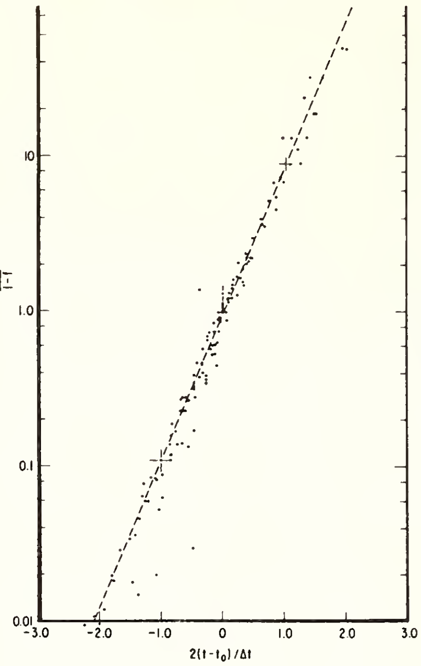
FIGURE 10



U. S. FIBER CONSUMPTION VS. YEARS--DATA AND PROJECTION USING THE SUBSTITUTION MODEL

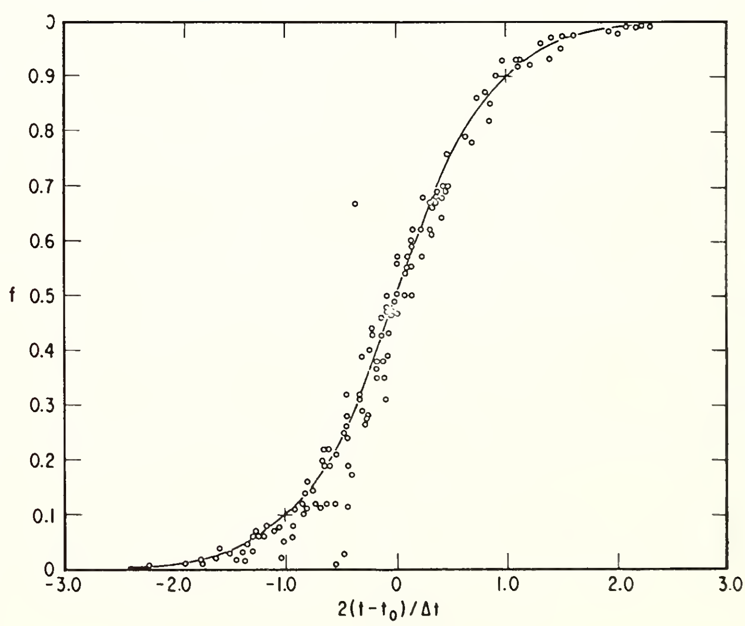
SOURCE: "A Simple Substitution Model of Technological Change", John C. Fisher and Robert H. Pry in Industrial Applications of Technological Forecasting, Cetron & Ralph, N.Y. John Wiley & Sons, Inc. 1971.

FIGURE 11



FIT OF SUBSTITUTION MODEL FUNCTION TO SUBSTITUTION DATA FOR ALL 17 CASES VS. NORMALIZED UNITS OF TIME

FIGURE 12



SOURCE: For 11 and 12. "A Simple Substitution Model of Technological Change." John C. Fisher and Robert H. Pry in Industrial Applications of Technological Forecasting, Cetron & Ralph, N.Y. John Wiley & Sons, Inc. 1971.

TECHNOLOGY ASSESSMENT OF MARINE RESOURCES DEVELOPMENT

MARINE TECHNOLOGY SOCIETY CONFERENCE
May 15-17, 1972

by

JOSEPH F. COATES
NATIONAL SCIENCE FOUNDATION

After a general introduction to technology assessment, I will attempt to relate the concept to some of the specifics of this symposiu. But, first, an antecdote. A distinguished civil servant, reflecting one day on his 30-year career, observed that for a generation he strove to make the desert bloom. Then a few years ago he learned that he was really raping the environment. At least that was the perception of some who disapproved of his agency's programs and policies. The same issue is central to today's discussion. Under what circumstances will a short-term gain or series of short-term gains destroy a resource. Under what circumstances does plucking the fruit kill the tree.

The following propositions define the essence of technology assessment.

First, technology assessment is the systematic exploration of a full range of societal consequences of the intrusion, the development, the intervention or introduction of technology on society.

Second, technology assessment is a policy or decision-oriented tool. Its aims, techniques, methods, approaches are best conceived as yielding systematic inputs into the larger political-economic decision processes.

Third, while an assessment may cover the full range of impacts, it is particularly important that emphasis be on the secondary, incidental, long-term and side effects because in the long pull, these consequences may be the dominant ones. Furthermore, undesirable consequences may be the dominant ones. Furthermore, undesirable consequences often can be eliminated or minimized if they are recognized early enough. Similarly, secondary benefits which might otherwise be overlooked can be optimized if recognized early. The emphasis on secondary and higher order impacts also follows with the fact that with regard to a particular technology, especially a physical technology, the lion's share of the planning goes into the primary impact, that is, the dominant intention of the project.

What Is A Technology?

There is little question that the manipulation of physical things or the environment for some human purpose qualifies as technology. The concept which I think should be central to thinking about the development of marine resources is that technology also embraces social invention. In general I take technology to be the conscious use of knowledge to organize, control, or manipulate the affairs of men or to realize man's physical or social objectives. In that light a social invention such as a value-added tax or one-way streets is as much a technology as are radio, toasters, the automobile, or a dam. The concept of social invention may be particularly important to marine technology, inasmuch as that physical technology is relatively weakly institutionalized and has relatively few firm decision processes or decision-making agencies operating based either on law or convention. In other words, the infrastructure is weak and therefore the physical technology can be profoundly influenced by the choice of institutions to oversee or manage it.

A few illustrations of social technology and institutional invention may give the flavor of what might be included among those technologies relevant to marine development. The development of a concept of government subsidies, particularly farm subsidies, clearly qualify as social invention. The agricultural extension service, social security, pay as you go income tax, unemployment insurance, licensing of automobiles, summer school vacations, each are social inventions that have a direct impact on our lives and a substantial impact on our economy.

Why Is Technology Assessment a Significant Issue Now?

A half dozen long-term developments in our society have made the closer attention to the impacts of technology on society a particularly pressing subject in general. In a few areas it is an urgent concern.

First, our society is becoming fully integrated. That complexity is no longer a complexity by aggregation but is a complexity by integration. Consequently there are now more opportunities for the total system or any sub-system to go awry. We have the functional equivalent of brownout in more and more geographic and socio-economic sectors of American society. Complexities by integration demand more and finer control, which in turn demand more knowledge, which in turn demand more and finer control, which in turn demand more knowledge, which in turn demand better forward planning and feedback to integrate and manage that complex system.

Second, for all practical purposes, there is not a single objective that man and society might conceivably want, which we cannot already accomplish, begin to undertake, or at least make a substantial solid technical scientifc approach to undertaking. We can with serious intention given consideration to: blocking the Bering Straits; reversing the flow of the river in Siberia; moving ice islands from Antartcia to the temperate zones as a source of fresh water; or to selectively arranging the thermal balance in the ocean to make the oceanic deserts bloom. We can tap the ocean floor and presumably if it seems desirable, drain the Mediterrenean Ocean. This new enormous capability for remaking the face of the earth, in both social and physical terms, demands that we look ahead and anticipate the consequence of our action.

Third, contemporary and scientific technical knowledge has engendered a set of tools and concepts which allows us to better anticipate what may happen. That anticipation itself drives toward better anticipations and finer control. The fact that one may forecast seems to automatically demand that consideration be given to control and regulation of that which may be forecast.

Fourth, the scale of human enterprise is continually enlarging. We talk now about billion and multi-billion dollar enterprises the way people just a generation ago spoke of million dollar enterprises. These large investments involve not only great amounts of money, but they tend toward a relative permanency which cannot be ignored. Whether good or bad the federal highway program has placed countless tons of steel and concrete all over the nation, and there isn't much we can do about it right now even if it were socially undesirable. Similar kinds of impacts may be anticipated from the unfolding technology which will allow us to manipulate and exploit the oceans, the ocean surface, and the ocean floor.

Fifth, the success of technology in meeting human needs has not led to stasis but has in fact brought about a shift in values demanding more things of higher quality. Technologically grounded prosperity has provided the time and leisure on a broad scale to enjoy those finer things. Most significantly, it has spawned a wide and pervasive concern about the quality of our lives including the effect of those technologies which have made those new values possible. The unfolding new values are not just a consequence of technology but are rapidly becoming a part of social control feedback governing that technology.

Sixth, on a more immediate and political level these factors concerning technology have affected the Congress and more specifically have led to the passage of the National Environmental Policy Act of 1969 (Public Law 91-190).

Besides establishing the Council for Environmental Quality, the law has required every U.S. Government agency that is planning a project to file with the Council an assessment of the impact that the project may have on the environment.

In the words of Section 102 of the Act, each agency must

> ...include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on:
>
> (i) the environmental impact of the proposed action,
>
> (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
>
> (iii) alternatives to the proposed action,
>
> (iv) the relationship between local short-term use of man's environment and the maintenance and enhancement of long-term productivity, and
>
> (v) any irreversible and irretrievable commitments of resources which would be involved if the proposed action should be implemented.

Preparation of these environmental impact statements has created a general demand throughout the Federal System for the systematic exploration of the secondary impacts of projects, and a consequent demand for the development of methodologies, techniques, approaches, and protocols, much of what is occurring as a result of the Environmental Policy Act will benefit and influence technology assessments in general.

The Consequences of a Technology Assessment

In view of the widespread hostile ambience toward technology in our society, particularly as reflected in many journals of opinion, the impression could be gotten that technology assessment is another way of laying low technology, that it is another manifestation of the general anti-technology attitude growing in our society. While there is a fairly widespread hostility toward technology such that some would shut it off altogether and even move backward to a more primitive or less complex society, I don not believe that movement represents a substantial intellectual or political position. The question is not how to arrest technology but rather how to regulate and control technology for the commonweal. Against that background I think one can identify a half dozen consequences of technology, the least likely of which is the arrestment of a project or a technology. More likely consequences are the following:

First, the project itself may be modified to correct or compensate for deficiencies or adverse consequences revealed by the assessment, These project modifications could be major or minor.

Second, may be an increased recognition of the need for closer monitorship of the physical or social environment. In many cases empirical evidences and theoretical concepts may reach the limit in their ability to forecast the detailed consequences of a specific technological intervention. But the assessment may reveal certain significant effects which could occur. The logical way to manage that alert in many circumstances would be to monitor the effects of the project as it becomes operational, or to exercise the concept on a small scale and monitor for effects there. Monitorship is by no means the simple and straightforward notion, however. Any technological instrusion into the environment and even into the oceans is likely to have an enormous number of specific impacts. We are, therefore, pressed by the need to develop coherent and selective approaches to defining the what, the where, and the how for monitorship of those various consequences. A calculus of priorities is badly needed with regard to environmental effects.

Third, R&D may be stimulated as a result of an assessment. It may be for a variety of purposes. First research to better sharpen or define what the potential risks may be. Suppose for example some process is anticipated to create a risk to a species of turtle. It may be that we don't know enough about thephysiology of that species and therefore specific research would have to be undertaken on that interaction. Another kind of research priority may develop from the need to forestall adverse consequences once they have been anticipated. This seems to me to be a major implication in many assessments. A third kind of research which may be stimulated by an assessment is the look for a wider range of alternatives. The Alaska Pipeline study is an example of an assessment stimulating the look for, in the case, alternative modes for transportation of oil. Finally, research may be stimulated on corrective measures. Some technologies are undoubtedly going to have negative consequences which cannot be eliminated. Yet if the overall value of the technological intervention is such as to justify going ahead with the technology, it may be necessary to support specific research on identifying means of correcting or undoing the negative consequences.

A fourth consequence of an assessment may be the potentials for exploiting or enhancing the hitherto unrecognized benefit of a technology. In the early days of water resource development the recreational aspects of those projects were to some extent overlooked. As it became clear that these were demonstrable and social significant benefits, they came to be more explicitly recognized for their value and consciously integrated into planning. These positive aspects flowing out of assessments therefore are by no means trivial and should not be overlooked. The positives should be given equal emphasis in the exploration of secondary consequences of a technology.

A fifth consequence of a successful technology assessment is likely to be the introduction of new means of social control. These social controls are likely to come about either in law, administratively, or by other institutional or organizational means. With regard to ocean, I anticipate that at several different administrative levels, the international, the federal level, and the state, an important consequence recognized by assessments will impact on the decision apparatus to lead to closer regulation of the development of the ocean. As it stands now, the weak decision apparatus controlling the ocean is premised on historical issues reflecting technological issues relatively less significant today. It is not clear who is in charge of the ocean, who has what responsibilities either temporarally, administratively, technicall, or economically. In some areas of the ocean development, such as the petroleum industry, one might make a fair comparison with the Japanese Zaibatsu, where government-industrial relationships are such that you cannot tell who does what to whom, how, and why. In other cases such as mariculture, there is no industrial complex as yet proliferated which opens up the major opportunity to direct the development, not only the technology, but the industry in such a way as to optimize for the common good.

<u>Three Views of Technology Assessment</u>

Assuming that technology assessment is a decision policy-oriented tool, there are three basic views that various people involved in the field have taken. The first and publicly most prominent is the advocate's view, which sees technology assessment as just another tool to be used by the parties to a dispute in bolstering their already preconceived positions. Unfortunately that is a widely held view by a number of environmentalists and by a number of environmental lawyers. While in the short run this may yield clear benefits, in the longer run it may be socially destructive in that it drives away from a central need of our society, namely to bring the contemporary tools of modern science, technology, and analysis to bear on significant social issues. If every attempt to bring them to bear is already in favor of a preconceived conclusion, several things automatically follow: relevant facts will be surpressed, arguments will be distorted, parachialism will prevail, and the common good will not be served, since there will be no generally publicly recognized mechanism for a relatively objective analysis and display of consequences.

A second view would take technology assessment to be an even-handed neutral objective analysis. In the second view the two principal outcomes are first, the conclusions themselves with regard to what the impacts may beof alternative technological developments and second, and equally important is the analysis itself. In many situations people seem more concerned with the conclusions than how they are arrived at. In my judgment a good technology assessment should be explicit, clear, forthright, complete, and publicly available for scrutiny and review, since the means by which the conclusions are arrived at are themselves essential to understanding the conclusions. If one views technology assessment as an interative process, it is important to be able to identify assumptions and identify the source of data going into an analysis. At any future time these may be open to revision or reevaluation. The central notion of this view of technology assessment is that it should make its outcome available to all parties in dispute as well as those who are neutral with regard to the dispute and provide a basic input for them to make what they will of it.

A third view similar to the second would carry the analysis one step forward and without submerging the analysis would attempt to draw some valid conclusions or priorities among the options. I think either the second or the these views of technology assessment is a sound one from the point of view of public policy and so far as a technology assessment is supported by public funds I think they represent the only two choices.

It is appropriate to mention a view of technology assessment which I think creates unnecessary and undesirable confusion. The process of assessment is already conceptually and analytically an extremely complex one. However, it is only an adjunct or supplement to the traditional socio-economic, political decision-making process. There are some who tend to confuse the utilization or the implementation of a technology assessment with the technology assessment itself. I think that this so muddies the waters as to obfuscate the value in the exercise itself. Suppose, for example, a study were done on the impact of snow-mobiles on the countryside. The assessment of those impacts could be both conceptually and practically separated in a useful way, from the delivery of those results to various public and private decisionmaking groups and public interest groups. The study can also be distinguished from the actions, the utilization, and the use or the misuse made of those studies by those recipients. I recommend narrowing the view of the assessment to the analytical-synthetic study of the impacts themselves, not to its implementation as public policy.

A less clear distinction can be made between the assessment and physical, experimental, or observational research which may be conducted in conjunction with it. In some cases if one looks at the assessment as an iterative process, part of that iteration may involve the following sequence: An analytical study, recommendations for specific research, the conduct of that research, the reassessment in a second technology assessment.

To some extent it is arbitrary as to whether one includes that physical research in the assessment process, but I think it is often useful to make the distinction because the analytical study may cost only a small fraction of the related experimental studies.

How IsIt Done?

The methodology of technology assessment is complex and variegated. It draws on a variety of disciplinary techniques and technologies and therefore cannot be arbitrarily defined, delimited, or described. Al that notwithstanding, it does not follow that a technology assessment cannot be done. It only follows that it is difficult and the method has to be appropriate to the task. The central difficulty in an assessment is to hit a balance between being comprehensive and exhaustive on the one hand and at the same time not being exhausting but being useful. And it is this striking of the balance which is a critical organizational, management, and methodological problem. There are some people who argue that technology assessment cannot be done because the problem is so complex it overwhelms the investigator. The evidence is quite to the contrary. It can be done, because it has been done. Those who argue otherwise are either flat out wrong, ignorant, or misleading.

In general there are two methods now available for structuring a technology assessment. Both of them essentially depend on a systematic approach to the technology that one is dealing with. The first method takes advantage of and depends upon a particular technology within a system which is straightforward enough that it can be used to define the loci of impacts. Let me illustrate that with a project we are now supporting. It is a study of the consequences of snow enhancement in the San Juan Mountains of the Colorado River Valley. The problem roughly is the following: Technology has reached the point where snow-fall may be increased, let us say, 15% over the winter season. The assessment we are supporting has to do with unfolding what else will happen to agriculture, recreation, international relations, industry, education, and the full range of other areas, should snow enhancement become an annual routine practice. The backbone of that analysis turn out to be quite interesting. One may follow the air mass, the clouds that yield the snow, the subsequent water, and that physical system may then be traced out and the various points of impact along the way identified. Similarly the downwind air mass may then be followed and its impacts and interactions traced out and followed. Conceptually it is clear what needs to be done, the details of course are extremely complex and difficult.

But there are systems which do not have that clean, analytical, methodological backbone. Let me suggest two of them. One is the problem of telecommunications, the other is the impacts of alternative power plants automobiles. In neither case is there a perfectly clear system which structures the analysis, and one can therefore do one of two things. One can attempt to construct such a system which is likely to be itself a major undertaking. Or one can take the alternative strategy for defining an assessment generating exhaustive lists of possible areas of theimpacts and consequences and go through them one at a time asking in a detailed way, does the system have an impact here? How do we know? How do we determine which are important? How do we evaluate it? That technique is very nicely illustrated in the US Geological Survey Circular, 645, A Procedure for Evaluating Environmental Impact Statements. The heart of that analytical approach or as I call it, the method of exhaustion, is to display some 88 categories of possible effects and some 100 categories of possible impacts in a matrix. Then with regard to some particular environmental intrusion, one analyzes, cogitates, as you will, over each of the 8800 cells of the matrix and answers two questions. Will there be an effect? Will it be important?

A related conceptual technique has been developed at George Washington University under Louis Mayo for conducting technology assessments. Of necessity the conceptual framework is more elaborate and broader. Related analytical techniques have been proposed for other purposes which potentially lend themselves to technology assessment, but as far as I know have never been utilized. Among those are the technique developed by Fritz Zwicky, called morphological analysis.

One is automatically driven to the question of how much money doesit take to conduct an assessment. Before addressing that question I believe it is important to recognize that a technology assessment is an iterative process, a set of nesting or interlocking studies, and it is extremely unlikely, therefore, that any particular study will be absolutely final, complete, and definitive. It may be followed by either a more comprehensive study or a more detailed study of one or another of its aspects. But I would say as a first approximation if one were doing an assessment on a subject or a field for the first time one might anticipate a 9 to 18 months study employing an interdisciplinary team of 4 to 7 people. In many cases one would want engineering, biology, physical sciences, law, chemistry, and systems analysis, psychology, and sociology represented. I am inclined to believe that a study of any consequence is probably going to cost at a minimum $80,000 to $125,000. One dealing with any relatively complex problem will cost a quarter to a half million dollars. These data are based on information from several federal agencies in conducting these studies both in-house and on contract with universities, commercial, and non-profit think tanks.

