TECHNOLOGY ASSESSMENT ACTIVITIES IN THE INDUSTRIAL, ACADEMIC, AND GOVERNMENTAL COMMUNITIES

MONDAY, JUNE 14, 1976

CONGRESS OF THE UNITED STATES,
TECHNOLOGY ASSESSMENT BOARD,
OFFICE OF TECHNOLOGY ASSESSMENT,
Washington, D.C.

The Board convened at 10 a.m., in the Regional Planning Hearing room, room 150, Hail of Records, 320 Temple Street, Los Angeles, Calif., Hon. George E. Brown, Jr. (member, Technology Assessment Board), presiding.

Present: Dennis Miller, OTA staff.

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Mr. BROWN. This hearing will be in order.

This is the fourth day in a series of hearings conducted by the Technology Assessment Board for the purpose of seeking to more adequately define the parameters of the art and science of technology assessment (TA), and how it can most usefully serve the Congress of the United States. For most of you, I do not need to outline the background of the Technology Assessment Act, which was passed about 3 years ago after several years of struggle.

The Technology Assessment Board perceives a lack of clarity in defining the specific boundaries of the technology assessment field, and the specific methodologies that are most appropriate to the conduct of TAs. In general, the Board can use this new tool to most effectively fill in the gaps in any information system setup to serve the Congress. The purpose of these hearings is to create a record that the Board can use to help achieve an improved definition of its role, and assist it to be more effective in general in its work.

These hearings are part of an ongoing process. Our interest in opening and developing communication between the public and private sectors will not conclude with this particular series of hearings. This record will be the first part of a continuing dialog that will take place on a regular cycle. Thus the Board will hopefully get the most out of those TA activities in which it is engaged.

This morning a distinguished group of TA practitioners are testifying. The hearing will be conducted in a relatively informal fashion. There is enough time so there is no need to be rushed, except for those of you who need to catch planes. Each witness will be asked in turn to present his statement, and then to engage in a brief discussion of its contents. I hope I can do justice to our discussion. Normally there is no objection to all of the witnesses participating in the discussion after each of the statements. But if we do that, we may not be able to keep the discussion within a reasonable time frame. However, if

the spirit moves any of you to interject at any point on a particularly important matter. I will welcome your comments.

Our first scheduled witness, Dr. Mueller is not yet here. The second witness is Mr. Jack B Moore, who is vice preside.nt, advanced engineering, Southern California Edison, a major utility in the southern California area. Mr. Moore, would you like to come up to the table. Since I haven't had a chance to read your statement, if you would proceed at a sedate pace so that I can keep up with you, I will be able to digest it a little more fully.

[The biographical stretch of Jack B. Moore is as follows:]

MR. JACK B. MOORE, VICE PRESIDENT, ADVANCED ENGINEERING, SOUTHERN CALIFORNIA EDISON

B.S. **mechanical engineering, Texas A&M College; additional technical and management courses at the** University **of California and Stanford University; registered mechanical engineer in California.**

Joined engineering department of Edison, 1949, where served successively as senior mechanical engineer, chief steam station design engineer, and manager of engineering; elected vice-president, 1967.

Present professinal activities include memberships in: The American Society of Mechanical Engineers (Chairman of Los Angeles Section, 1963) ; the Advisory Committee On Solar Energy Research Institute: the American National Standards Institute Policy Committee; the Atomic Industrial Forum Committee on Reactor Licensing; Edison Electric Institute Codes and Standards Committee; Electric Power Research Institute; Nuclear Power Divisional Committee; Electric Power Research Institute Nuclear Safety and Analysis Task Force (Chairman) ; and the Los Angeles Chamber of Commerce Water and Energy Committee.

Past professional activities include memberships in: Edison Electric Institute's Prime Movers and Research Project Committees; the Executive Committee of the Nuclear Standards Board, American National Standards Institute; the Association of Edison Illuminating Companies' Committee on Power Generation: the Nuclear Mutual Ltd. Engineering Advisory Committee; and the California Legislative Council of Professional Engineers.

STATEMENT OF JACK B. MOORE, VICE PRESIDENT, ADVANCED ENGINEERING, SOUTHERN CALIFORNIA EDISON CO.

Mr. Moore. Thank you, Congressman Brown.

As the Congressman stated, my name is Jack B. Moore, vice-president. Southern California Edison Co. In his letter of invitation, the Honorable Olin E. Teague, chairman of the Technology Assessment Board, stated that the purpose of these hearings is to identify technology assessment-related activities and develop information on the experience gained im the practice of such assessment that will be of benefit to the public, industry, and Government.

The first point that must be addressed is the definition of 'a technolo-g assessment (TA). Although several definitions have been stated, I believe that the definition written by Vary T. Coates in July 1972, best expresses the concept.. She stated that the process is "the systematic identification, analysis., and evaluation of the real and potential impacts of technology on social, economic, environmental, and political systems and processes". It must include second- and third-order imparts, and planned and unplanned consequences whether good or bad.