Technology Assessment in Relation to Business and Industry

What are the implications of technology assessment for industry? First, it should be noted that to only a minuscule extent is business or industry supporting broad-scale assessment of the impact of a technology on our society. There is, of course, the long-term and continuing efforts of market analysis, but that is a different activity for a different purpose. It generally has a much shorter time scale associated with it. I believe that a pervasive fear that any disclosure even internally to the corporation of possibly negative effects of its potential products is widely feared within industry. That is one of the reasons why the look at long-term consequences has not received greater impetus. More to the point, business has not recognized the positive value in conducting its own assessment. The business community may move ahead with the greatest vigor and confidence in utilizing its skill to the maximization or optimization of profits, only when it knows the groundrules under which it operates. Uncertainty breeds paralysis. Technology assessment is undoubtedly going to lead to a redefinition of some of the conventional groundrules insofar as it is effective. It will have an influence on public policy and therefore on public law. If industry begins its own assessments with its own funds in fields of interest to itself, it can derive at least the benefits of being better able to anticipate (a) the kinds of objections or opportunities that will flow out of the technology of concern to them, and (b) what the potential range of rational and reasonable policy options may be. This should of course put that particular business or industry in a better position to relate to the government and to its critics. A more widespread adoption of a technology assessment as an internal planning tool of industry could very well get it off the dime of being so totally defensive in the face of every charge that it is anti-social or socially destrictive in what it may be doing. We are past the period where every question raised about the consequences of technology have to be taken as a mortal attack on the free enterprise system. The world has become too complex to be left to the machination of narrow self-interest, even if that narrow self-interest is reflected in multi-billion corporation. There must and I predict will be more rational means of making decisions on managing technology. Insofar as industry resists adopting the new techniques and methods of anticipating and controlling technology, it will have to be dragged kicking and screaming into the twentieth-first century.

Some Specifics on Marine Technology

Let me try to identify some special problems associated with technology assessment in the area of marine technology and resource exploitation.

First, the decision apparatus is weak and inexperienced. It is particularly inexperienced with regard to being reflective on the consequence of its own actions and policies. I believe a case could be made that is not only true absolutely, but it is also true relative to other government-regulated and supervised or run operations.

Second, subsidiary to the above, it should be recognized that the U.S. Government functions best with regard to domestic issues. The structure of the Federal Government is essentially a structure for domestic governance, yet the subject which is the theme of today's discussion is one which will carry over into international affairs, and involve international relations. As a collectively our system does not and has not worked well in international problems of a subcritical sort.

Third, the obvious alternative of turning much of the responsibility for controlling international technology over to international agencies is not particularly a felicitous one. I commend to your attention the recent work by professor Eugene Skolnikoff of MIT, who has just completed a study of the international civil service. Some of his conclusions are quite dark and suggest that it would be rash to expect the international civil service to function in its role in the management of international ocean technology even as well as the domestic civil service functions in its various responsibilities. One would be safe in making the assumption that to throw responsibility on to or expect imagination, innovativeness, boldness, or any other of that long list of administrative positives from the international civil service is to court serious disappointment.

Fourth, in the absence of an adequate decision apparatus, we are then faced with the interesting opprotunity of identifying alternative structures which would be adequate. One aspect of marine technology which is already well-managed from an industrial-business point of view is petroleum. Yet the decision apparatus relating private enterprise to governments in the area of oil technology is, as suggested above, at least in a state of complex confusion. With regard to other technologies, such as mariculture, we don't have an apparatus to speak of and still other cases such as the traditional fishing industry the enterprise is so disaggregated, uncoordinated, and on such an uncertain economic base, that the infusion of new technological approaches seems at times to meet nearly insurmountable obstacles. This creates a situation wherein one must simultaneously deal with present decision apparatuses however inadequate while attempting to develop better methods for the management of particular technologies.

Let me point out a conceptual limitation with regard to technology assessment, that is one fundamental to our system of education and fundamental to our organization of both professional and non-professional work. We are basically unaccustomed to dealing with truly complex problems. To use a high-flown phrase, we lack the capability of architechtonic thinking. We generally lack the capability to take a complex situation or problem and handle it in its own terms. Rather our educational and organizational apparatus drives us to analyses based on either narrow disciplinary concepts or relatively narrow industrial commercial categories. The automatic processes fractionate all complex problems in engineering, economics, sociology, political theory, and management modules. What often happens in that process is that we generate socially suboptimal outcomes because the connective issues, the meta issues are lost sight of or ignored. The consequence of not being experienced in thinking about complex problems and treating them as complex problems is that we tend to come to believe that it cannot be done, or if it could be done, that it is impractical. The analysis of the Alaska Pipeline Study shows not only that dealing woth complex problems can be undertaken but also illustrates the fact that it can be of extremely practical consequence. My advice therefore in undertaking to deal with such complex problems as a technology assessment is to begin. Do not fret over it. Let the analysis carry you where it will. If one makes an assumption that something cannot be done, then one will not even undertake to search for methods with which to do it. A typical example of this has a calculation of indirect costs, the social cost, or the external cost of particular technology. Many who have never taken five minutes to consider what techniques might be brought to bear on such an issue are quite prepared to assert authoritatively that one cannot do such and such things, that one cannot assess the value of beauty, or one cannot cost our the worth of an national forest, or the value of a life. Not only have these things been attempted, but quite plausible outcomes have resulted. Forthermore one is not necessarily hamstrung by dollar considerations. Alternative scaling techniques can often be brought to bear on these complex questions.

As a side consideration on the questions of costing, one must keep in mind that almost all procedures, used for the costing out of major projects are in some sense "hokey" and do not necessarily represent the best, most comprehensive, or conscientious application of modern economic analysis to particular problems. We definitely need an intellectual shake-sown in the cost-benefit area to lead to better defined methods, protocols, and procedures for different kinds of problems. I would not suggest that dishonesty is the issue but rather a certain anachronistic use of decision procedures and conceptual frameworks which were more appropriate two, three, or four decades ago.

Let me close with a recommendation for the Marine Technology Society. I believe the membership of the Society, but individually anc corporately, would be well served by a collective endeavor to work out a handbook or a guidebook to technology assessment in marine areas. If done on a Society basis, one could cut across many organizational and conceptual obstacles which prevent it from being effectively done by individuals or by smaller organizational entities. The availability of such a handbook, guidebook, set of protocols could move the assessment of marine technology substantially far forward.

Finally, let me note one irreducible value in a technology assessment, whether ornot it ever influences public policy, whether or not it ever has the impact intended by those who conduct it. That is the value in making explicit the assumptions in a particular concept, procedure, proposal, or operation. Only when the assumptions are made wxplicit is there the conscious opportunity to challenge those assumptions move in new directions.

ASSESSMENT OF TECHNOLOGIES FOR THE PROTECTION
AND ENHANCEMENT OF THE MARINE ENVIRONMENT

MARINE TECHNOLOGY SOCIETY CONFERENCE
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by

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ANYTHING THAT MAN DOES AFFECTS SOMETHING SOMEHOW SOMEWHERE SOME TIME

If we keep this fact in mind at all times, the task of assessing man's activities and his technological innovations can be made more objective and dispassionate.

In order to arrive at a reasonable for of assessment, one must begin by defining the activities to be examined, the relationships and interaction among them, the common grounds they share, and the conflicts they create. These activities have to be viewed as part of a larger entity with the population at the root, then descending from a bird's-eye-view to the individual parameters of each activity.

Man's activities affecting the marine environment are concentrated for the most part in the near-shore, or coastal zone. From here oceanward, his activities decrease considerably, except for surfact transportation and military use. The effects of these activities range from considerable severity in the estuarine and intertidal areas, to mild, less noticeable in the open ocean areas. And the problems they create range in extent from local beach and waterfront stretches, to vast expanses of international dimensions.

Of course, the most important occupant and user of the coastal zone is man himself; in burgeoning numbers people are progressively flocking to coastal metropolitan areas, creating more tenants and generating and multiplying the demands to utilize this area. Demographic and socio-economic trends project a rapid increase in private waterfront development. As a result of continued urbanization, 75 per cent of the U.S. population, for example, is predicted to be living in these areas by the year 2000, and they will obviously impose the greatest demands for waste disposal, industrial development, and recreational facilities. Aquatic recreation includes boating, sport fishing, and swimming. The latter, of course, creates the demand for clean, pollution-free beaches, and eventually competes for space with commercial fisheries.

About 70 per cent of the U.S. commercial fishing is done in the coastal zone; U.S. coastal waters are estimated to have an annual sustainable fish yield of 30 billion pounds. Aquaculture is becoming increasingly important, progressing from pilot-plant to full-scale commercial operations. These activities have to compete with dredging for sand, gravel, and other building materials, an activity which contributes its own share of pollution, creating turbidity and reducing bottom organisms, which deprives such species as young trout and salmon from two basic needs--food and cover.

In the same area we find also such necessary tenants as power-generating plants which contribute what is termed as thermal pollution, the effects of which are considered devastating by some scientists and beneficial by others. In this respect, I find it interesting that even when thermal pollution is suddenly eliminated, large numbers of fish are killed. A case in point is the Oyster Creek Generating Station, New Jersey, which has been using some 460,000 gallons of water a minute to cool the generating plant, then dumping it 15-20 degrees warmer into the bay. The plant was shut down for routine repairs late in January, 1972, and less than a week later the fish kill occurred. 1/

Alongside power-generating plants a relatively newcomer is making its appearance on the coasts of the world--the desalting plant. This new occupant of the coastal zone accentuates the problem of incompatibility among the tenants; it produces its own share of the pollutants that affect the biota, and add a new effect that has been called entrainment. Entrainment is the massive kill of schools of fish resulting from passing too close to the intake conduits of these plants. Actually entrainment in another form has been known for years--some sort of mechanical pollution if you please--as hundreds of thousands of porpoises are killed annually as a side effect of tuna fishing.

In the last two decades, still another newcomer has appeared offshore as drilling platforms began to spring up on the horizon in quest of petroleum. Although offshore oil drilling has been vehemently condemed, and its pollution widely publicized, it is by no means as serious as contributor to the degradation of the marine environment as some of the other tenants of the coastal zone. In fact, recent reports indicate that throughout the world most of the oil pollution comes from tankers rather than offshore oil wells. 2/ And in the coastal zone itself, man's own municipal and industrial wastes by far exceed all the others. The advantages and facilities offered to industrial development siting on the waterfront have always been a prime target for lower-cost, profitable operations. Take the steel industry, for example; it is little known that all the steel mills of the United States, except two, are located at ports.

With little variation, technology assessment requires three main steps: (1) raw quantitative data, (2) evaluation of data, and (3) decisionmaking.

Although the actual users of the environment can be easily identified, there are numerous unknowns and a conspicuous lack of the basic data required for evaluation. The immediate need therefore, is for hard quantitative data which can only be collected and evaluated by competent scientists. These data will include not only the technological and biological aspects, but a total systems approach encompassing all the social and economic aspects. The political considerations are usually the final state in the decision-making process. In extremely simplified fashion, technology assessment can be expressed as the definition of options between the most and the least desirable effects. From here on, each of these elements can be broken down into its numerous components, the complex relationships among these compoenents established, and their interaction and net effects determined. The final answer is obviously in the form of alternatives, each alternative course of action having (hopefully) clearly-defined end results. Once these hard facts are digested, and the alternatives defined, the decision to choose one alternative course or the other is probably ultimately a political one. The ease with which the decisionmaking process can be accomplished may vary from the very fast and simple, like the choice a woman makes between the discomfort and the improved figure a girdle would impart on her body, to a tedious analysis of a complex and elaborate systems approach like the recent study by the MITRE Corporation on methodology to determine the impacts of aquaculture on the developing countries.

To simplify methodology, the total systems approach should be temporarily relegated to the background, and an inventory of the actual physical parameters should be taken with a temporary postponement of the economic and social factors. Once the basic data have been collected and the physical parameters defined, then the variables could be inserted into the analytical process and the net results of each noted. As these results accumulate, they in turn will be related to each other in an effort to establish a coherent network connecting the components of the total system.

Suppose that we look at the problem of oil pollution and examine carefully one of the contributors, the offshore development of oil and gas. We are told that there is an energy crisis and that the only alternative we have is to explore and exploit the petroleum resources under the ocean floor. Obviously, the first stage of the assessment is to find out how much oil is there in the world, how much do we consume, and how much of this demand can be supplied from land resources.

In a report to Congress last year, my inventory indicated that the hard data negate the presence of an energy crisis, and that the actual physical quantity of petroleum resources in the world would last well into the second half of the twenty-first century. 3/

The "free world" consumption of liquid petroleum for 1969 totaled 37,192,000 barrels per day (b/d), representing an increase in demand by 8.4 per cent over the previous year. The following year the growth rate rose to 12 per cent (5 per cent for the U.S.). Projections for the 1980's indicate that, at an average rate of growth of seven per cent annually, world consumption of oil will be nearly four times that of today, and the use of petroleum gas will increase as much as five times in the same period.

Against this demand, world production is variously estimated at between 34.4 mb/d and 41.3 mb/d. Offshore production accounts for 16-18 per cent of the world's total. It has been estimated that by 1978 an offshore yield of 23 mb/d is expected, representing 33 per cent of a world total of 70 mb/d. Proved world oil reserves total about 500 billion barrels, which would last at least through this century. Moreover, the ultimate world potential of all resources offshore totals 1.6000 billion barrels. For comparison, ultimate world potential of comparable resource on land was estimated at 4,000 billion barrels. 4/

Let me emphasize here that the land potential estimate does not even include the vast amounts of synthetic petroleum in bituminous rocks such as oil shales and tar sands. The U.S. Bureau of Mines estimates that the Green River Formation oil shales contain two trillion barrels of oil; 8000 billion barrels at a yield of 15 gallons of oil for a ton of shale, and about 500 billion barrels of 25 gallons of oil per ton of shale are considered practically exploitable. The proved reserves alone are about four times the total proved U.S. petroleum reserves. Other than oil shale, there are still greater amounts of potential synthetic oil and gas in coal. It is estimated that the world has enough coal to last 1,500 years. Then there are tar sands, nuclear power supplemented in time by the virtually inexhaustible fast breeder reactor, and other land sources of energy (possibly even fusion) which will be eventually developed and become competitive with oil and gas. There are also those regions on land that have not been explored, and new discoveries like the Alaska North Slope are not to be ruled out. Some scientists believe that a very high percentage of land surface is still unexplored and is considered potentially promising.

These figures indicate that the actual physical supply of petroleum does not warrant crisis alarm, and that no urgency exists for the present rush into the offshore domain.

Without looking into the hardware of offshore operations, we now insert into the equation some of the basic costs of drilling and production. The majority of above-water production facilities is effective for wells in waters no deeper than 340 feet, although new designs have pushed this limit to twice this depth. As water depth increases, however, drilling costs increase drastically. In the Gulf of Mexico, for example, the costs for existing platforms rises from $1.5 million in 100 feet of water to $4 million in 350 feet, and an expected $12 million in 600 feet. 5/

The cost of drilling and completing a platform well rises from $200,000 in 100 feet of water to $425,000 in 350 feet. (Within 1971, costs of drilling rigs and other equipment jumped 25-30 per cent.) Adding a share of the platform cost, the cost of drilling and completing a 12,000-foot underwater exploratory well is $550,000 in 100 feet of water. When projected to 600 and 1,000 feet of water, the cost rises to $990,000 and $1,100,000, respectively. 6/

Operations on land are generally less costly than those offshore, More costs are added to offshore operations as the new consciousness of environmental concern gains momentum. Hazards of offshore operations include those encountered in land operations, aggravated further by the marine environment, plus a new breed of hazards peculiar to the underwater world. Safety and anti-pollution requirements have already added a heavy burden on the industry's outlays, and more stringent regulations will add further to the spiralling costs of penetration into deeper water.

Although exploration expeditures offshore are less than those for land, drilling and production make up for this margin several fold. Besides exploration, one is further faced with the following factors:

-- Skyrocketing costs of lease sales and bonuses, particularly in the United States ($600 million each in Santa Barbara Channel and Gulf of Mexico):

-- Higher overall costs for offshore operations;

-- Projected increase in future expenditures toward deeper water;

-- Higher costs eventually passed on the consumer; and

-- Offshore hazards like blowouts, fires, and oil spills increasing in frequency and magnitude.

Despite all these opposing factors, all considerations of present and future technological developments indicate that penetration into the deep-sea basins is only a matter of time. One element that has been neglected in this assessment is pricing. When all the facts have been identified and evaluated, pricing emerges as the main factor in the energy crisis. This factor involves other related parameters like quote, politicking, lobbying, and other complex interrelated elements, some defying numerical or quantitative assessment.

Because of the pricing of salable oil, and the economic factors controlling production costs, some of the physical supplies of oil become economically undesirable and, therefore, are dropped from the list of producible resources. For example, with the exception of theSanta Barbara Channel, areas deeper than 600 feet will present formidable problems for production, and the size of the field will determine the economics of development. In the Gulf of Mexico, a typical field is 200 to 300 million barrels. In depths of 1,200 to 1,300 feet, as in the Santa Barbara Channel, a field in the Gulf of Mexico will have to be close to a billion barrels in order to economically offset the costs in equipment, bad weather, pollution and other hazards. _7/ Therefore, any field below that size in water of such depth will be dropped from consideration, not because petroleum is not physically there, but because the complex interaction of other parameters renders its development prohibitive.

This situation is analogous to that of mining the manganese nodules off the sea floor. Without critical evaluation, it is generally stated that these nodules literally blanket the ocean floor, particularly in the Pacific. But in economic-geological terms, an ore body is defined as a deposit that can be mined at a profit; otherwise it is just another geological formation. In Pennsylvania, or other coal mining areas, for example, a six-inch coal seam can be an ore, whereas the coal bed I discovered in Antarctica, close to the South Pole, is just a geological formation although it is 25 feet thick. Thus, we find that profitable extraction, with all its parameters and connotations, will determine availability of petroleum and, hence, the gravity of the energy crisis.

As one moves from one parameter to another, it becomes clear that qualitative and abstract factors are also involved which complicate the process of technology assessment. Measuring them in meaningful quantitative expression is often elusive. They are factual but non-real; however, they exist and they must be taken into account. They are also the cause of passionate arguments and controversies and therefore should be defined and treated.

In this respect, we have to consider the philosophy of technology assessment. One can assess a past event, an on-going practice, or a future undertaking. You establish a case history, predict, forecast, project, and envision. The unknowns are often more than the knowns, and the long-range goals of assessment are sometimes not so clearly visible. What is needed, therefore, is the proper attitude and goals.

Since the industrial revolution, any invention has been considered a breakthrough that should be developed and utilized for man's progress. Although progress has never been scrutinized, any change was considered progress. Adverse effects had never figured prominently in the production, marketing, or consumption of a new product or technology. The consumer may still be viewed by some as a creature targeted for exploitation, rather than a fellow human to be served by technology. In the Federal Government numerous institutional constraints aggravate the situation. The Department of the Interior, for example, was created to promote the development of natural resources, yet it is expected to keep an eye on strip mining practices and offshore platforms for the protection of the environment, which creates a statutory conflict of interests. The Army Corps of Engineers similarly was created to perform and promote one type of activity, and now is faced with an equally conflicting responsibility. The Atomic Energy Commission, ditto; and so on.