Mr. BROWN. If I may interrupt, Mr. Moore, and I will try not to interrupt too frequently, there is just one minor flaw in that definition, and that is that it doesn't define what technology is. Of course, there

are many definitions of technology, but one of the problems that confronts us is trying to clarify whether technologies include not only hardware technologies and software technologies, but also what you might call institutional innovations. These are a third type of activity that sometimes gets woven into definitions of technology.

Go ahead. We need to clarify all of these points if we can, as we go along.

Mr. Moore. Well, buried in this statement, and one of the reasons that I selected it as being the closest of any that I had seen in print, is a very broad definition of technology. Thinking back to the time that I was in college as an engineer, technology then was strictly the analytical process applying to systems and equipment, and the use of these systems and equipment. Certainly, we in the utility business have learned that probably the smaller portion today of the meaning of the word, technology, applies to the system and equipment that you are applying to some need. So certainly part of the technology is the analytical approach to understanding fully the impact on almost any manageable situation that could occur once the system or equipment is applied to do some function. I think this is a moving target that we have to look at today. So as you suggested, a definition of technology is difficult. But I think in the broadest concept, technology includes not only anything that is economic and functional but also the impact on any area of society.

To continue, it is clear that Congress and Federal Government agencies require TAs on a grand scale due to the scope of Federal activities that require policy and legislative actions. It is possible that certain industries may conduct assessments in this same broad context because of the very nature of their business.

For electric utilities such activities would properly be done by the Electric Power Research Institute, the Edison Electric Institute, the Atomic Industrial Forum, or other national associates. I will not address any efforts by these ups; rather, I will concentrate on efforts conducted by Southern California Edison. However, I should point out that Southern California Edison does use as inputs to our efforts assessment results produced by these associations and the Federal Government.

There are several types of assessments that a large electric utility such as Southern California Edison, may conduct. First, there are generic evaluations to assess the applicability of an advanced technology to meet the projected needs of our system which in turn will be responsive to the needs of our customers. Second, there are the specific evaluations related to new and existing facilities.

The generic evaluations most closely resemble the t e of TA being conducted by the Office of Technology Assessment (OTA). This type of study, although conducted for management guidance, may be given external distribution. Once completed it serves to provide management with the information needed for decisionmaking. Generic evalua - tions of new alternatives are quite straightforward in approach. An alternative can be studied for its technical feasibility. From such a study, judgments can be made of a technology's current level of devel - omnent, means of implementation, environmental impacts, and need for research and development.

Such an assessment can be conducted in a controlled environment with reasonable assumptions being made of the factors affecting the technology. The outputs can provide a reasonable picture of where the technology stands and serve as excellent input to the decisionmaking process of what next steps should be taken. The decision may be to consider the technology as a viable resource at a date in the future and conduct R. & D. directed at developing it in that time frame. The viability date and research required would depend on the current level of the technology.

An excellent example of such an assessment is the study performed for Southern California Edison by the Jet Propulsion Laboratory (JPL) entitled '(Assessment of Solar Heating and Cooling for an Electric Utility," completed in August 1975. A copy of the summary report is appended to this statement. The full report, which I might say is about 8 or 9 inches thick, is available if the Board wishes a copy.

Mr. BROWN. Without objection the summary will be included in the record. If we need to have the full study, we will ask for it.

[The material referred to above is found in appendix D, exhibit 1 of this report.] .

Mr. MooRE. As stated in the introduction, "The basic objective of the study was to understand the interaction between elements of the heating and cooling energy supply system well enough so that utility objectives and directions for R. & I). activities in solar heating and cooling could be defined.)' The study included assessments of impacts on both Southern California Edison and on society . Potential overall societal benefits were evaluated by integrating solar devices into the energy system and estimating the reduction in the total cost of heating and cooling as well as the benefit of conserving energy in this area. Benefits to the utilit, and the customer were accounted for without any prejudice, based on existing institutional arrangements.

Four categories of factors that influence the market penetration of solar energy were included in the study. These were: (1) buyer decision criteria and market resistance to adoption, (2) energy scenarios, (3) solar-system costs, and (4) financial incentives. The relationship of these factors on the level of market penetration is not well understood. However, the historical resistance to market penetration of new concepts may be overcome by public enthusiasm based upon concerns for the environment and finite energy sources (conservation). It was assumed that the legal, economic, organizational, and cultural characteristics of the building industry would not change greatly.

We consider the study to be successful since it has defined appropriate project areas for company sponsored research in the field of solar heating and cooling systems. I might add that we are currently looking at or studying systems that were pointed out b-y this stud-y. The systems currently being researched are those identified as fitting the requirements of conserving energy and reducing the total cost of heating and cooling.

If there is a deficiency in studies. of this type it may be in the areas of analysis of social and political impacts. By this I am referring to possible actions by the Federal. State and/or local governments, and reactions of the general public to such actions. The effects on the technology by implementing any governmental policy can be anticipated; however, the impact of any such action can only be crudely

estimated in *many cases. We* must realize and always be aware that TA studies do not promise to accurately predict the future. Their purpose is to make us aware of future possibilities. This type of assessment generally can fulfill the need by identifying the technological status and the requirements for implementation. By doing so, it serves to bring about change by the orderly development of the new technology.