Now a reordering of attitude and priorities is compelling, and well-defined goals should be set. The major issue now is how our technology can be utilized to help society. The abuse that has case on technology the notorious image of the ecological villan should be now avoided at all reasonable cost, and totally new practices should be adopted in the service of man and his environment. Technology should be the savior rather than the curse.

This fact should be eloquently conveyed to the public. The Government as well as industry should shoulder the responsibility of informing the public and creating awareness. Awareness not merely of pollution, but more importantly of what the public can and should do about it. The public simply has to be educated. The demonstrations for the environment, declarations of a nationwide Earth Day, and all such passionate displays, are for the most part of a result of ignorance.

By far the largest pollutant of coastal waters throughout the world is municipal waste. Also by far, the most urgently needed ingredient for better and more efficient sewage plants is electric power. Somehow, there is inexplicable anomaly where the very people who complain about the polluted beaches scream even louder to stop oil, gas, and coal, and shut down badly-needed electric-generating plants.

Let me hasten to add here that I am not condemning one side or absolving another; I am merely illustrating public ignorance and supporting my call for all out education of the public. The public should be made aware that we live in a closed system with depletable resources, and that there are natural processes that in one blow can do damage to the environment that would take man hundreds of years to accomplish. People should be made to understand that a dead lake does not mean the end of the world; geologically, this is a normal process, and all lakes eventually die and dry up, although man has been doing his share of speeding up the process.

But no matter how many laws we pass, and how much we assess our technology, the implementation is the final test. Perhaps if industry can set a scale for a reasonable profit, then the problems of wages, costs, and pricing, would be minimized, and more could be done to improve the environment. In a world where nobody gets anything for nothing, it is only fair that the users and tenants of the ocean environment should pay something for their occupancy.

The compatibility among the uses of the ocean is most important. When you consider theocean potential as a whole, its future productivity is certainly enormous. However, like a mineral deposit which unless economically utilized cannot be an ore body, the living resources of the ocean might prove disappointing unless the technology, economics,incentives, and other parameters are made favorable for their utilization. It is generally conceded that food from the sea is not exactly a cure-all for the world's problems of overpopulation and malnutrition. However, it is ultimately the major source of animal protein that will become progressively essential to satisfy the nutritional requirements of the world's population.

By far the biggest portion of this productivity will come from a mere ten per cent of the world ocean; that is, from continental shelf areas where biological production is well over two orders of magnitude higher than that in the remaining 90 percent. This is essentially the coastal zone; and in this zone concentrate most of man's marine activities.

With this in mind, analysts and policymakers the world over should establish the food potential of the oceans as a prominent parameter in the assessment of marine technologies.

On a worldwide scale, the abuse of the ocean environment is outrageous, and very few countries are doing anything about it. Bear in mind that industrialization in the developing countries is no innovative but adapted through simple technology transfer. Bear in mind also that the technology being transferred originated in the developed countries. This lays a certain amount of responsibility on the shoulders of the developed countries, and makes it necessary to have some sort of assessment, call it Assessment of Transferred Technology.

Under certain circumstances, when the technology being transferred is handled by a competent and technologically-oriented country, the originating country is not responsible for the consequences. A case in point is the high rate of development accomplished by the state of Isreal in two decades. Here, technology transfer and development was allowed to run unbridled; and when the adverse effects began to appear, the results are now believed to be irreversible. The famous Lake Galileé, for example, is so polluted with agricultural, industrial, and untreated human waste that the Israelis believe it has only a few years of life left in it.

Under other circumstances where a developing country is not technologically competent to assess the impact of transferred technology, the assessment should be the responsibility of the originating country or company. Most of the ruling governments of developing countries are interested only in making a fast buck, so to speak, while some are merely ignorant of the consequences. A case in point is the technology being transferred to the Arabian Gulf states. With no other source of food indigenous to the area, the people of these states depend heavily on sea food. Some have also spent millions of dollars developing modern fishing fleets and canning factories. Competing for the same waters, other coastal industries have begun to appear, particularly desalting and power-generating plants, and the offshore petroleum industry.

One particular development occurred recently which illustrates this point: The gian funnel-shaped storage tank that has been placed on the Gulf Floor, off the beaches of Dubai. 9/ Khazzan Dubai No. 1 holds 500,000 barrels of oil, and more tanks are planned for the area. It was placed on location with fanfare and worldwide publicity, but the dangers implicit in this innovation have never been aired. In case of an accident, the immediate question arises as to what happens to the fishing grounds of the Gulf, and what happens to the population to whom sea food is the staple diet? Perhaps the ruler of Dubai has been duly warned of the dangers; of that I am not aware, and I also have my doubts that the compnay who was responsible for this offshore menace had done any technology assessment prior to putting it to use. I shudder at the thought of the devastation that this might wreak on the population of the area, their economy, their livelihood, and the ecology of the environment!

Another example of the lack of assessment is Fish Protein Concentrate. When the issue of FPC was being debated during U.S. Congressional committee hearings, it was revealed that the

Agency for International Development (AID) had been distributing FPC in developing countries while the Food and Drug Administration labeled it unfit for human consumption. The implication to the developing countries is that their people are not considered human.

This sort of double standard, and the failure of a developing country to assess fully whatever it is transferring to another country, albeit inadvertant, should be strictly avoided. I doubt that any developed country would relish playing the role of the international drug pusher.

The final responsibility for decisionmaking, of course, lies in the recipient or implementer. This depends mostly on the non-rational components of technology assessment such as human frailty, individual needs, and cultural pressures and mores. The lady will wear that girdle, even if it's killing her; the man will wear that tie even if it chokes him; they will smoke cigarettes even though they know their handkerchiefs; and the developing nations envy the affluence of the developed nations, and strive to reach it despite its environmental consequences. These are the non-digitizable behavior components which will defy definition and are likely to defeat the purpose of technology assessment. They should not, however, deter us from performing an objective assessment and making a concerted effort to effect the most favorable decision and impress upon the public the need for its cooperation and understanding.

As we move in our assessment from the individual house to the city environment, the state, the continent, and the full extent of the hydrosphere, the ultimate in our assessment is the planet itself.

As a geologist, I have seen recorded in the rocks the rise and proliferation of a species, its specialization in a limited environmental niche, its dominance and population climax, its exhaustion of its life-giving resources in the limited niche it occupies, and its final extinction. To me, this is an expected course of existence, and permanence has no place in the life of this planet.

Man as a species is limited not to a single ecological niche like the species of geological past, but in global terms he has the whole Earth as a niche. It is a space ship, and man is its occupant. This means that we live in a closed system of limited air, limited water, and depletable, non-renewable mineral resources. No matter how far into the future of the planet you may want to probe, eventually it is exhaustible; it has a definable finite end.

We are like a candle burning under a bell jar; eventually the oxygen will be exhausted and the flame will be extinguished. In the case of *Homo sapiens*, population controls notwithstanding, we will eventually saturate this planet. Population figures projected to the year 2200 show that, at the present rate of growth, every inch on the Earth's continents will have the density of Washington, D.C. today! 10/ Other factors considered, we hope this may not happen so soon.

The question now is, what exactly do we mean by "long-range" forecasting and "long-range" effects in assessment? Are we assessing for the year 2000 only, which seems to be the most popular target nowadays, or are we looking ahead a hundred years or two hundred years?

If all we have to worry about is the immediate future, then all these arguments about pollution and the destruction of the environment are highly academic. If we are concerned only with the "here and now", then there is no sense in agonizing over problems we do not intend to solve. If we consider the ocean as merely a liquid medium of transportation and commerce, then let us benefit from whatever riches it has to offer and forget about a sources of food, future habitat, and recreation.

Fortunately for our posterity, this is not the case; it should not be. We should face and accept the facts of the natural processes at work on and inside this planet, and adjust our activities to achieve some sort of balance or equilibrium between what this Earth can give, and what we should take. The adjustment is a matter essential for the survival of all mankind, not merely an issue of esthetics and enjoyment.

It is also an adjustment of time: The time in which man is accelerating the destruction of the planet, and the time in which Mother Nature eventually accomplishes the same fate.

The obvious answer, therefore, is for man to slow down.

Here again, the choice has to be made between living it up in one big bang, here and now, or enjoying our stay piecemeal. Will it be blind hedonism and "after me the deluge", or will it be carefully-spaced and rationally-protracted progress? In the realm of the grape, it is an inviolable practice that wine is never imbibed in throat-choking gulps; it is taken in lip-smacking sips.

As the poet said:

> In small proportions we just beauties see
> and in short measures life may perfect be.
>
> (Ben Jonson: from Underwoods)

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REQUIREMENTS OF THE CONGRESS FOR TECHNOLOGY ASSESSMENT

The Honorable John W. Davis
Congressman from Georgia

I would like to dispense my comments on Technology Assessment today in four doses, which, I hope, will be reasonably brief and palatable. I have arranged them in the following categories:

1. What is the nature of Technology Assessment?
2. Why does Congress need Technology Assessment?
3. An example of a possible future assessment.
4. Where does Congress stand now with regard to Technology Assessment?

WHAT IS TECHNOLOGY ASSESSMENT?

At this point in time, it appears to me, technology assessment has come to mean just about anything anyone wants it to mean. Admittedly the term is broad, a bit vague and, I suppose, in some instances it can be misleading. But the term has caught on and even if, as Harvey Brooks remarked recently, "it is not the first phrase which has been murdered by over-popularity," it is still a useful appellation.*

Dr. Brooks has pointed out and described very well about half a dozen different connotations which have been given to the term.

I will make no effort to go into these variations, but I will try to say what technology assessment means to those of us in Congress who helped develop current legislation on the subject. Perhaps the quickest way to do this, if you will forgive the technique, is to quote from comments I made on the Floor of the House at the time our bill to establish an Office of Technology Assessment was passed by that body last February. The definition I used was this:

> "Technology assessment is a mechanism which may be used to evaluate the impacts, good and bad, which new or developing technology may be expected to have on legislative programs with which the Congress must deal; the intent is not to evaluate the technology itself, but to evaluate the impacts, physical, economic social and political. Most importantly, it is devised not only to provide Congress with early warning of possible troubles -- but to help move new technologies into action rapidly in areas of society where they can be helpful."

In other words, what we in Congress are talking about is the development of information of a kind which is not now available to us. This is evaluated

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* "Technology Assessment Reconsidered," lecture delivered by Harvey Brooks, Carleton College, November 16, 1971.

information, to be developed through the Office and made available to congressional committees and to Members on the technological aspects of whatever program, investigation or legislation may be under consideration.

It is important to note that most of these assessments would be done in advance of the hearing stage. As a lawyer, I sometimes tend to equate it with pre-trial depositions or stipulations, though I realize the analogy is by no means perfect. But the point is that by having such information available at an early stage we hope to improve the quality, speed and efficiency of committee proceedings as well as improve general Congressional understanding of technological issues and possibilities.

Hopefully, this will help us go beyond current procedures which sometimes require weeks of inquiry and/or hearings before we can even perceive the proper questions to ask. This is not to say that assessments would preempt in any way the hearing system or adversary proceedings before Congressional committees. It will, we believe, help us move into our work from an advanced and more sophisticated plateau.

Now I want to throw in a couple of disclaimers which, perhaps, will help allay certain misimpressions of what assessments are inteneded to do or not do for the Congress.

As we visualize it, the technology assessment process in no way attempts to tell Congress what action to take on any piece of legislation or any program under consideration. The OTA would not even have authority to make recommendations. One can argue -- and some do -- that bias can nonetheless be built into assessments simply by virtue of who does them, what data is used, what material is not included and so on.

For the most part, we think this argument is specious. We recognize that probably no study can ever be totally devoid of some bias, but we are confident that an experienced Office of Technology Assessment will be able to eliminate most of it. Hence we have built a system into the OTA bill providing that assessments be done by outside groups in order to eliminate possible built-in bureaucratic prejudices. The assessments may be done by a single group or by several and, undoubtedly, in many cases by special ad hoc groups.

So when we talk "technology assessment" in Congress this is what we are talking about. It is not just cost-benefit, not just forecasting, not just technology transfer -- neither is it a "systematic planning" in and of itself. While it involves all of these things, it boils down to the provision of reliable, independent information of the type described.

The preamble of the bill states:

"The present mechanisms of the Congress do not provide the Legislative Branch with adequate independent and timely information concerning the potential application or impact of . . . technology, particularly in those instances where the Federal government may be called upon to consider support, management, or regulation of technological applications. It is therefore imperative that the Congress equip itself with new and effective means for securing (such) information . . . and that such information be utilized whenever appropriate as one element in the legislative assessment of matters pending before the Congress."

Finally, let me emphasize that our concept is not anti-technology, as many people seem to think, particularly industrialists who are not informed on exactly what it is we are proposing. We are just as interested, actually more so, in the pluses of technology as we are in the minuses. As the bill states, "the growth in scale and extent of technological application is a crucial element in (our major) problems and either is or can be a pivotal influence with respect both to their cause and to their solution."

WHY DOES CONGRESS NEED IT?

I do not believe I need to spend more than a moment explaining why Congress needs some new mechanism of the kind we are talking about.

The answer is that almost every major problem with which the Congress deals today -- whether it does so in bits and pieces or whether its approach is all-encompassing -- has a very large technological component. It is difficult to name any category of active programs which does not. You can tick them off for yourself. Mass transportation. Pollution control. The energy crisis. Urban blight. Population management. Environmental stability. National security. The reduction of crime. Health care. Each of them involves a sizable investment of technological knowhow of one kind or another.

If one wanted to make a list of specific problems, certainly these are not hard to find either. For, more and more, we in the Congress are having to make decisions on such well-known matters as those involving supersonic transports, Alaskan pipelines, space programs, nuclear applications, antiballistic missile systems, drug abuse, science education and the like.

I recently was leafing through the latest issue of the digest of public bills and resolutions that have been introudced in Congress in the last month or so. I was struck by the fact that so many of these bills, 95% of which are the type about which the public never hears, contained some technological facet -- for example, those dealing with research on transportation for the elderly and handicapped, tax benefits with regard to marine sanitation devices, alterations in medical assistance under the Social Security Act, the handling and labeling of cyclamates in food production, the technical assistance for comprehensive child development, the establishment of a national information and resource center for the aging, study of new methods and research involving highway safety. The list could go on and on. And if one reads the summaries of these bills, invariably a technological phase will be encountered in each.

A TECHNOLOGY ASSESSMENT SCENARIO FOR THE FUTURE

Let me provide you with a sort of bob-tailed scenario of an imaginary situation which could be facing the Congress in a few years -- and attempt to paint a picture of the various factors which might come into play.

Let us suppose the year is 1985.

That is not very far away and yet is still a year beyond the disturbing Orwellian year of 1984.

The scene is a high-level Washington conference attended by scientists, government officials, public health representatives, theologians, lawyers, sociologists, engineers, psychologists and perhaps delegates from other professions or other countries.

The theme is improved national health.

The decision to be reached is whether or not to commit a new and considerable government investment into a developing line of research which promises to delay the normal processes of aging by a factor of 50 per cent and, correspondingly, reduce the incidence of serious disease by the same rate. If successful, the application of this endeavor will produce a much more disease-free population which has on the average a life expectancy of 105 years.

The chance of success is two to one. The financial commitment to the research, while large, is not prohibitive. Those attending the conference are themselves generally in good health and in the 40 to 60 age bracket.

What is the decision?

Well, most of us would say, is not the answer obvious? The return is great, the risk is small. By all means -- let us give it the green light.

Yet it turns out that things are not that simple and a formidable argument develops.

The engineers say that the only feasible way of distributing this new elixir of life will be through public water systems -- which means it will reach the genetically and mentally defective population (now quite large) as well as other segments.

The theologians raise some of the objections we have already heard in connection with past disputes over fluoridation.

The ecologists note that the rise in life expectancy will throw nature's balance of animal species even further out of kilter with possible disastrous results to other forms of life.

Economists and actuaries are concerned that retirement and pension plans will be badly disrupted -- particularly since the need for productive human laborers is easily filled by the younger people and is, in fact, falling in relation to the overall population.

Demographers are alarmed at the prospects of adding a new expanding factor to the population dilemma which is already known to be responsible, in large part, for the overwhelming difficulties apparent in urban blight, transportation tie-ups, unchecked crime, decline in education quality, shortage of food, the disappearance of resources and so on.

Conservationists and housing authorities decry the added strain that will be placed on the world's vanishing natural resources and land reserves.

Psychologists point out that the human race -- already deprived of many traditional factors which have comprised the struggle for existence and have thus provided incentives for work and frugality as well as philosophy and creativity -- will be relieved of one additional personal element. Now, they suggest, human personality, secure in its new invulnerability to physical ailment, will tend even more to acquire the characteristics of colorless vegetation -- sinking further and further into the faceless mob.

Now, I am aware that competent counter-arguments can be made to these points -- perhaps conclusive ones. Nor am I suggesting that the decision in the imaginary situation just described would necessarily be negative. I do not know.

The point of the foregoing exercise is simply to demonstrate that policy decisions with regard to the application of new science and technology are no longer the easy, humanitarian or cost-benefit matters they once were. Such decisions today are often incredibly complex, difficult and -- often as not -- painful.

It was not hard, for example, to decide that fire, the wheel, and the cotton gin could be highly useful devices and should be widely utilized. It was not hard to see the many benefits inherent in the railroads and the steamship, in fertilizer and hybrid corn, or in the Flexner method of developing first rate medical skills and services. At least, it was not hard in the frontier society which had always existed, until after World War II.

Today, however, we have difficulties in proving the overall plus-side to the SST and the jumbo-jet, in deciding what security rating to attribute to missiles, F-111's or the ABM or proving the utility of television or the computer in education; and we are in fairly complete discord when it comes to solving the enigma of health care and new delivery systems for medical services.

Today, many new elements, new potentials, new effects and new interests must be integrated into the equations of decision. Not just the physical and the economic, but the social, the political and the philosophical must be integrated as well.

This is why the concept of Technology Assessment has generated substantial interest.

WHERE WE STAND NOW

So, as a practical matter, where do we in Congress stand at the present time?

Most of you are aware of the many years of work which our committee, and particularly our Subcommittee on Science, Research and Development, have put in on this task. The Committee record goes back as far as 1966 and includes hearings over two years, seminars, staff investigations, outside contract studies, international conferences, and a variety of other activities.

They resulted in a bill which was reported from our Committee in the Summer of 1971 and passed by the House several months ago.

I think it may be useful if I brief for you the basic elements of the bill as it was formulated and reported from our Committee.

The bill would set up an Office of Technology Assessment within the Legislative Branch of the government. The Office would be responsible only to the Congress. It would be composed of a Technology Assessment Board, which would be the policy making body and a higher level Director, equivalent in pay and protocol to the heads of independent Federal offices, who would be responsible for the day-to-day operation of the office.

The Board would be composed of 11 members as follows:

Two Senators, one from each party, appointed by the President pro tempore of the Senate; two Members of the House, one from each party, appointed by the Speaker; the Comptroller General of the United States; the Director of the Congressional Research Service of the Library of Congress; four especially qualified members from the general public appointed by the President with Senate approval; and the Director of the Office.

The four Board members from the general public would be appointed for 4-year staggered terms. The Chairman and Vice Chairman of the Board would be elected by the Board from among its general public members.

The Director of the Office would be appointed by the Board for a 6-year term. Once appointed, he would also become a member of the Board and would be a voting member in all matters except with regard to his reappointment. No limit is placed on his reappointment.

The usual powers and authorities of a functioning agency of Government are provided for the Office of Technology Assessment, plus powers of subpena, subject to safeguards where proprietary information or invasion of privacy might be involved.

The Office would itself be prohibited from operating laboratories, pilot plants, or test facilities in the pursuit of its mission.

The Office would be directed to maintain special coordination and cooperation with the National Science Foundation with respect to: (1) Grants and contracts formulated or activated by the Foundation which are for purposes of technology assessment, and (2) Coordination in areas of technology assessment and the avoidance of unnecessary duplication of research activities in the development of technology assessment techniques and programs.

Assessments could be initiated by the Chairman of any Committee of the Congress, for himself or on request of the ranking minority member or a majority of Committee members; by the Technology Assessment Board or by the Director. All results would be freely available to the public except in cases involving national security or when public information statutues would prohibit it.

When this bill reached the Floor of the House earlier this year, it was altered in several important respects by amendments offered by Representative Brooks of Texas. The chief changes were these:

1. The composition of the Board was completely altered. In its place there was substituted a sort of Joint Committee arrangement consisting of five members of the House and five members of the Senate. The Chairmanship of this group would alternate between the House and Senate from one Congress to the next. Appointments to the Board would be made, as before, by The Speaker and President pro tempore of the Senate.

2. The Director was relieved of his powers to initiate assessments.

3. The subpena power, which the Office previously had, was eliminated.

The Senate has now completed its hearings on this bill, with all the testimony being in favor of some sort of an OTA.

One point on which there appeared to be unanimous agreement was that since the change in the Board eliminated all public members, an additional device was needed to provide adequate and appropriate liaison with the public. This feeling was generally expressed in terms of recommendations for an Advisory Council to the Board, to be composed primarily of from 8 to 12 public members, plus possibly the Comptroller General and the Director of the Congressional Research Service of the Library of Congress.

At the present time, it is my understanding that the Senate Committee on Rules, which has jurisdiction of the bill, is considering three or four possible variations of the bill -- at least one of which would probably cause a considerable dichotomy between the Senate and the House. This is the version reportedly proposed by Senator Metcalf of Montana, which would substitute the existing Joint Committee on Congressional Operations for the Technology Assessment Board.

The Joint Committee on Congressional Operations was set up just last year by the Legislative Reorganization Act of 1970.

Initially this Committee would have been given 7 specific functions, all of an internal administrative nature. But Congress reduced these functions in the final form of the Act to three. These are (1) make studies of the organization and operations of the Congress with a view to making recommendations for their improvement; (2) identify any court proceedings which might be of particular interest to either House of Congress; and (3) administer the Office of Placement and Office Management, which was set up to help Members and Committees locate appropriate staff personnel.

The Joint Committee is specifically enjoined from concerning itself with the rules of either House or with "any matter on the Floor of either House." In other words, the Joint Committee has no substantive authority, nor any legislative jurisdiction.

The position of our Committee is that if the Technology Assessment Board provided in the bill is to be composed solely of Congressional members, there should be an equal number of members not only from both Houses, but both parties. This would result in parity and would take the Office out of a politicized atmosphere.

We also think that authority to originate assessments should be restored to the Director, particularly since one of the most crucial factors of the OTA is to anticipate the needs for assessments well in advance and get them started before they are inaugurated by a Committee on a crash basis. We believe that the Office should be a strong, independent entity if it is to prove worthwhile. It is our view that if the Office is watered down to the status of a joint Committee or placed under an existing joint Committee, with all authority and powers being removed from the Director, the mission of the Office cannot be fulfilled.

Joint Committees almost invariably become the personal vehicle of the Member of Congress who happens to be Chairman at the time, and in spite of their popularity with political science theorists, Joint Committees, in practice, have rarely been effective. This may be considered a biased view, but I seriously doubt if you could find more than a dozen Members of Congress, other than those who happen to be Chairmen or Vice Chairmen of a Joint Committee, who are not "biased" in the same direction.

It is interesting, of course, that Congressman Brooks and Senator Metcalf happen to be the Chairman and Vice Chairman, respectively, of the Joint Committee on Congressional Operations.

So what is the outlook for the creation of an Office of Technology Assessment this year?

I believe, basically. it is still good. Much depends on what changes the Senate decides to make and whether the differences are so great that they cannot be resolved in conference. I do not believe the latter will happen. I believe the Senate is doing a conscientous and careful job, and while I suspect that its version will be considerably different than ours, I am sure that the differences can be ironed out eventually.

Even if no OTA comes into existence during this Congress, it is my conviction that the work which has been done will not be wasted.

The technology assessment concept has been created; it is spreading, not only at the Federal level, but at the State and international levels as well. Governments everywhere have become conscious of its ultimate need and potential -- regardless of the final form it may take.

We think this is a genuine step forward.

PLANNING A BALANCED UNIVERSITY PROGRAM OF
OCEANOGRAPHIC EDUCATION AND RESEARCH

by

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MARINE TECHNOLOGY SOCIETY
CONFERENCE

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I am sure that there are some of you who think such a title as "Planning a Balanced Research and Educational Program in a University" is at least whimsy, if not an actual non sequitur. Most close observers are quite certain that planning does not exist in a university; programs just grow. A university administrator can describe what exists but to call it planning is a rationalization at best, and more likely self-delusion. I make no claim that planning is a closely scrutinized in university research groups as it is in industry or government laboratories; but neither is it a completely laisez-faire operation. A major type of planning (or decision making) is of a negative sort; you decide what you are not going to do. By such a process of elimination you then decide what types of programs you can develop. I make no claim that all of my colleagues in this business will agree with what follows. I think most would concur, but perhaps the emphasis and details would be different. What follows then is a personal credo.

First, you do not get involved in research that has no educational content. Graduate students, or at least post-doctorates, should be involved in a meaningful way in all research activities at a university. During and after World War II many universities took on special assignments for the government, many of them highly classified. Some continue these activities. Some may continue to be justified in terms of the public interest. But in general, I do not think it is a good practice for a university to establish a Lincoln Laboratory or an "applied physics laboratory" that is almost, if not completely, isolated from the primary educational function of a university. My reasons for believing this are several. The first is that I believe that a modern university is sufficiently complicated and diversified without becoming overly involved in peripheral activities. My second reason is more pragmatic but perhaps more important. It is my opinion that over the long run the university will lose control of the quality of the research if it is not closely tied to the primary function of the university. I freely admit that there is probably insufficient evidence to test this opinion. However, I believe there is sufficient evidence to show that there is nothing like the spur of good graduate students to keep a university research and education program in top form.

I also believe there are some important exceptions to this belief that universities should not be engaged in peripheral research activities, and I wish to discuss some of these later; but in my opinion the burden of proof is on those who want to establish non-educational research programs. The propriety of continued university support should be reviewed regularly.

Second, in designing your research program, you do not go out of your way to compete with industry research groups and, to a lesser extent, with government laboratories. You attempt to find your own niche. Sometimes the competition is unavoidable. When this happens, I sympathize with the screams of anguish from industry. University cost accounting is different. If the research project included the opportunities for students to do thesis research, or if it is somehow coupled with other ongoing research and educational activities, there is not an industry in the country that can compete on a dollar cost with a university, although admittedly, it may take us a little longer to get the job done.

In general, I am against university research groups bidding against industry for projects. Again, there are some major exceptions. For example, if someone needs ecological data for an environmental impact statement in Narragansett Bay, I am willing to risk the unhappiness of those industries who think they can do the job. We need to know as much as possible about the ecology of Narragansett Bay and if someone is willing to finance studies beyond our present level of effort we will consider doing the work.

Third, you do no do proprietary research. You never do it for industry and you only do classified research for the government if you are confident that the national interests override university interests. Again, there may be exceptions; I have seen one in the last eight years where a man's personal research interest could not be met except by working on a classified project. However, I feel strongly that classified or proprietary research is an anathema to a university. Again, I would argue that the burden of proof is upon the man or the group who wants to do it.

Now let me say a few words about the forces that guide development of a research program. I see two. The first is that a university should attempt to sponsor the most innovative anc creative research possible. The second is that it should sponsor public service and related research activities which are in the public interest. I believe the latter is particularly true in public universities such as the University of Rhode Island.

University research has a long proud history, and it has had unparalleled opportunities. Speaking specifically of oceanography I believe that any review of the literature since World War II will show most of the new concepts and ideas have come from university research. Those of us in the business of directing university research programs hope it will continue and are working hard to see that it will. University research scientists have much more freedom to choose problems than do those in industry or governmental laboratories. Our work is less likely to be mission-oriented. There is less need to show cost effectiveness and immediate payoff. Even in our mission-related work such as that sponsored by the Sea Grant program we generally have greater flexibility than government or industry laboratories. Given this freedom, it is imperative that we make the most of it.

To insure this happening, my formula (and that of most others) is to find the best scientists you can, try to provide the necessary resources, and leave them alone. The research director makes one important decision. He chooses the staff. All other decisions are secondary. He must also provide the climate and the incentives which make successful research possible.

If he also feels he should be telling the scientist what to do then one of several things may have happened. He may have chosen the wrong man--for this system to work the staff must be excellent. It is possible, of course, that the research director really knows in detail what should be done and how to do it, even though he is not as familiar with the problem as the scientist proposing it. If he does, he probably should be back in the laboratory. The more likely possibility is that the research director has an overly developed opinion of his own abilities.

I do not say that the research director has no influence. He can suggest; sometimes he can guide. Most important he can decide that work needs to be done in certain new areas. For example, a good scientist can often find a lot of intellectual excitement in Arctic research if it turns out that is the only area in which he can find adequate support. But even that carrot and stick combination does not always work. The only formula I know for developing a first class program of innovative and creative research is to find the best people you can in the fields you wish to emphasize, give them the support they need and let them pick their own problems. And if you have bright graduate students coming along they will keep the senior staff on their toes--either that, or force them into a premature retirement from an active research program.

The second force determining university research is public service. I feel strongly that universities should encourage public service related activities and this is particularly true in state universities. Most universities and university scientists are involved in public service in one way or another. The complex National Academy of Sciences-National Research Council committee system is one manifestation of this. However, the land-grant college, its agriculture and engineering experiment stations, and its extension service are the prototypes that most of us think of when considering public service research. These institutions have had a long and honorable history with many more successes than failures. The Sea Grant program is designed in many ways to be patterened after them. As the former director of such a program, I can assure you that design, value judgments, etc., are much tougher than directing a basic research program. Many of the same criteria hold. There is no substitute for talent. But the researcher must see clearly (or be made to see) the true societal needs, and design his research accordingly. Again, I shy away from the concept of directed research. I still feel that if the goals are clearly outlined a good research man is better able than any research director to define the problem and plan the work necessary to find a solution. He will not always win, but I think the percentage of success will be higher than in a highly structured, directed program. I should also note in passing that in this type of research one often finds the greatest source of possible conflict between university research and industry and government laboratory research.

With respect to public to public service activities I would like to mention a problem that has intrigued me for several years. How can a university (particularly a state university) help state and local government? Even states the size of California and New York seldom have the intellectual and material resources to handle its problems comparable to to that found in the federal government. Yet, many of the most complex problems today are state and local problems; urban planning, drugs, crime, education, management of the environment. Many universities are involved in assisting state and local governments but I believe that much more can be done. It's an intriguing problem in state-university administration as to how to do this effectively and efficiently and not compromise the historic independence and separation of the university from government. We have tried several experiments at the University of Rhode Island in the marine field through our Marine Experiment Station, our Sea Grant Marine Advisory Services, and most recently by establishing a special advisory mechanism to a newly formed group in Rhode Island charged with managing the coastal zone. We call it the Coastal Resources Center and it is at least part of our response to the coastal zone laboratory concept called for in the Stratton Commission. It is designed to provide an effective interface between the state's Coastal Resources Council and the coastal zone activities of the University. Our idea is to establish a small technical staff, but to rely mostly on the wide range of talents that are available in the University. The Coastal Resources Center must be prepared to provide a fast response to a need. It must also be able to tap the university for longer-range studies. Perhaps most important it keeps the University locked in on the current problems and what the problems might be in the future.

Finally, I would like to say a few words about education, particularly marine-related education. Some problems are common to all education and are not unique to the oceans. For example, how do you train students that they are not technologically unemployable in five to ten years? Or, how do you provide a more flexible format for continuing education?

There are educators much more knowledgeable than I who are struggling with these problems and I have nothing new to say on the subject. I recognize that one must concentrate on the fundamentals even at the expense of advanced state of the art courses and that one must find some reasonable mix between training the generalist and the highly trained specialist. My experience in continuing education has been limited but I feel, as do many others, that there must be ways to develop meaningful training programs for those some years out of college. Too often, shallow, survey courses pass for continuing education.

In the oceans we have special problems which are in some ways variations on the above. First, it is necessary to decide whether the oceans are to be considered as an example of specialized discipline or is the field big enough, the intellectual challenge great enough, and the problems sufficiently unique that one can have specialized programs of ocean studies. In other words, do you study the ocean as a part of a program in chemistry, biology, electrical engineering, economics, or do you set up departments of oceanography, ocean engineering, and ocean economics? On a national basis, I think you need both approaches. My personal commitment, however, is to establish ocean-oriented programs. I feel time has justified those early programs in oceanography such as established by the Scripps Institution of Oceanography. We would not be as far advanced as we are today without those programs and their graduates. I believe time will show the merit of such programs in ocean engineering and the ocean aspects of the social sciences. I am not an absolute traditionalist in educational matters. If there is a current need for a program and it can be justified on its intellectual scope, then I am in favor of setting up such a program, and, if useful, establishing a special department. There is nothing that argues that the program has to be continued for the next 40 years; although having watched the slowness and conservatism of university faculties when it comes to managing our own affairs I sometimes wonder at the effort of disestablishing a program once under way.

To show that we mean what I say about ocean-oriented degree programs I should point out that we have five degree programs in ocean affairs at the University of Rhode Island. So far as I know, this is more than any other university in the country. They include the following:

Oceanography--This is the oldest degree program at URI and is the biggest. It attempts to cover all fields of ocean science from biology to geophysics. We have about 135 graduate students at present working toward their M.S. and Ph.D. The program is similar in many respects to programs at other oceanographic institutions such as Scripps, the University of Washington, Oregon State, University of Miami, Texas A & M, etc. Very heavy emphasis is placed on individual research at both the M.S. and Ph.D. level.

Ocean Engineering--This is also a graduate program offering the M.S. and Ph.D., although we are experimenting with an ocean option to our regular undergraduate engineering major. The graduate program has about 80 students. The department has a small number of faculty assigned 100% to the department and a larger number of faculty with joint appointments between Ocean Engineering and other engineering departments within the University. Students study both the special problems about the oceans in a common core of oceanography and ocean engineering courses and have an opportunity to continue specialization in their own particular field of engineering.

Economics (Marine Resource option)--At the moment, this is only option offered in the Ph.D. economics program at URI. The program is patterened on those in Resource Economics common to many schools, particularly land-grant colleges, but with special emphasis on marine resources including fisheries, offshore oil and minerals, transportation and the coastal zone.

Fisheries and Marine Technology--This is a teo-year associate degree program with heavy emphasis on practical experience and training students to enter the commercial fishing industry. It has been highly successful. At last count all but one of the graduates and most of the nongraduates in this program are working in marine-related fields today. Many of them are on commercial fishing vessels.

Master of Marine Affairs--This is our newest marine program. It's essentially a mid-management type program. About 20 students a year are accepted into theprogram. Students may enter with any background, whether it be business, engineering, law or science. They are exposed to a variety of core courses related to oceanography, ocean engineering, resource economics, international law, and marine geography. In addition, they have an opportunity to take additional courses in their specialty. Heavy emphasis is placed upon interdisciplinary seminars and individual study and reports.

To summarize, I think the most difficult task in planning a balanced education and research program in a university is attempting to foresee the future. Some of the moves we have made at URI in recent years were obvious ones, such as moving into the marine-related social sciences. Others are less so. I think it is possible to see broad trends in the future but not the details. A program that is to train students to be productive for the next 30 years cannot get hung up on details. It must provide a broad based, fundamental education. Similarly, a research program that is to provide leadership must depend upon the ability and wisdom of its staff. Planning, therefore, if it exists, cannot be too heavy-handed or too detailed. Ideally, the job of the research director is to simply try to find the resources and to let others carry out their plans.

CRITERIA FOR CORPORATE INVESTMENT IN OCEAN RESEARCH AND DEVELOPMENT

William E. Shoupp

In discussing corporate investment and the criteria for its use in ocean research and development, we must first think a bit about "what is investment." Investment involves the use of corporate funds but really, whose funds are they? They are your funds that you have invested in the corporation or your equity in the corporation that are used, whether they have been invested directly or indirectly. It is important, therefore, that wise and benificial use be made of such funds for the corporate good.

It would be easy for me to state that the criteria for investment by corporations in ocean research and development would be simply that an appropriate return for such investment, of say 15% per year on a discounted cash flow basis was apparent. This criterion is obviously an oversimplification since corporations, like people, have other needs and constraints than an immediate return on a single investment. These needs are, 1) long term existence, that is the corporation desires to live and perpetuate itself, 2) the corporation desires to grow and increase its ability to perform the reason for its existence of providing for the needs of its customers and the public.

The corporation must also have both natural and unnatural resources to use in order to provide the products and services that it supplies. These resources are people, equipment, raw materials, natural resources and capital, but more importantly, a corporation must have sufficient knowledge to use these to meet the short and long term needs of its customers in a way the customer wants them met. To do this, the corporation must understand the parameters that permit the utilization of the required natural and unnatural resources necessary to guarantee its continuance as well as to make possible the growth of the corporation by continuing to be able to supply the ever increasing complex demands of its customers and the needs of society. You may ask why "societal" and not just "customer" needs? If a dynamic, competent and rational society is not maintained, there may be no customers, or indeed, no rational needs to be fulfilled. Thus, for long term existence and growth, corporations must have a corporate "conscience" as well as technical, manufacturing and marketing competence if it is to continue to exist and to fulfill the reasons for its existence.

I would like to discuss briefly what industrial researchers do and the criteria we may use in our selection processes for corporate research and development investment. But first, I'd like to state that I have little faith in the accuracy of the reported national expenditures in industrial and, indeed, non-industrial research particularly as they are broken down into the categories of basic, pure, or fundamental research and into applied research and development since I believe the numbers we see include much purchased conventional capital hardware and too little understanding or definition of the various kinds of research and development that are tabulated. There seems to be a belief that basic research (whatever that may mean) is confined to the universities, and that development and engineering is that which is done in industry. I should like to indicate that I believe there is much more "development" taking place in the universities that is called "basic research" and much more "basic research" is taking place in industry and not-for-profit institutions, that is called development or applied research,than is commonly recognized. I am not accusing anyone of incorrectly handling the data or in its publication, or am I against the attempt to collect such data, but I hope we may sometime find means of truly getting a good set of definitions and better numbers from a national and worldwide survey and analysis of just what the efforts and expenditures really are. In order that you may not think me to be unconstructively critical, I am trying to put together my own set of data on this subject so that I may see if my beliefs are true or not.

But, back to the main subject, criteria for corporate research and development. Generally, corporations' efforts fall into three research and development areas, 1) research and development directed to assisting the corporate operations arms in improving existing product lines and in reducing the costs of supplying their products or services, 2) basic research, permitting scientists and engineers to carry out fundamental studies in areas that have a good chance of significantly influencing the future business of the corporation, and 3) development and identification of new products or services.

These criteria for types of research and development for corporations are very little different from those used by government, not-for-profit institutions, or in many cases, by academia except that in the latter case, it is frequently true that less attention is paid to the relevance or utility. This, in point of fact, does not mean that a particular research and development program is different in academia, but that the motivation of the researcher, or his management (whether dean or research director) may be somewhat different.

It is also time that we paid more formal attention to the subject of research in engineering, whether it be in academia or industry. We must recognize the importance of learning the "what" of science and technology, as well as the "why." Sometimes we may tend to write off research in engineering as empiricism and not appreciate that "what happens" usually leads to the more basic work on "why it happens." In fact, there is an old saying that I believe to be true, it is simply that "application usually precedes understanding." So, in setting our criteria, it is well to consider relevance in our research whenever it is possible. It is also necessary to recognize that the blind application of a relevance requirement will cause us to miss many uses and discoveries; so, in planning and setting up of criteria for research and development, an appropriate balance between subject and direct utilization of research and development programs is a criterion. This is true whether the research and development occurs in corporations, government, or institutions In fact, there are really more similarities than differences in the programming and criteria for research and development in corporations, government and institutions. To illustrate this, please consider the similarity of the research interests and programs of a certain representative corporation to those in government and institutions. Those areas of research and development are shown in biology, hydrology, biochemistry and geology.

As another specific example, you may be interested in the civilian markets to which these technologies are relevant in a particular company. As the possible goals are made viable by research and development, markets, jobs, products, goods and services are increased and the criteria discussed before are satisfied

In addition to the directed programs, there are always expected and unexpected spinoffs that may occur. These may occur from directly funded or outside funded research and development efforts. Two cases in point are: 1) the applicability of ocean life support equipment and physiological knowledge to mine rescue uses, and 2) the use of sonar doppler effect equipment to velocity measurements in water flow equipment for power generation. I mention these only as an illustration of another programming criteria for corporate research and development; that is, to select such efforts that may have expected spinoff into other products and services than those intended. Intelligent management or scientific projection analysis can frequently predict such spinoff possibilities.

I would like to discuss briefly another aspect of research and development criteria, that of overall national value. My point is simply this; there is entirely too much separation and sometimes disagreement among the three domains in which research and development is done; that is, in government, institutions and industry. We must soon recognize we are all in the same nation with the same overall national goals. We must learn to work closer together toward these common objectives so that our efforts will augment and assist one another without leaving voids of producing undersirable duplication. Since no one group, institution, or government agency, or corporation, can do all of the work in any sizable field of science or technology, I arrive at another criterion for corporate research and development; that such research and development must involve, wherever possible, an overall national effort or commitment for the national good.

A corporation must select its programs in fields to which it can contribute, understand and develop competence or the program will mean little to his corporation. In thinking of the role of industry in ocean research and development and the criteria for selection of programs, I am struck by the similarity of the selection of such programs to those I developed for the power systems business. There are three basic levels of risk associated with research and development efforts. I believe government should be associated generally with those programs of highest risk and that industry ought to concentrate on research efforts with lowest estimated risk. In the middle area is the place for joint, cooperative government-industry programs.

In closing, let me elicit another criterion for corporate research and development, that is one on timing. Late research and development leads to late entry into a product or service area of business. Lateness in evolving new business is just as fatal as lateness in military development and sometimes the results can be almost as disastrous to a business as to a poorly prepared nation. Strangely enough, research and development results can sometimes come so early that they yield little direct good to the corporation. In fact, I personally hold patents from research and development output that were not capable of being used until after the patents had expired. Does this mean that a criterion should be not to do industrial research and development on long range items? I say no to this-but timing must be watched in evaluating research and development program tradeoffs and in setting program priorities. In addition, it is particulary important that as a criteria for corporate research and development that sufficient effect must be able to be applied so that the program is not subcritical. This is, the effort must be applied with enough vigor to be really responsive to the difficulties and problems in order to meet the corporate or social needs. Thus, my criteria are, in brief:

1. Research and development to ensure the corporations' existence and continuance of a competitive position.

2. Research and development sufficient to ensure the growth of the corporation and to ensure the confidence of the shareholders.

3. Research and development to supply the needs of the corporate customers and societal needs in the corporations area of business.

4. Research and development to satisfy the corporate conscience.

5. Research and development in frontiers of science and engineering so as to understand, interpret, and to contribute those fields necessary to protect the corporation from unexpected major shifts or changes in its products, businesses or markets that would unfavorably impact the corporation.

6. Research and development efforts should be properly timed, balanced, phased, and mounted with sufficient effort to satisfy the corporate needs.

I have given you examples of criteria that have been used in selecting ocean research and development programs. These criteria express a philosophy of need and relevance as well as that of the furtherance of scientific knowledge. Selections of such work efforts can be made upon such criteria and in general, I feel that serendipity is not sufficient in itself for research and development program justification.

OUR CHANGING OCEAN PRIORITIES

Dr. Robert M. White

Administrator
National Oceanic and Atmospheric Administration

Mr. Chairman, ladies and gentlemen: the topic I have been asked to discuss relates to the question of priorities for support of Federal ocean programs. It raises the basic question of why, we in the Federal Government, place more emphasis on particular programs, and less on others. This in truth, leads to questions as to the basis for the decisions reflected in our ocean programs.

As you all appreciate, penetration of the Federal decision-making apparatus is not easy. Decisions result from so complex a process that even some of us involved intimately in it are not always certain we have comprehended all of the factors that finally manifest themselves in a decision to support one kind of activity or another.

The decisions ooze from an enormously intricate web of multiple and many times conflicting pressures, suggestions, advice, and action emanating from innumerable individuals, institutions, and pressure groups, both within and outside the government.

What the Federal decision-making process is trying to reflect, however, are the underlying needs of our society. It is trying to come to grips not only with the relative importance of one aspect of ocean affairs as compared with another, but also with the relative societal importance of our ocean needs.

All pressures, opinions, recommendations and calls-to-action start initially as the views of one "special interest" group or another. I do not use the phrase "special interest group" in a pejorative sense. Engineers recommend high priority for engineering ventures through their societies and the Academy of Engineering. Environmentalists recommend more attention to environmental conservation programs through their numerous societies and associations. Each of us can stack our desks at least three feet high with reports of our National Academy of Sciences, the reports and recommendations of our professional societies, the hearings of the Congress, the reports of the various agencies and departments of the Executive Branch, the resolutions passed by State legislatures, and so on. There is no lack of recommendations--the problem is in reconciling them.

The genius of our system of government is that there are mechanisms which do work to compose these widely varying views and to establish priorities--the final decisions being made within the Congress and the Office of the President. Many ocean policies of the Nation are set out in the laws passed by the Congress, providing broad strategic guidance for the Nation.

These policies, representing the best assessments by the Congress and the Executive Branch, of the ocean needs of the Nation, are rather simple and straightforward. Let me quote from the Declaration of Policy of the Marine Resources and Engineering Development Act of 1966: "It is hereby declared to be the policy of the United States to develop, encourage and maintain a coordinated, comprehensive and long-range national program in marine science for the benefit of mankind, to assist in the protection of health and property; enhancement of commerce, transportation and national security; rehabilitation of our commercial fisheries; and increased utilization of these and other resources."

The Statement of Policy and Objectives goes further. It states that as a matter of policy the United States should conduct its marine science activities so as to contribute to a number of objectives, such as the accelerated development of the resources of the marine environment, the expansion of human knowledge of the marine environment, the encouragement to private investment enterprise, etc. Our policies are dynamic and changing concepts. They are under continuous evolution. Even as we discuss these policy issues, the Congress and the Executive Branch are debating new laws which will set the United States policy for many years to come in the fields of ocean dumping, protection of marine mammals, management of the coastal zones, and many others. In each of these laws, we could cite the statements of policy. These, then, form the basic criteria in accordance with which Federal programs and ocean research are initiated, given statutory basis and provided with funding.

Our policies are phrased in soaring rhetoric. But how do we give flesh to the bones? What specific programs of ocean research or technology, or education and training will we undertake to give life to these policies? Sometimes we are too close to the battle to assess how the war is going. We are too involved in the twists and turns generated by the emotions and politics of the moment to appreciate where we have been and what we have accomplished in executing such policies. I propose to examine where we have been, and how we have been executing policies enunciated by the President and the Congress.

I believe that a good place to start would be with the year 1967, the year following the passage of The Marine Resources and Engineering Act of 1966. We have available to us, through the annual Marine Science Council Reports, a seven-year record of our national performance revealed in a reasonably consistent set of statistics. Having participated in contributions to these reports, I am aware of the difficulty of definitions and problems encountered in categorizing the broad national purposes of our ocean effort and the even more difficult task of estimating expenditures by such national purposes. However, I believe that in a gross sense both the categories adopted and the expenditures estimated are sufficiently useful and accurate to serve as a basis for the analysis and conclusions I will draw. I will base my comments on the statistics of the funding for the thirteen major national ocean purposes defined by the Marine Science Council for the seven fiscal years 1967-1973.

The most basic question we can ask is what changes have taken place in the total Federal investment in marine science activities. The statistics in Figure 1 show that our national investment has increased 53 percent, from a level of 438 million dollars to a level of 672 million during this period. Is this good or bad? Each of us will have to make his own judgment. However, we do have some measures of how other programs have fared during the same period. One we can use is the performance of the total Federal R&D budget. This grew only 16 percent, from 16 billion to 18.6 billion.

This gives us information only on the grossest level of generalization. We will find a wealth of information by penetrating these numbers in greater detail to see how this money was actually invested. What, for example, has been the trend since 1967? During the first half of the period there was an increase of 75 million dollars, but in the last half an increase of 159 million. The growth rate appears to be accelerating.

The splitting of the ocean pie among our national programs and purposes, begins to expose our national investment strategy, and we can ask whether this strategy, as revealed by the numbers, correlates with the policies developed through Congressional and other actions.

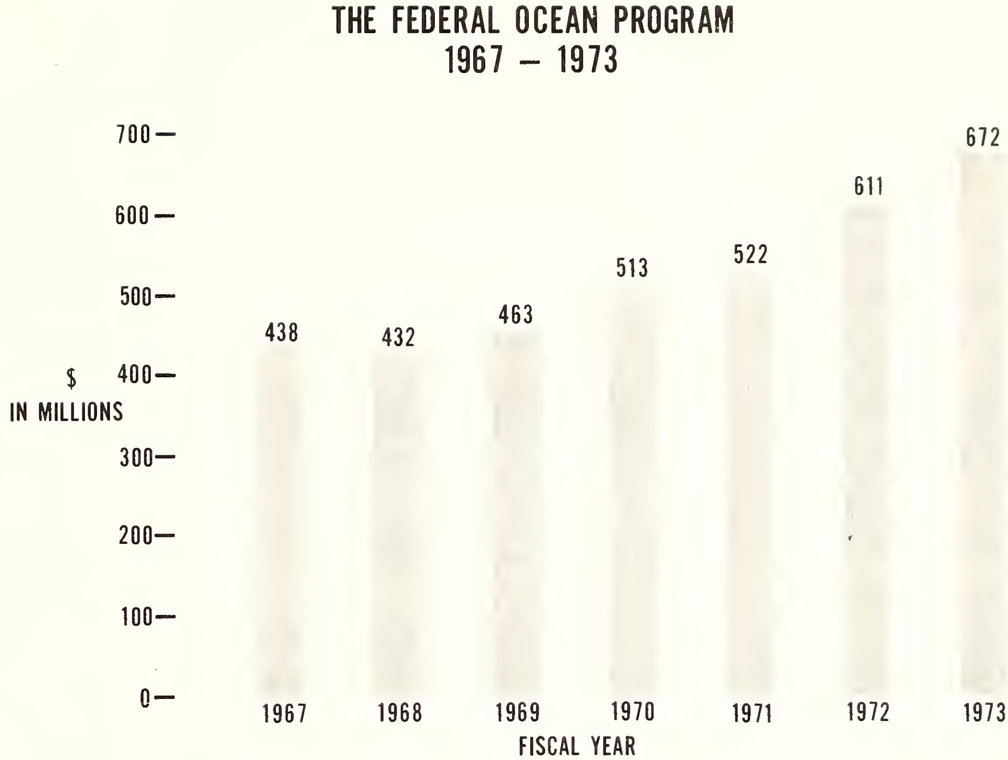

Figure 1

We can examine two measures of priority and importance. We can ask what percentage of the expenditure for each year, from 1967 to the present has been devoted to particular program areas. This is one measure, though not a perfect one, of the relative priority or importance we have attached to each major purpose. The change in this percentage over the years, however, is a good indicator of our changing view of priorities.

The other measure is one that pertains to the adequacy of our investment in particular programs. The adequacy is measured not by percentage, but by the total dollars invested. The rates of change of these total dollar amounts by program are an indication of when adequacy has been attained. By adequacy, I mean as judged by the total governmental decision-making apparatus, and not as judged by you or me--a downturn in total dollars indicating that a decision of adequacy had been made. In reaching conclusions about the performance in any ocean program it is necessary to look at both the relative priority and adequacy.

As a percent of annual ocean expenditures, the standout fact is that those programs devoted exclusively to national security (in accordance with the Marine Science Council definition this is not the entire Department of Defense program) have suffered the greatest loss in relative priority. National security programs have in seven years gone from 37 percent of the total effort to only 14 percent--a loss of some 23 percent, as shown in Table 1.

Balanced against this decline, the big gains have been in three major program areas. The largest gainer was the coastal zone program, moving from 5 percent to 14 percent of the total, a gain of some 9 percent. The other two large gainers were marine transportation and general-purpose ocean research. Transportation went from 3 percent to 10 percent of the total, and ocean research from 14 percent to 19 percent of the total. The remaining activities continued through this period without significant change in their

PERCENT OF ANNUAL BUDGET RANKING BY MAJOR PURPOSE

1967	PERCENT OF TOTAL PROGRAM	1973	PERCENT OF TOTAL PROGRAM	1967–1973 CHANGE IN PERCENT OF TOTAL
NATIONAL SECURITY	36.9	OCEAN RESEARCH	18.8	+4.8
OCEAN MAP'NG & CHART'NG	17.7	OCEAN MAP'NG & CHART'NG	15.0	–2.7
OCEAN RESEARCH	14.0	NATIONAL SECURITY	14.5	–22.4
FISHERY DEVELOPMENT	8.7	COASTAL ZONE	13.9	+9.1
OBS. & PREDICTION	5.6	TRANSPORTATION	10.4	+7.7
COASTAL ZONE	4.8	FISHERY DEVELOPMENT	9.2	+0.5
OCEAN ENGINEERING	3.4	OBS. & PREDICTION	6.4	+0.8
TRANSPORTATION	2.7	OCEAN ENGINEERING	4.4	+1.0
NON-LIVING RESOURCES	1.6	NON-LIVING RESOURCES	3.0	+1.4
INTERNATIONAL	1.6	INTERNATIONAL	1.6	0.0
HEALTH	1.5	EDUCATION	1.3	+0.4
EDUCATION	0.9	HEALTH	1.1	–0.4
DATA CENTERS	0.4	DATA CENTERS	0.6	+0.2

Table 1

relative priority.

Our National expenditures for both living and nonliving resources, ocean monitoring and prediction, mapping and charting, general purpose engineering, and education, were relatively constant as percentages of the total.

These numbers reveal a very clear reordering of our national ocean priorities. The increase in emphasis on our coastal zone activities certainly conforms with the growing national demand to do something about environmental conditions. It conforms with the policies established by the President and the Congress as reflected in the new Environmental Policy Act of 1969, the Clean Water Act of 1969, the pending legislation on Ocean Dumping, Coastal Zone Management, and so on.

Our greatly increased emphasis on transportation reflects our growing National concern with our economic position in the world and our National attempts through research and technology to once again have a Merchant Marine fleet adequate to the growing needs of our Nation. It also reflects a growth in marine law enforcement activities of the Coast Guard.

Lastly, the increased National emphasis on general-purpose ocean research reflects the policy set forth in the Marine Resources and Engineering Act of 1966 and reflects a National determination to seek the understanding of the oceans which underpins all else that we would seek to do.

An interesting aspect of the general-purpose ocean research efforts in this country is that in the fiscal year 1973, general purpose ocean research represents the single largest slice of the National ocean budget standing at 19 percent of the total. This is testimony to the success of organization of the ocean science community in convincing the Federal Government of the validity of their claims to an increasing share of the Federal ocean budget.

One can't have it all ways in considering relative priorities. There have to be winners and losers--one at the expense of the other. It is not surprising, therefore, that many major program areas show no substantial percentage change. In fact, the surprising thing is that the national reordering of priorities was so sharply focused impacting only a few areas rather than being diffused over many programs.

Now to the question of adequacy of our ocean investments. Before we examine program adequacy, however, it is important to reiterate that the overriding feature of our changing ocean priorities is revealed by the fate of the ocean budget of the Department of Defense.

There has been a decline in Defense expenditures for ocean activities from a level of 278 million dollars in 1967, to a level of 252 million dollars in 1973, or a decrease of 26 million dollars in the six-year period. It is the only Department, which for reasons other than reorganization, has seen a decline in the absolute number of dollars devoted to ocean science activities. Not only has the Department of Defense suffered a decline in the amount of money which it spends for oceanography, but where in 1967 the Defense ocean budget represented 63 percent of the total U.S. oceans expenditure, by 1971 it had declined to less than 45 percent, and in 1973 its budget will represent 38 percent of the total Federal expenditure for ocean activities. While it retains the largest budget within the ocean field, our governmental decision-making apparatus has made a judgment that its ocean programs have reached a level of adequacy, given the status of other pressing claims on the defense and ocean dollar.

While the Federal ocean program has grown by 53 percent, many of the programs of the national ocean effort have far exceeded this percentage growth. Table 2 reveals substantial growth for all segments of the national ocean program except National security. The greatest growth rates are found in the fields of marine transportation and coastal zone activities. The budget for marine

FEDERAL OCEAN PROGRAM RANKING BY MAJOR PURPOSES 1967–1973

1967	MILLIONS OF DOLLARS	1973	MILLIONS OF DOLLARS	DOLLAR CHANGE MILLIONS	PERCENT CHANGE
NATIONAL SECURITY	161.8	OCEAN RESEARCH	126.4	+64.9	+105
OCEAN MAP'NG & CHART'NG	77.4	OCEAN MAP'NG & CHART'NG	100.6	+23.2	+30
OCEAN RESEARCH	61.5	NATIONAL SECURITY	97.2	−64.6	−40
FISHERY DEVELOPMENT	38.1	COASTAL ZONE	93.7	+72.3	+338
OBS. & PREDICTION	24.4	TRANSPORTATION	69.7	+57.8	+486
COASTAL ZONE	21.4	FISHERY DEVELOPMENT	61.7	+23.6	+24
OCEAN ENGINEERING	14.8	OBS. & PREDICTION	42.7	+18.3	+75
TRANSPORTATION	11.9	OCEAN ENGINEERING	29.8	+15.0	+101
NON-LIVING RESOURCES	7.2	NON-LIVING RESOURCES	20.2	+13.0	+180
INTERNATIONAL	7.1	INTERNATIONAL	9.8	+2.7	+38
HEALTH	6.6	EDUCATION	8.7	+4.7	+118
EDUCATION	4.0	HEALTH	7.6	+1.0	+15
DATA CENTERS	1.8	DATA CENTERS	3.9	+2.1	+117
	438.0		672.0	+234.0	

Table 2

transportation and coastal zone activities. The budget for marine transportation practically quintupling from about $12 million to about $70 million in the six-year period and the budget for coastal zone activities quadrupling from about $21 million to $94 million in the same period of time. Ocean research activities have increased 100 percent from a total of $62 million to about $126 million, and by 1973, represented by a substantial margin, the largest single activity in the Federal ocean budget.

Those fields of our ocean activities that increased at a rate substantially greater than the average included ocean resources, both living and nonliving. Fisheries activities increased from about $38 million to $62 million, a gain of 62 percent, and our nonliving resource activities have increased substantially from $7 million to $20 million, an increase of about 181 percent.

Other fields which gained more rapidly than the general ocean budget were those of Ocean Observation and Prediction and General Purpose Engineering.

My assessment is that except for one or two areas, the decision-making mechanisms within the Federal Government during the period 1967-1973 have followed the policy changes as expressed by the President and the Congress quite well.

I would single out two programs which in my view are clearly candidates for greater emphasis in the future. These are our national programs directed at the exploration, development and conservation of our non-living and living resources. There is already an indication in the statistics that these two fields are coming into their own. The principal increases in both fisheries and non-living resources have taken place during the last few years. I believe we are seeing a reflection of the growing realization that the oceans offer substantial hope for meeting some of our pressing national resource needs.

It is difficult not to be aware today of the growing energy problems of the Nation. Our oceans may very well be a key to at least certain vital facets of its solution. Our continental shelves offer substantial hope of providing a significant portion of petroleum and gas resources. This is quite apart from the critical role marine transportation will play in providing oil from foreign sources. This latter role will carry with it already pressing demands for deep water and offshore terminals and their attendant environmental and coastal zone problems. Our needs for additional sources of other minerals under our national jurisdiction will make the exploration and development of the mineral resources of the continental shelf of increasing importance as the years pass.

Similarly, the growing realization that there is a desperate need to preserve and protect our living resources in the face of threats which, if not countered, will destroy them, is pushing us more vigorously towards a comprehensive living resource management system and its attendant scientific and technological imperatives. The need for new technologies of fish stock assessment, the need for new understanding of the effects of pollution on marine ecosystems, the need to establish national systems of fisheries resource management via new institutions will, in my view, give rise to the need for increasing investments in the protection and management of this invaluable resource.

The fate during the past six years of General Purpose Engineering requires some thought. It is an activity which in the scheme of things, has generally not been as well funded as many would have liked. It has remained a relatively static element of our ocean effort. I recognize that the total amount of money being spent for marine engineering is not well represented by the 30 million dollars allocated to the general prupose engineering category. All our programs such as National Security, Transportation, the Coastal Zone, etc., have as integral parts of their efforts the technological development and engineering activities directly related to those national purposes.

We must ask ourselves why there has been a reluctance to make a large investment in general purpose engineering. For one, there has been a fear of ballooning budgets and a fear of technology for technology's sake. Whatever the reason, we have not made our case.

The concept that our national ocean program requires for its vigor a base of engineering knowledge and technique that can be drawn upon by many different programs with many different kinds of applications has not found favor. The decision-making mechanisms of our government reflect different attitudes toward general purpose research and general purpose engineering. The rationale behind the one, however, is not unlike the rationale behind the other.

I regard this as one of the important tasks before the ocean engineering community, and those interested in developing a national capability in the oceans. Specifically, it seems to me that this is a key task for the Marine Technology Society representing the broad interests of those interested in ocean technology, and our National Academy of Engineering representing the engineering sciences within our Nation.

As the Nation plots its future course in the oceans it will be responding to new sets of circumstances and new sets of pressures. As we have seen during the past six years, our priority concerns have changed. Six years from now it will be instructive to analyse similar sets of data to see how our national purposes have changed again. I'm convinced that we will find as substantial changes then as we have found during the past six years.

Where will some of these new pressures derive from? One of these, I believe, will result from the general deterioration of the U.S. economic position in the world. We are now seeing a change from a period of economic, scientific and technological dominance of our country to a period when our country will have to compete as never before with the foreign industries and their technologies on the world scene. President Nixon's new economic policy is a signal that the economic world has changed.

One of the major drives to which we will be required to respond, will be to make our industry more competitive and more productive. We will be faced with a parallel pressure to lessen our dependence on other Nations for resources vital and essential to our well-being. One of the important stimulants to a more competitive and innovative industrial and commercial system in the United States will be the way in which we can bring technology to bear on the development of new industries, and the revitalization of old ones.

In his message on Research and Development to the Congress, the President called out a number of new initiatives looking towards the problems of technological innovation and technological transfer within our industrial society. I believe the time is here when the Federal Government is prepared to join with industry and the university community in innovative and highly focused approaches to the development of new industries or revitalizations of old ones.

Specific funds have been allocated this year for the first time, for example, to the National Bureau of Standards of the Department of Commerce, and the National Science Foundation to help stimulate through the R&D process, a more competitive industry in this country.

In our own field we have been a little ahead of the game, for the Sea Grant Program has had as one of its objectives, the stimulation of new ocean industry through partnership with the Government. I believe, more and more, we will come to regard the Sea Grant Program as a key element in the total national effort to stimulate the transfer of R&D into the industrial scene.

We in the marine field have a new climate and a new opportunity for innovation in marine industry. The oceans offer excellent opportunities of substantial potential--acquaculture, marine mining technology, and environmental preservation, to name a few. And I see encouraging opportunities arising for collaborative work between the Government and industry. I believe that these kinds of opportunities will be among the principal determinants of the nature of the National ocean program over the next six-year period.

REMARKS OF H. CRANE MILLER
TO THE MARINE TECHNOLOGY SOCIETY
CONFERENCE WORKSHOP ON
TECHNOLOGY ASSESSMENT OF MARINE
RESOURCE DEVELOPMENT
MAY 15, 1972

"THE ROLE OF CONGRESS IN MARINE RESEARCH AND RESOURCE DEVELOPMENT"
or
What to do 'til the trumpet sounds

My assigned task today is to discuss the role of Congress in marine research and resource development. I have subtitled my paper, "What to do 'til the trumpet sounds", an indirect reference to that passage in 1 Corinthians 14:8: "For if the trumpet given an uncertain sound, who shall prepare himself to the battle?" Previous speakers today, and notably Congressman Davis at lunch, have concentrated on technology assessment per se. I want to place technology assessment and Congress's need for technical information in the larger context of Congress's role of leadership in marine research and resource development. As others have emphasized, technology assessment is not an end in itself, but a useful art in the larger sphere of political decision and leadership. My basic theme is that Congress must find new ways to assert its leadership in marine research and resource development if it is either to sound the trumpet or to heed its call.

In the historical perspective of the last thirteen years, it does not seem to me that a need for technical information has been a decisive factor in the events that have led to the present Federal oceans program. During the 1960's basically one body sounded the trumpet for the gains that were made in oceanography and oceans programs. That was the Congress, led by a small band of men -- Senators Warren Magnuson and Norris Cotton in the Senate Committee on Commerce, and Congressmen Alton Lennon and Charles Mosher in the House Committee on Merchant Marine & Fisheries. But the gains they made were always with reluctant acceptance of the Executive Branch. When you consider how small the constituency for oceanography was during the 1960's, perhaps it is remarkable that the program progressed as much as it did. There was the Navy and a group of predominatly academic scientists in 1959, and neither group of oceanographers had a wide following. The competition was terrific: the United States was committed to the space program; the National Institutes of Health and NASA were getting under way, both as Congressional initiatives, and both with runaway budgets over which the Bureau of the Budget had little control. The last thing BOB wanted to see was another independent agency pushing an oceans program initiated and substantially controlled by the Congress. And you will recall that during this period the United States was building up its effort in its all-time favorite war.

Within the Executive Branch the competition among agencies for jurisdiction and the limited funds available for oceanographic research was fierce. It depends on who you talk to whether you agree that the Federal oceans coordinating mechanism was effective. What success was enjoyed may have had a high serendipity factor, for the Executive Branch response was limited, In one of his last appearances before Congress, Wib Chapman put it this way:

> "I am only too alive to the great damage our oceanic effort has taken from these recent years of internecine fighting and level funding. One can only go for description of this to an analogy drawn from the history of feudal government. When the king's attention is concentrated on great affairs of state, the dukes and princes are apt to fall a-fighting over small matters. When this happens, the barons concentrated on protecting their own; the vigorous knights take to the highways, and the prudent squires sit on their hands."

During the early 1960's the Congress was having its problems of coordination also. You will recall that it took about two or three Congresses before the Marine Resources and Engineering Development Act of 1966 was enacted, incorporating compromises of both the House and Senate versions. Relations between the two bodies on the Hill have traditionally been sensitive, and their common interest in the oceans did not diminish their difficulties in arriving at mutually acceptable legislation.

With the creation of the National Council on Marine Resources and Engineering Development and the Commission on Marine Science, Engineering & Resources in 1966, oceans programs took on a wider interest than oceanography alone. Although conceived only as an interim measure until the Marine Science Commission made its recommendations, including organizational recommendations, the Marine Science Council caught on, under the vigorous personal leadership of Vice President Humphrey, and the skill of Dr. Edward Wenk. Nor would I discount the strong personal friendship between President Johnson and Senator Magnuson, and any influence that friendship may have mad on the growth of marine programs during the late 1960's.

As the Johnson Administration drew to a close many hoped that there would be substantial growth in oceans programs during the 1970's. But a variety of things happened that were portents of darker days for oceans programs. Today's submersible mothball fleet tells part of the dark story of the aerospace industry's attempts to get into the oceans. Enthusiasm was not matched by markets and profits, and the oceans divisions of many companies became their loss leaders. Experience shows that the oceans are not going to provide the answer to unemployment and the salvation of the aerospace industry.

While the Stratton Commission report carried the taint of the previous administration, and that small band of Senators and Congressmen were without their principal entree into the White House, and there is still no effective outside constituency making itself felt within the Nixon Administration, additional factors made it easy to shunt the oceans programs to a level-funded hold pattern. The rapidly deteriorating economy, the endless war, crime, the busing backlash, all of these and more have vied for priority interest of the Presidency. So a holding pattern was created and a new competition grew between the Democratic Congress and the Republican Administration, a competition in which the administration seems more concerned with neutralizing or diminishing any attempts by Congress to bring about growth and substantial change in the Federal oceans programs.

Examples of thislatter point can be found in the diminished role that the Marine Science Council played before it expired; the creation of NOAA as a part of the Department of Commerce rather than the establishment of an independent agency; the consistent advocacy of smaller appropriation authorizations in bills such as the coastal zone management bills; and the level-funded budgets, essentially, of NOAA.

What does this historical treatment of the Federal oceans programs have to do with the subject at hand -- the role of Congress in marine research and resource development? It seems to me to be this. When we look at the development of the Federal oceans programs over the last thirteen years, it has not been for a lack of technical information to Congress that the oceans programs have grown so modestly. Other, larger factors were at work. The economy, the war, the space program, growing unrest in the country, and other factors against which the oceans programs do not compete well. The types of issues with which the Congress wrestled in the 1960's on the oceans programs did not suffer for lack of techincal information, but for predominantly political reasons. The overriding factor is that in the last thirteen years no one has clearly sounded the trumpet to prepare us to the battle for the oceans. For a time we thought the trumpet was being sounded, but it has proven to be a false echo.

What then of the role of Congress in marine research and resource development in the 1970's? Can it assert its leadership in marine affairs more effectively? I think it can, and I think that the moves of Congress toward greater independence and strength, and the increased interest of many different committees of Congress, can contribute to strengthened Congressional leadership in this area.

During the past five years a trend has been growing within the Congress to assert its leadership more effectively, more forcefully and idependently. Evidenced particularly in Congressional concern over the execution of the war in Vietnam, there is a distinct trend in other subject areas to lessen the preeminence of the Executive Branch and to strengthen the ability of the Congress to perform its role. This trend is growing at a time when there is a need for stronger leadership toward a national oceanic program, and the oceanic program may well benefit from Congress's new-found assertiveness.

Raw assertiveness will not suffice if Congress is to achieve its own full measure of power. That new assertive spirit is welcome and essential. But one of the ingredients it will need is new sources and methods for authoritative, accurate, and technically sound information on which to make decisions. The new power and independence of Congress will be based on information. A second important element will be the increased number of committees of Congress directly interested in marine-related programs within their spheres of jurisdiction. Let me treat both of these elements in order.

Congress already has an impressive array of information sources on technical issues, and these sources will continue whether or not an Office of Technology Assessment is created for Congress. As classified by Dr. Franklin Huddle of the Library of Congress in his excellent study "Technical Information for Congress", they can be broadly described by five categories: 1) Congressional initiatives; 2) Information supplied by the executive branch; 3) Information contributed by nongovernmental persons; 4) Institutions specifically equipped to provide information; and 5) Information devices and media.

Congressional initiatives are familiar to most, such as use of the Library of Congress, the Comptroller General, and field investigations. The predominant initiative in the marine area in my experience was the committee staff study.

Of the 12 categories of information supplied by the executive branch, statutory reports such as the Marine Science Council's annual reports; presidential commission reports such as the Stratton Commission report, "Our Nationa and the Sea", agency data supplied to justify appropriation requests and for congressional oversight purposes, and agency testimony on legislation, have been the most commonly used sources in the marine area.

National recognized authorities and personalities, and other people with special qualifications are frequently turned to. They provide not only substantive information, but also act as advocates, draw attention to needs that exist, and publicize those needs.

Among institutions specifically equipped to provide information, lobbies and trade associations are the most consistent to work with Congress in the marine area. Except as the committee staffs might seek out universities, specialized groups, or private businesses, we rarely heard from such groups on their own initiative during the period that I was with the Commerce Committee. As far as I could tell, they simply were not following the subject matter well, and were generally not equipped or staffed to know what was going on in the Senate and the House in marine programs.

There are several information devices and media commonly used by both the House and Senate committees in their oversight of marine programs. Investigative and legislative hearings are well-known devices that have many different purposes, including making a legislative record; educating the committee, its members and staff; publicizing the members; bringing pressure to bear on the executive branch; and criticizing the status quo. In the Senate our hearings were as public as we could make them, but unless we had a Jacques Cousteau or Barry Commoner, or an emotional subject such as marine mammals, we rarely found much that attracted public attention and helped build an outside constituency.

One strong characteristic of both the Senate Commerce Committee and the House Merchant Marine & Fisheries Committee is their demand for authoritative, accurate, and technically sound information, I do not think that they are necessarily looking for objective information, for all testimony and information presented to Congress has an inherent bias. I found a distinct preference among members to learn what the strongest positions were, both pro and con. To do so sets the outside parameters with which the members would have to deal, I can't think of a single instance during my tenure when a member could't make a sound decision once he had a well-rounded picture of a given problem and knew the polarities of the subject.

Turning now to the proposed Office of Technology Assessment, those of you who heard Congressman Davis's talk at lunch today heard an excellent summary of the pending legislation and its status. To what little extent that I can, I want to reinforce what Mr. Davis said -- there is a genuine need for an Office of Technology Assessment to serve the Congress. I think that the atmosphere is quite conducive to its establishment, either before the end of the Congress, or early in the 93rd Congress. An Office of Technology Assessment would be a mechanism to help committees begin inquiries on a more sophisticated and knowledgeable basis, from a source responsible to the Congress. The Office would be an instrument of the Congress, for the Congress, and by the Congress. Within Congress there is a high demand for information with which to evaluate programs and analyze policy.

To date Congress has relied heavily on the Executive Branch to provide essential information, and that information is inherently biased. The mood of Congress is for its own sources of authoritative technical information. The Office of Technology Assessment could increase the capability of Congress to acquire and develop technological information.

In the performance of its role in marine research and resource development, I can think of a number of instances that occurred while I was still with the Committee on Commerce where the Office of Technology Assessment would have been helpful. One notable one had to do with attempts to find out what the potential environmental impacts of an offshore nuclear power plant about 2.9 miles offshore New Jersey. Consolidated Edison appears approximately two years away from a decision whether to locate a plant offshore, perhaps in the New York Bight. On inquiry we found that the Atomic Energy Commission has done no research on the problem and has none planned; and when we began asking about two years ago, the companies involved had not initiated any such research.

I know of no committee of Congress or its staff that has eigher the time or the requisite skills to provide the type of information that would be necessary to assess the impact of an offshore nuclear power plant; an offshore airport; deep water ports; development in the coastal zone, or any other of a myriad of technologically based problems that arise in the marine environment. And the size and normal uses of committee budgets rarely would permit committees to commission outside studies to provide such information. Soundly evaluated information from an Office of Technology Assessment on these and other problems would greatly enhance the Congress's leadership role in marine subjects.

I said earlier that I felt that there are two elements that are desirable for Congress: the one is new sources and methods for information on which to make decisions. The development of new sources and methods, through devices such as the Office of Technology Assessment, could have a salutary effect upon the second element that I feel is needed -- having more committees of Congress active and interested in marine-related programs within their spheres of jurisdiction.

In the past when you thought of Congress and of marine programs, you thought almost automatically of the Senate Committee on Commerce and the House Committee on Merchant Marine & Fisheries. With certain important exceptions, almost all marine-related legislation would be referred by the respective Parliamentarians to these two committees. Those two committees, in turn, have fought hard over the years to assert and maintain the exclusivity of their jurisdiction in marine matters have been preoccupied with more land-oriented pursuits, or interior waters.

What is needed now is to strengthen and encourage the activity of committees such as Interior, Public Works, Banking, Housing & Urban Affairs, Foreign Relations, and the Joint Atomic Energy Committee, in the marine aspects of their jurisdiction. The marine area has been relatively neglected by these committees for too long. We should welcome their interest and their activity. We should encourage them to work within their legitimate spheres of jurisdiction in the marine environment, and, if possible, find ways to help them resolve the jurisdictional conflicts that inevitably will arise. The nature of problems that we are facing goes well beyond the jurisdiction or the competence of any one committee to handle. The oceans can no longer be viewed as a one-committee sphere of influence. To those of us who advocate an enlarged national oceanic program, expanded committee interest in marine matters would encourage growth of thenational oceanic program.

Growth of the program is one factor, But there are other compelling reasons. For instance, after two years of consideration it seems reasonable to expect that coastal zone management legislation will be enacted toward the end of this Congress. The Senate version recently passed 68-0, and the House may have a debate and vote soon. But if thisimportant legislation is enacted, there will still be major gaps that must be filled.

There is still basically unresolved the interaction of coastal zone management with the pending land use policy legislation in the Interior Committee. I know of no place in the United States that has come to grips with the interaction of planning and management of the coastal zone and interior lands adjacent to the coastal zone. Nor have either the coastal zone management billor the land use policy bill grappled successfully with the peculiar problems of urban communities. Modifications should be made in existing urban planning legislation to interact more fully with the land use and coastal zone management concepts coming to the fore. In turn, these three must work closely with marine water quality problems and marine research needs for management decisions. In naming these problems, I have touched on the jurisdiction of at least six committees in each House of Congress.

The example I used before of the offshore nuclear power plant touches the jurisdiction of at least five committees in each House of Congress. But who is looking into the attendant problems? I feel that we should welcome the attention of all of them.

Those are only two examples. There are countless others, and they will continue to grow just as our population trends are burgeoning in coastal and urban areas. It is imperative that congressional committees take interest in and assert their particular jurisdiction in the marine environment. The salutary effect of an Office of Technology Assessment may be that it would help those committees perform their tasks better.

Marine programs in the United States need strong leadership. It does not appear that it will be forthcoming from the Nixon Administration. The past leadership and procedures of the Congress in marine research and resource development, adequate for the '60's , must be strengthened for the '70's. New sources and methods for marine information, such as through an Office of Technology Assessment, are one element by which Congress can sound the trumpet once again. Greater diversity of interest and activity by more committees of Congress is another. And when the trumpet is sounded, I am certain that all of you here today will prepare yourselves to the battle. Thank you.

THE ROLE OF THE OFFICE OF SCIENCE AND TECHNOLOGY

F. Gilman Blake

To quote from the U.S. Government Organization Manual, the functions[1] of the Office of Science and Technology, Executive Office of the President, include the following:

1. Evaluation of major policies, plans, and programs of science and technology of the various agencies of the Federal Government, giving appropriate emphasis to the relationship of science and technology to national security and foreign policy, and measures for furthering science and technology in the Nation;
2. Assessment of selected scientific and technical developments and programs in relation to their impact on national policies;
3. Review, integration, and coordination of major Federal activities in science and technology giving due consideration to the effect of such activities on non-Federal resources and institutions;
4. Assuring that good and close relations exist with the Nation's scientific and engineering communities so as to further in every appropriate way their participation in strengthening science and technology in the United States and the free world; and
5. Such other matters consonant with law as may be assigned by the President to the Office.

In carrying out this broad spectrum of activities related to science and technology, the Office serves as an advisor to the President - and to the Office of Management and Budget - independent of the many Departments and Agencies of the Executive Branch. Each of these has its own interests, missions, and biases, which must be balanced off not only against each other, but also against those of the even more numerous non-Federal institutions, groups, and individuals impacted by the activities of the Federal Government.

Clearly technology assessment, whether or not consciously and systematically recognized as such, forms a major segment of the activities of OST's staff members, especially in carrying out functions 2 and 3 listed above.

In the context of this session on Current Planning in Marine Science and Technology, numerous examples arise of program areas that require broad evaluation and assessment. It is normally not OST's function to carry out such studies, but rather to assure, in collaboration with other offices of the Executive Office of the President, that they are carried out in a properly coordinated fashion by the

1/ These functions are being performed as of July 1, 1973, by the Science and Technology Policy Office, which is the staff for Dr. H. Guyford Stever in his capacity as Science Adviser to the President. Dr. Stever is also Director, National Science Foundation.

appropriate agencies. OST's functions are advisory in nature, not operational. To cite a few illustrative examples of problems associated with the development of marine resources, OST might appropriately concern itself with the scientific and technological aspects of the following:

<u>Non-living resources</u>

Minerals -
Pollution effects of dredging
Impact on other resources
Impact on other uses

Petroleum -
Role of the Federal Government in offshore surveys
Safety of offshore petroleum operations
Impact on other uses of the Outer Continental Shelf
Impact of fuel shortages ("the energy crisis") on need for increased offshore production on increased imports, including need for new or enlarged transportation facilities
Impact of developing deep-water technology on the law of the sea

<u>Living resources</u>

Fragmentation of coastal fishing jurisdiction in the U.S.
Impact of expanded U. S. and foreign coastal state fishing jurisdictions on freedom of navigation and research on the high seas
Role of the Federal Government in resources surveys and in the development of fishing technology

Obviously the legal, economic, or political aspects of problems such as these are often as great or greater than the scientific or technological aspects. As Dr. Brooks said earlier, the hard choices must often be political.

This is not to say that decisions or recommendations by OST (or any other Governmental entity) are always made as they should be, even with the best of intentions. Sometimes the data or information available to the decision-makers is inadequate or faulty; hence the widespread interest in development of management data systems to assure that no available pertinent or necessary information - or the lack of it - will be overlooked.

Today the need for an adequate assessment or prediction of the external as well as the internal effects of proposed or ongoing programs is so widely recognized that the responsible agencies provide such assessments almost as a reflex action. Yet one may ask whether it is sufficient to rely upon one's reflexes. We are developing management data systems to assure that adequate attention be given to the provision of the data needed for decision-making. Would it not be appropriate to develop technology assessment "systems" to assure that adequate attention be given to this element of decision-making?

Studies of this nature have indeed been made. One such is contained in "A Technology Assessment System for the Executive Branch", a report of the National Academy of Public Administration, prepared for the House Committee on Science and Astronautics, July, 1970 (available from the U.S. Government Printing Office, Washington, D.C. 20402 - Price 45 cents). This report contains much interesting food for thought, including, as an Appendix, a paper by Charles V. Kidd, "Technology Assessment in the Executive Office of the President". Mr. Kidd recommends the following as the more important technology assessment functions of the Executive Office:

1. Initiate Proposals for Presidential Action
2. Surveillance of Problems and Opportunities Involving More than One Agency
3. The Long Look
4. Initiation of Studies
5. Provision of a Receptor for Ideas
6. Sustain Effective Links with Congress

However, Mr. Kidd does not recommend that OST be given full responsibility for all these tasks (for one thing, he feels that it does not have a large enough staff - a sentiment which I endorse!).

While not necessarily agreeing with every statement in the NAPA report, I recommend it as a thoughtful study of the problem addressed. I close simply by quoting its Summary of Panel Recommendations:

> 1. Technology assessment should be made a continuing responsibility of each Executive Department and Agency, and should be integrated into program formulation, review, decision, and execution through the planning-programming-budgeting system.
>
> 2. Central responsibility for Government-wide policy, coordination, and review of technology assessment should be vested in the Council on Environmental Quality. However, the Council can discharge this responsibility only by working closely with, and receiving the full support of, the Office of Science and Technology and the Office of Management and Budget.
>
> 3. Each Executive Department and Agency should assign clear responsibility for monitoring and evaluating technology assessment to the most senior level within the central planning programming-budgeting organizations in departments, agencies, and bureaus.
>
> 4. Each Executive Department and Agency should work closely with interested agencies on assessments with implications beyond its own areas of responsibility. Agency technical staff should be involved fully in all assessments via the chief official responsible for scientific and technological activities.
>
> 5. Technology assessment should utilize the broadest and most diverse kinds of data from the widest array of relevant disciplines, techniques, and interests. Public contributions should be welcomed and solicited, and assessments should be available to the public under the terms of the Freedom of Information Act.
>
> 6. Agencies should seek independent assessments from qualified groups at universities, Federal laboratories, private research institutes, or industry to supplement their own capabilities. Federal laboratories with special competences should be assigned special assessment responsibilities and provided with some discretionary funds to undertake unsolicited assessments.

OCEANOGRAPHY - A BUDGETARY CONTROLLABLE WHOSE TIME MAY NOT COME

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INTRODUCTION

Being asked to speak on the role of OMB in the context of this conference provides a great latitude in choosing the specific subject matter for the program. Historically, OMB was reconstituted in 1970, officially recognizing the need for increased emphasis on management. My perspective, however, is from the more traditional budgetary or program analysis side of the house--and while everyone likes to think of himself as a renaissance man--my official perspective and this paper is limited to NOAA and some other agencies in the Commerce Department and Executive Office. I am what is politely referred to as a budget examiner. I and my examiner colleagues constitute roughly 40% of OMB's professional population.

My talk is based on my observations as a veteran of the FY 73 budget campaign and the incipient skirmishes of the FY 74 budget, more reverently and institutionally referred to as Spring Preview. I think it should be interesting and maybe revealing to you because it will indicate how your field is viewed from a vantage point in OMB.

The examiner occupies a somewhat unique and ambivalent position. He must carefully scrutinize and dissect, subtracting from and sometimes adding to, the agency's budget request from the standpoint of a show-me type of adversary in terms of program effectiveness and efficiency. Then he must present the agency's budget to his bosses and be able to defend his judgements. Thus, it is necessary to change from opponent to proponent of the program hopefully while maintaining objectivity.

The title I have chosen is my conclusion. In the next few minutes I will attempt to show you how I got there, also, hopefully in an objective manner and how OMB's perspective has shifted.

WHERE DOES OCEANOGRAPHY FIT INTO THE FEDERAL BUDGET?

Because there is no section in the Federal budget for oceanography should one assume there is no Federal ocean program? Not at all. Several notable organizational and budgetary steps have been taken in the marine sciences area, most notably the creation of NOAA in 1970 as the leading civilian ocean agency. More recently, the establishment of the Interagency Committee on Marine Sciences and Engineering has provided a government-wide means of coordinating the ocean-related programs of other Federal agencies. In addition, many other groups exist to provide different perspectives such as the newly established National Advisory Committee on Oceans and Atmosphere, the National Academies, and professional societies.

Just as new organizational steps have been taken, funding for ocean programs in NOAA have increased markedly in FY 1973 more than a 20% increase over

FY 1972 up to $165 million. But more critically, how and where does oceanography fit into the diverse scope of Federal activities? First, oceanography enjoys a miniscule portion of the Federal budget, less than 1/2 of 1% of expenditures planned for FY 73. Why? There can be many answers. Primarily oceanography has little meaning in OMB. It is too generic. That translates into unsalable. The undefined profile of oceanography presented at the Federal level militates against successful competition for scarce resources. Secondly, and more importantly, it is a relatively controllable activity from a budgetary standpoint. In a time of growing emphases on solving domestic problems of unemployment, inflation, education, housing, transportation, drugs, crime, consumer problems, energy problems, environmental problems, agriculturral problems--not to mention international, economic, and military problems, the demands on the Federal budget are immense.

Many of the budgetary demands are built-ins and increase with population growth, legislation, and so forth. These built-ins must be treated before any discretionary actions can be undertaken. What are built-ins? Contractual obligations of prior years and the wages and salaries of government workers are also budgetary built-ins, controllable to some degree but generally built-in obligations. To illustrate the problem in real terms in the President's FY 73 budget $175 billion of $246 billion projected outlays were deemed uncontrollable. That is, in excess of 70% of the total could not be avoided with changing laws or voiding valid contracts. The fiscal dividend or fiscal mortgage depending on your viewpoint available for discretionary spending has been much discussed. Given projected revenues, the cost of existing and new programs proposed in the '73 budget the budget margin for FY 76 is $5 billion (excluding the allowance for contingencies), down $25 billion from the previous year's projection.

The great paradox of the situation is that these seemingly insatiable demands are being accompanied by demands for tax reductions. What does all this mean to the members of the Marine Technology Society? Well bluntly, that the competition for Federal spending will be intense in the FY 1974 budget. This doesn't mean that ocean programs cannot compete, but that new initiatives will only be undertaken at the expense of less urgent activities. The leadership in NOAA is aware and conscious of the need to present programs that are accompanied by evaluation of investments and benefits. A good beginning was made in the FY 73 budget by NOAA in this direction. Additional effort is needed.

WHAT WILL BE OMB's ROLE IN THIS OCEANOGRAPHY BUDGETARY FUTURE?

The general role has changed significantly. Not only has the emphasis on management, the M in OMB, been great, but also it has been accompanied by a shift in perspective by the OMB budget examiner. It has meant in OMB a shift from analysis to evaluation.[1/] This is not a semantic word game. Evaluation - or assessment is necessary, especially during times of shortages in resources. Evaluation in this context is distinct from analysis--as being ex-post while analysis is ex-ante. This means that the assessment of on-going activities is necessary for two main reasons: (1) to document those programs that are achieving their stated objectives and the ones that are not and (2) to redirect programs toward more critical objectives. New initiatives - especially in budgetarily controllable areas must come from the re-direction of current activities.

Analysis, another part of the management cycle, is more concerned with defining alternative ways to reach a specific objective. One of the major problems now confronting OMB is the lack of evaluation in the programs introduced during the 1960's. There was an abundance of analyses preceding and accompanying the Great Society programs - but no built-in mechanism for providing evaluation, no baseline against which to manage. Many of these programs are responsible for the current lack of budgetary wiggle-room. And, as you know, analysis can often be formed and shaped by iffy assumptions.

1/ Schick, Allan, "From Analysis to Evaluation," The Annals, American Academy of Political and Social Science, March 1971.

While analysis and evaluation may be different parts of the management cycle, the validation of demand is central to both. This, to me, is the most difficult task of the budget examiner. In many cases, we are faced with proposals where the "nobility of aim is presumed to determine program effectiveness." 2/ To a pack of wolves, the consumption of Red Riding Hood can be justified; to Grandma it is a different story. While I would not go that far in comparing our positions, what appears self-evident to you may not be so obvious to us.

Demand for government spending for oceanography in the foreseeable future will have to be justified by all Federal agencies to a much more skeptical audience than it has been in the past. First of all the role of civilian public oceanographic spending will continue to be, in the foreseeable future, generally limited to research, mapping, and monitoring and prediction. The idea that government spending by itself will solve problems facing society today is mythical. For example, The President's Economic Report emphasizes the move toward greater cooperative relationships between government and business in problem solving related to productivity, balance of trade and other important areas. 3/ This type of guidance also applies to oceanography. Many of the reports and recommendations of distinguished Commissions and Task Forces seem to imply that Federal spending holds the key to developing the marine areas of interest to the United States. While some Federal spending is undoubtedly necessary especially in research these groups continue to emphasize or to imply that Federal expenditures hold the key to marine development.

Where a basic knowledge gap exists--in mapping, in living and non-living resource research and assessment, it has been the government's role to seek to close the gap. Another example in this case is shown in the FY 1973 Budget Perspectives. Here the government's role in research to mitigate the impact of natural disasters and to provide new sources of energy are two good illustrations. 4/

In development of the resources, however, in our country this has been the role of private enterprise. Government also has an important function to perform in the conservation area both for resources and the general environment. If there is a larger oceanographic role for government aside from defense and transportation - the case has not yet been made.

In addition to the more skeptical audience mentioned earlier, agencies will be required to indicate the effectiveness of--or lack of--past expenditures. Where programs have not proved effective or efficient, agencies will be required to show cause why they must continue--and more importantly from a program expansion standpoint why older, less effective programs can not be discontinued.

While analysis can a priori be built on iffy assumptions - evaluation can be built on facts. Success in evaluation will go to a large extent with success in competition for scarce resources.

A CHANGING ROLE FOR OMB

In shifting the emphasis from analysis to evaluation this does not mean that OMB has abandoned the concepts of program budgeting. We have abandoned much of the liturgical nature of the PPB System that superimposed a third structure of staff, forms and documents on an already paper-laden government (the budget - appropriation structure and the financial management-accounting structure are the other two). PPB was introduced as innovative and

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2/ Shultze, Charles L., The Politics and Economics of Public Spending, Washington, D. C.: Brookings Institution, 1968

3/ Economic Report of the President, President's FY 73 Budget, Wash. D.C.: U.S. Government Printing Office, Jan. 1972, pp. 117-130.

4/ Budget of the United States Government Fiscal Year 1973, Wash. D. C.: U.S. Government Printing Office, Jan. 1972, pp. 54-59.

became rubrical. It "faced and failed to solve one of the persisting dilemmas of administrative innovation: How to introduce change without its becoming an additional layer of administrative makework." 5/ The makework aspect of PPB was a disadvantage. There are good aspects of PPB and we have maintained them; specifically the integrated principles and techniques that put a premium on:

- identifying specific goals and objectives
- establishing responsibility and accountability for achievement within a specified level of resources
- a time-phased plan for accomplishment with evaluation of performance
- requiring analysis of relative cost-effectiveness
- providing projections of full systems or future year costs and consequences of current decisions

The study process associated with PPB has also been reoriented. We feel that it is not realistic to ask figuratively that the Chemistry Department abolish itself. That is, we are not sanguine about receiving analyses from agencies concerning their own proposals. To greater degree in the study process we are getting data from the agencies and performing the analysis in OMB. This has led to the development of the Performance Measurement System being introduced on a pilot basis as a management tool. It employs a simple tenet - the notion of relating work accomplished to specific goals, and goals to specific field activities. NOAA has recognized this need to estabish a new program structure and goals, and as I mentioned - is making progress in this area.

Citizens are expecting government to be responsive to their needs - but as mentioned earlier with a lesser tax burden. This will call for greater emphasis on managerial aspects of government programs. Tight resources and inflationary pressure are constraining both the expansion of existing and institution of new programs.

The pressures to improve management will be more intense. My boss has said "it is going to be a much more sporty course than in the past," calling for ingenuity in management, more responsiblity and accountability placed on the manager, and above all programs that are responsive to valid demands. Change will become the only constant in the desire to be more responsive to public needs. 6/

In 1900 one percent of the GNP went for government programs. Today it is 33%. Elimination of lower priority programs will be necessary to finance new things. The Space Program, for example, has decreased by 50% in the last five years from approximately $6 billion. Agencies that provide good evidence of program performance against realistic objectives will fare better than those with unconvincing arguments. But those even with less convincing arguments will receive more attention than programs accompanied by testimonials.

If Oceanography is to increase in importance in the Federal budget - a great deal of thought will have to be expended to point out the public vs. private roles, the importance, and relevance of marine activities. In fact, in the foreseeable future for oceanography to maintain its relative budgetary position it will be necessary in the tradition of Alice in Wonderland to run twice as fast just to stand still. At any rate, oceanography's time will not come in the near future in the Federal budget to the extent you would probably like, unless the demand for fiscal resources is validated. The marine affairs field is just beginning to be recognized as a genuinely

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6/ Young, John D., "OMB's New Emphasis on Management" talk delivered at Executive Seminar Center, Berkeley, Calif., Jan. 26, 1972.

urgent activity by people outside the disciplines represented here. It must relate to solving the national problems or acquiring knowledge that will assist in solving problems in the near term to receive a larger share of the Federal budget. It must be demonstrated that the Federal and the non-Federal roles can be identified or defined. The case must be made to government decisionmakers in a concise manner.

To finish, in the tradition of budget examiners, on an unreasonable note, while the short-run prospects for Federal spending in oceanography may appear less than spectacular - the long range future looks good. Ocean research - especially in the coastal zone has been recognized as multi-disciplinary - a necessity for increased public awareness. More of the U. S. population is concentrating in the coastal areas. Legislative re-districting is reflecting this trend. The awareness of marine affairs is being reflected in the activities of all levels of government. Ultimately there will be a greater public awareness of these problems. Until that time, and until the private sector in cooperation with the government can demonstrate the need for an increased Federal role, oceanography will continue to be a controllable in the Federal budget. As the controllable part of the total budget has grown smaller, there is an increasing degree of pressure to retain the character of controllable items to permit effective fiscal policy to be instituted. If you are seeking a larger portion of the Federal budget for oceanography in the immediate future, the competition will be shark-like.

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"TECHNOLOGY: REASSESSMENT AND REASSURANCE"

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Neither technology nor its assessment is new in principle. They may seem so because today we have so much technology, with so little understanding of the phenomenon, and of its consequences. In a recent report, "A National Policy for Technology," the National Science Board said, "Many of the problems facing us today are the result of the increasing size, complexity, and affluence of our society." The Board cited increases, over the last 30 years, in the population, the number of automobiles, our requirements for energy, and our consumption of food. Exponential growth is a characteristic of many facets of our American economy.

We have assessed technology before; today, we are reassessing it, and more importantly we are reassessing ourselves, for man is the key component of the process of technological change. Historically, technology has provided man with assurance that any gains made in knowledge could be applied to meet some human need. Always inherent in technological change is the possibility that technology could be misapplied. It is precisely on this point that modern man needs reassurance. Can we trust the men and institutions responsible for employing technology? Will technology continue to be applied, by men and institutions, not only in the United States, but in the other industrialized nations, for beneficial purposes? In the trade-offs necessary in a complex society, will technology be developed and applied so as to maximize the good for the maximum number of people and to minimize the bad for the minimum number of people? The truly modern tool for reassuring society on such questions is called technology assessment.

Pioneering examples of assessment can be cited in every field. Let me tell you about one that's always appealed to me, so much so that I have a memento of it framed and hanging on my office wall. It's a photoenlargement of a letter signed by the Assistant Secretary of the Navy in 1898, Theodore Roosevelt by name. Teddy Roosevelt wrote to the then Secretary of the Navy saying that the director of the Geological Survey, having just been to see the President, had then come to see Roosevelt with--and I quote--

> ...some interesting photographs of Professor Langley's flying machine. This machine has worked. It seems to me worthwile for this government to try whether it will not work on a large enough scale to be of use in the event of war. For this purpose I recommend that you appoint two officers of scientific attainments and practical ability, who in conjuction with two officers appointed by the Secretary of War, shall meet and examine into this flying machine, to inform us whether or not they think it could be duplicated on a large scale, to make recommendation as to its practicability and prepare estimates as to the cost.

The Secretary of the Navy did set up such a panel. It looked into the scientific and technological feasibility of Professor Langley's flying machine, and into the problems and economics of scaling up to production. The result was a favorable assessment of the airplane, and the rest is history.

THE CRISIS IN SCIENCE AND TECHNOLOGY

The National Science Board's recent report acknowledged this nation's strong commitments to defense and to space and stated: "The Nation now needs an equally strong commitment to the technologies of peace, suffused with a sense of national purpose."

That's an interesting phrase, "national purpose," for it signifies unity on goals, yet our age is characterized by a crisis of confidence in our institutions. Many people feel that Government, business, labor, and sometimes even the church are too entrenched and remote to solve the problems of those who are in true need. In an earlier age, people would have turned to science and technology when faced by some of these challenges. Paradoxically, today, when science and technology are more capable than ever before of being put to use to solve our massive social and economic problems, they suffer most of all from this crisis of confidence. Lawrence Lessing of Fortune wrote two years ago:

> The assaults on science and technology have developed a variety of themes and come from many directions. Technology is pictured as a powerful juggernaut...irresponsible...out of control...this juggernaut is also seen to be so weak that it is suffering all sorts of breakdowns...in power, transportation, and telephone services in our cities, for example.

Those who assault science and technology, and their use by one institution, namely government, overlook both the downward trend in defense and space and the rise in Federal R&D expenditures for civilian-oriented functions, which rose 5 per cent between 1970 and 1973. Just a few examples:

--health, where R&D expenditures have risen steadily through the past 10 years, in such areas as cancer, heart and lung, and child health and human development.

--education and manpower, where R&D expenditures also have risen continuously over the past decade, especially in research applied to national needs and in basic research.

--natural resources and environment, with more than one-half of the relative increase in expenditures for the last three years going for pollution abatement.

Total Federal R&D expenditures rose from $11.3 billion in 1963 to an estimated $16.6 billion in 1973.

Until 1966 approximately 90 per cent of these R&D expenditures was devoted to two national purposes, namely defense and space. The joint share of defense and space is expected to drop to 77 per cent of Federal R&D total in fiscal year 1973.

Despite the most generous investment any government has ever made for science and technology for critical and social problems, we still have many unmet national needs and unsolved national problems. The public demands reassurance that the total Federal R&D expenditures are adequate. And that our priorities and goals are proper.

Despite our critical problems, I believe, with the National Science Board, that "there is now a bright promise that American scientists and engineers can indeed help to meet our material and social requirements and help to solve major societal problems." I believe that the Nation in developing a strong commitment to the technologies of peace, suffused with a sense of national purpose. I believe that this effort will produce solutions to health problems--cancer, heart disease, aging, among others--to our needs in housing, mass transportation, the environment, and other civilian-oriented programs.

THE CONGRESS' CONCERN AND LEGISLATION

The House Subcommittee on Science, Research, and Development (of the Committee on Science and Astronautics) long has provided national leadership with regard to technology assessment. In 1967 its then-chairman introduced the first bill to set up an Office of Technology Assessment. The Subcommittee also has sponsored a number of contract studies which have greatly advanced the state-of-the-art. Under the leadership of the present Subcommittee chairman, Representative John W. Davis, of Georgia, the House has passed his bill, H.R. 10243. (An identical act, introduced in the Senate (S.2302) by Senator B. Everett Jordan of North Carolina, is now before the Subcommittee on Computer Services of the Committee on Rules and Administration.) This legislation established an Office of Technology Assessment with the responsibility of providing "an early warning of the probable impacts, positive and negative, of the applications of technology and to develop other coordinate information which may assist the Congress in determining the relative priorities of programs before it." The Office would be an arm of Congress to conduct studies with assistance from the General Accounting Office, the Congressional Research Service, and the National Science Foundation.

To date, the most significant piece of legislation, so far as technology assessment is concerned, is the National Environmental Policy of 1969, P.L. 91-190, which President Nixon signed on January 1, 1970, as his first offical act of the decade. That act requires that all federal agencies assess the impact on the environment of technological programs for which they are responsible. A vast new mechanism had to be set up to provide the analyses and reports in order to comply with Section 102 (c) of that Act. So far as I can tell, the system is working well.

THE DEPARTMENT OF COMMERCE'S PROGRAM

On March 16 President Nixon sent to the Congress the first Presidential Message on Science and Technology. The President delineated the Federal role in shaping American science and technology. He declared that the Federal Government must encourage private research and development to the extent that the market mechanism is not effective in bringing needed innovations into use. He spelled out a number of specific steps which must be taken to enhance the climate for innovation.

The Department of Commerce has a key role in the Administration's program, assigned by the President in these words:

> To provide a focal point within the Executive Branch for policies concerning industrial research and development, the Department of Commerce will appraise, on a continuing basis, the technological strengths and weaknesses of American industry. It will propose measures to assure a vigorous state of industrial progress. The Department will work with other agencies in identifying barriers to such progress and will draw on the studies and assessments prepared through the National Science Foundation and the National Bureau of Standards.

The President's use of the verb "appraise" is interesting because it brings in the concept of costs and benefits, the worth of technology. The Department of Commerce has been engaged in appraising technology for a number of years. The Commerce Technical Advisory Board (CTAB) was established by the Secretary in January 1963 with several functions, one of which was to assess the future and to appraise the role of technology in solving major national problems. From time to time the Board has constituted panels of experts to investigate specific problems and to publish its findings. Its reports have included Surface Effect Ships for Ocean Commerce, Research and Development for High Speed Ground Transportation, The Automobile and Air Pollution, Technological Innovation: Its Environment and Management, The Housing Industry, the Noise Around Us, Automotive Fuels and Air Pollution, and several others.

As the President recognized in his message 60 days ago, the National Bureau of Standards is one of the nation's leading centers for technological research, and much of its work is in the area of technical analysis or technology assessment. The three-year study of the metric system, which resulted last year in a recommendation to the Congress by the Secretary of Commerce that the United States go metric over a 10-year period, was a congressionally mandated technology assessment performed by the Department of Commerce. The Bureau is involved in other such technology assessments as a high-speed ground transportation needs in the Northeast Corridor and housing innovation.

The President, in his fiscal 1973 budget message to the Congress, requested funds for an Experimental Technology Incentives Program at the National Bureau of Standards, which we call ETIP. This proposed program would investigate--by actual experience in cooperation with the private sector--the usefulness of a variety of incentives and mechanisms to stimulate the generation and application of private research and development in ways that will make our economy more competitive, improve its productivity, and provide new technological solutions to national problems.

The NBS effort would be funded next year by an appropriation of $14.4 million. NBS foresees that 90 per cent of the funds allotted to it would be expended on contracts with industry. The National Science Foundation would receive $25.6 million under the same program, and much of the NSF effort would be spent through universities.

What should result from ETIP? We believe that the primary result of this program will be a better understanding of the market mechanism for research and innovation and new experience with ways in which industry can seize the opportunities afforded by our national investment in science and technology.

TECHNOLOGY ASSESSMENT AND MARINE RESOURCE DEVELOPMENT

The past is prologue, and nowhere is this slogan better demonstrated to be valid than in the marine environment. President Nixon's Task Force on Oceanography report to the President, in December 1969, stated:

> The existing commitments to marine programs, such as those in resource development and managment, environmental services, commerce, research, and technology by the United States Government require reexamination to determine their effectiveness...It remains now to assign priorities for programs that have been identified and not yet started, and to reassign priorities to those initiated. This requires a complete and continual reappraisal by those responsible for both planning and operation.

That brief report emphasized, as well, that the public had expressed major interest in the ocean and expected and awaited action; that preservation and improvement of the environment must not be postponed; that international economic pressures require improved capability to use the ocean; and that the importance of recent international proposals required increased U.S. interest in the deep sea.

The recommended organizational arrangement reflected the task force's view that the nation's marine resource development problem is related to all other aspects of the oceanic and atmospheric sciences, to data, instrumentation, coastal zone affairs, the private sector, and, of course, education and research.

When the National Oceanic and Atmospheric Administration was established in the Department of Commerce, in October 1970, one aspect of its prologue was the National Sea Grant program, which first had been organized in the National Science Foundation in February 1967. Sea Grant is a partnership of the Federal Government, the universities, and participating industries. Today more than 100 institutions are affiliated with the Sea Grant program. Dr. Robert M. White, Administrator of NOAA, tells me that technology assessment is involved in many of the Sea Grant projects, for example:

--In the State of Washington, modern computer techniques have been applied to the difficult job of managing fish populations. One offshoot is a computerized simulation that fisheries managers can use to learn management skills. (Bob swears that the game is called simple salmon.")

--The Council on Environmental Quality recently asked NOAA to plan a study and analysis of the pollution-related problems which might be generated by deep-draft tankers and the availability of adequate port facilities in the United States. The Sea Grant institutional network along the Atlantic and Gulf Coasts--unique in combining the talents of many universities knowledgeable in regional and local problems--was enlisted in this technology assessment.

Many other NOAA projects, not under Sea Grant, involve technology assessment. For example, NOAA is endeavoring to develop the technological capability to predict environmental disturbances due to offshore mining for aggregate.

All of the myriad reports on the oceans, issued over the last 10 years, have stressed the coastal zone, where the land, the sea, and human activities come together in a complex of interactions. The Coastal Zone Management Bill, introduced by the Nixon Administration and already passed by the Senate, significantly includes an authorization for $500,000 for technology assessment in this area.

In concluding, let me cite, in a little detail, two cases which, in my opinion, clearly demonstrate that technological appraisal is essential to any massive development affecting the environment, particularly if it directly affects people. These cases are the proposed deep-water port off the East Coast and weather modification.

DEEP-WATER PORT DEVELOPMENT

The Maritime Administration of the Department of Commerce is engaged in a comprehensive study and assessment of deep-water ports. This consideration includes the rapidly increasing demand for energy resources, which has outstripped our domestic supply. An energy gap faces us now, in the current natural gas shortage, and, in one form or another, will persist until 1985. After 1975, a crude oil shortage will occur and extend into the 1980s. Imports of oil and gas that will be required to meet this energy demand over the next 10 years will come primarily from the Middle East and North Africa --distances that will dictate that this energy must be transported in very large ships. Supertankers require about twice the water depths now available in East Coast ports. This limit on ship drafts, coupled with environmental pressures limiting the expansion of domestic oil refineries, will force oil companies to turn to major deep-water port facilities for handling giant tankers. Such ports are now being developed in Canada and the Bahamas. Transfer of this industrial activity out of the country would add to our balance of payments problem. Use of foreign-flag tankers would make us more vulnerable to disruption of our overseas fuel supply. Those are just some of the aspects of this multi-faceted problem.

Our nation thus is confronted by a major and complex problem relating to new ports, deepening of existing ports, or alternatives. The Maritime Administration has conducted an extensive technological assessment, to establish U.S. requirements for imported oil, its foreign availability, shipping routes and tanker size, suitable potential sites for deep-water terminals, and environmental considerations of constructing deep-water ports. A list of 32 candidate sites for deep-water terminals was compiled, and all sites were evaluated. After the list was narrowed to five sites, the North Atlantic Off-Shore Delaware Bay site was chosen. It is approximately eight miles off the Mouth of Delaware Bay. It is convenient to refineries on the Delaware Bay and the New York - New Jersey area. It has a natural deep-water trench, with depths to 120 feet. Dredging would be minimized. Giant tankers in excess of 350,000 tons could be accommodated at the greater depth, with the marine terminal constructed alongside the natural fault but at half the water depth, namely 60 feet. The off-shore terminal would consist of a breakwater about 14,000 feet long surrounding a manmade island of 100 acres, capable of being doubled to 200 acres. This facility initially could accommodate oil imports at the rate of 100 million tons of foreign oil per year.

About 10 per cent of the cost of developing this ocean terminal would be spent on oil pollution control devices. Deep-depth curtains, which would be drawn about the tankers when they are loading or unloading, would contain most accidental oil spilled at the terminal. Such added costs for environmental protection could be justified only if the project is economically viable. The Maritime Administration's studies indicate that the Delaware Bay deep-water port could compete economically with foreign trans-shipment facilities located in Canada or the Bahamas because of shorter distances to transport the oil to East Coast markets, either by feeder vessels--which, by the way, would be American built--or by pipeline.

Such a deep-water port could be erected in stages, could be in operation by the late 1970s, and would contain technology adequate to minimize pollution and other environmental disturbances. Its advantages would include lower fuel costs and less vulnerability of the U.S. overseas oil supply.

WEATHER MODIFICATION

Finally, weather modification is a science with a curious history. It may be on the threshold of emerging into the next big super-science, and if it does, technology assessment will be one key to its stardom. The history of weather modification contains one salient lesson for those planning technology assessment in any other field. And that is the essentiality of including the public in the process of planning and evaluation of almost all technological change.

During the 1950s a rainmaking program over wheat-growing areas in Washington State aroused widespread opposition from cherry growers. So fearful were they of rain damage to their fruit that for several seasons they employed a counter-rainmaker to prevent rain! In the 1960s a group of fruit growers in West Virginia hired a weather modifier to suppress hail. When drought ensued, neighboring farmers were understandably upset. They got into a dispute with the fruit growers, there were threats of personal harm, boycotts, and even destruction of fruit trees in apparent retaliation.

In 1970 NOAA's Florida seeding experiments ran afoul of tomato farmers. Fearing damage if too much rain fell during their harvest period, the farmers delayed the experiments by permitting the farmers to select trusted observers to monitor the seeding and to reassure the growers that their interests were being protected.

Those incidents should serve as graphic reminders that in this republic in which we live and conduct our activities, the wants and feelings of the people must always be taken into account. Society itself forms a component of the process of technological change. Scientists and technologists cannot willy-nilly do things <u>to</u> people; they can only do things <u>with</u> people. How else can we justify the continued rise in support for scientific research and development? The public can and will assert itself, through the political process or sometimes directly, in such ways as chopping down the offenders' fruit trees. I much prefer explaining to those affected, in advance, the probable consequences of technological change. Thus assurance can become a two-way street, which is why I refer to technology appraisal and assurance as well as technology assessment.

--In the State of Washington, modern computer techniques have been applied to the difficult job of managing fish populations. One offshoot is a computerized simulation that fisheries managers can use to learn management skills. (Bob swears that the game is called simple salmon.")

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Many other NOAA projects, not under Sea Grant, involve technology assessment. For example, NOAA is endeavoring to develop the technological capability to predict environmental disturbances due to offshore mining for aggregate.

All of the myriad reports on the oceans, issued over the last 10 years, have stressed the coastal zone, where the land, the sea, and human activities come together in a complex of interactions. The Coastal Zone Management Bill, introduced by the Nixon Administration and already passed by the Senate, significantly includes an authorization for $500,000 for technology assessment in this area.

In concluding, let me cite, in a little detail, two cases which, in my opinion, clearly demonstrate that technological appraisal is essential to any massive development affecting the environment, particularly if it directly affects people. These cases are the proposed deep-water port off the East Coast and weather modification.

DEEP-WATER PORT DEVELOPMENT

The Maritime Administration of the Department of Commerce is engaged in a comprehensive study and assessment of deep-water ports. This consideration includes the rapidly increasing demand for energy resources, which has outstripped our domestic supply. An energy gap faces us now, in the current natural gas shortage, and, in one form or another, will persist until 1985. After 1975, a crude oil shortage will occur and extend into the 1980s. Imports of oil and gas that will be required to meet this energy demand over the next 10 years will come primarily from the Middle East and North Africa --distances that will dictate that this energy must be transported in very large ships. Supertankers require about twice the water depths now available in East Coast ports. This limit on ship drafts, coupled with environmental pressures limiting the expansion of domestic oil refineries, will force oil companies to turn to major deep-water port facilities for handling giant tankers. Such ports are now being developed in Canada and the Bahamas. Transfer of this industrial activity out of the country would add to our balance of payments problem. Use of foreign-flag tankers would make us more vulnerable to disruption of our overseas fuel supply. Those are just some of the aspects of this multi-faceted problem.

Our nation thus is confronted by a major and complex problem relating to new ports, deepening of existing ports, or alternatives. The Maritime Administration has conducted an extensive technological assessment, to establish U.S. requirements for imported oil, its foreign availability, shipping routes and tanker size, suitable potential sites for deep-water terminals, and environmental considerations of constructing deep-water ports. A list of 32 candidate sites for deep-water terminals was compiled, and all sites were evaluated. After the list was narrowed to five sites, the North Atlantic Off-Shore Delaware Bay site was chosen. It is approximately eight miles off the Mouth of Delaware Bay. It is convenient to refineries on the Delaware Bay and the New York - New Jersey area. It has a natural deep-water trench, with depths to 120 feet. Dredging would be minimized. Giant tankers in excess of 350,000 tons could be accommodated at the greater depth, with the marine terminal constructed alongside the natural fault but at half the water depth, namely 60 feet. The off-shore terminal would consist of a breakwater about 14,000 feet long surrounding a manmade island of 100 acres, capable of being doubled to 200 acres. This facility initially could accommodate oil imports at the rate of 100 million tons of foreign oil per year.

About 10 per cent of the cost of developing this ocean terminal would be spent on oil pollution control devices. Deep-depth curtains, which would be drawn about the tankers when they are loading or unloading, would contain most accidental oil spilled at the terminal. Such added costs for environmental protection could be justified only if the project is economically viable. The Maritime Administration's studies indicate that the Delaware Bay deep-water port could compete economically with foreign trans-shipment facilities located in Canada or the Bahamas because of shorter distances to transport the oil to East Coast markets, either by feeder vessels--which, by the way, would be American built--or by pipeline.

Such a deep-water port could be erected in stages, could be in operation by the late 1970s, and would contain technology adequate to minimize pollution and other environmental disturbances. Its advantages would include lower fuel costs and less vulnerability of the U.S. overseas oil supply.

WEATHER MODIFICATION

Finally, weather modification is a science with a curious history. It may be on the threshold of emerging into the next big super-science, and if it does, technology assessment will be one key to its stardom. The history of weather modification contains one salient lesson for those planning technology assessment in any other field. And that is the essentiality of including the public in the process of planning and evaluation of almost all technological change.

During the 1950s a rainmaking program over wheat-growing areas in Washington State aroused widespread opposition from cherry growers. So fearful were they of rain damage to their fruit that for several seasons they employed a counter-rainmaker to prevent rain! In the 1960s a group of fruit growers in West Virginia hired a weather modifier to suppress hail. When drought ensued, neighboring farmers were understandably upset. They got into a dispute with the fruit growers, there were threats of personal harm, boycotts, and even destruction of fruit trees in apparent retaliation.

In 1970 NOAA's Florida seeding experiments ran afoul of tomato farmers. Fearing damage if too much rain fell during their harvest period, the farmers delayed the experiments by permitting the farmers to select trusted observers to monitor the seeding and to reassure the growers that their interests were being protected.

Those incidents should serve as graphic reminders that in this republic in which we live and conduct our activities, the wants and feelings of the people must always be taken into account. Society itself forms a component of the process of technological change. Scientists and technologists cannot willy-nilly do things <u>to</u> people; they can only do things <u>with</u> people. How else can we justify the continued rise in support for scientific research and development? The public can and will assert itself, through the political process or sometimes directly, in such ways as chopping down the offenders' fruit trees. I much prefer explaining to those affected, in advance, the probable consequences of technological change. Thus assurance can become a two-way street, which is why I refer to technology appraisal and assurance as well as technology assessment.