The second type of utility TA comes about in the extremely dynamic political, environmental, and financial arena of developing and maintaining projects within the regulator-y process. In many instances the term, "technology assessment," is not used but, as we will see, this type of study does qualify as a true asssesment.

A key ingredient in this process is time. Anywhere from 5 to 20 years can be required to obtain energy from a modern, cpmplex project. During this time, the critical variables affecting the viability of technologies change:

Regulations change and become more restrictive.

Public and political attitudes evolve.

Costs continually increase and financing becomes more difficult.

Technology itself advances rendering the original proposal obsolete before it can be implemented.

It might be helpful to understand the interactive nature of these factors if I use as an example the steps through which a major generation facility must pass during its development. Each step requires an ongoing assessment of the proposed and alternative technologies. In addition, each of these steps must be integrated into the overlapping and complex regulatory process.

1. The need for generating capacity is identified based on yearly load increases projected to be required over a 20-year period.

2. The types of technologies available for each year must be based on the amount of time available between the present and the particular year in question. For example, as turbine units can be built with shorter leadtimes than large coal or nuclear plants. Refinements are included based on the environmental and regulatory constraints of a particular site.

3. The formalization of step 2 is presented in the form of an environmental assessment prepared by the utility, which includes an assessment of alternative technologies.

4. The project then enters the process of obtaining the particular approvals required prior to its construction. Next to construction, this is typically the longest phase of project development. During this phase, the environmental report is written, challenged, and usually rewritten. Challenges to the project and changes in the variables mentioned earlier, often. require reassessment of the various technologies making up the project. Many agencies and groups are involved in this process.

5. As finally approved for construction, the degree to which a project resembles the original proposal depends on the results of reassessments during step 4.

6. often during construction! the TA process continues; sometimes clue to the need for additional permits to operate, court challenges to the approved technology, or regulatory changes requiring new technology.

7. Even during operation, assessment studies continue as new air, noise and water quality regulations necessitate modification.

These variables when considered in the framework of the continual review and approval process required by a variety of regulatory agencies, have resulted in some changes in most of our generation facility projects. A good example of this is the Lucerne Valley Combined Cycle facility currently being developed.

The project has evolved since the late 1960's, a highly dynamic period insofar as the variables mentioned earlier. As initially conceived, it was intended to be a coal-fired plant in a particular location of the high desert. We found quite dramatically that coal technology, as developed at that time, was unacceptable to the high desert residents. They blocked the project by declining a ballot measure to sup-

Assessment of alternative technologies available and many sites resulted in a proposal to build a conventional oil and gas facility at another location in the desert. However, emerging air quality regulations, and adverse meteorological conditions rendered this alternative infeasible as well. During this time, we were also learning new methodologies for site selection and evaluation.

A meteorologically acceptable site was located in the upper desert in 1972. At that time, new technologies were emerging in generating equipment. The combined-cycle concept was being shown to be excellent in regard to air emissions at the expense of substantially higher fuel costs. In the 1973/74 time frame, it appeared that the combined-cycle system offered a better alternative for the Lucerne facility, and we have been developing the project in this mode since then. Thus we can see that this project has been evolving since the late 1960's although construction has not yet begun.

The continual TA as projects proceed through the approval process is unwieldy, expensive, painful, and cumbersome. However, it is not possible at the outset to account for all technological advances that will occur during project development, or to forecast those that will be acceptable several years in the future.

This second type of TA is an integral, ongoing part of long lead-time projects. In one sense this type of assessment meets the test of the definition of an assessment to a greater extent than the more classical generic study described earlier. This statement can be made when one considers the continual interactive environment in which this type of study is conducted. Secondary and tertiary impacts are scrutinized and qualified as perceived at that juncture.

We encounter one fundamental problem in studies of this type. An assessment without an upper bound in time complicates the decision-making process. As with any major project there comes a point in time when a final decision is necessary; to fix the system design, finalize financial resource requirements, plan for personnel needs, and permit the timely construction of a major generation project. Of course an alternate final decision not to proceed is possible, and I might add has happened, more often than not recently. But this too is necessary within a fixed time frame so as to allow sufficient time to adequately prepare alternative plans and to minimize such costs.

I am sure that the members of the Technology Assessment Board can appreciate this delimma in decisionmaking. Time will allow more

complete input to the assessment process. On the other hand, unlimited time is a luxury few, if any, can afford, whether it be an electric utility considering a new facility or Congress considering legislative action. Consequently, to aid the TA process there is need to develop and improve methods of gathering and evaluating relevant data such that a meaningful, well-defied assessment results within reasonable time.

We have several concepts along these lines in various stages-of development. One such project is an ongoing land use study program to assist in forecasting future electrical load growth and general facility planning. In addition to the technical program, which includes data from high altitude imagery, automating of the data, overlay and mapping studies, Southern California Edison has worked closely with various local and county planning agencies.

Another project, which we have initiated, should prove to be of assistance in helping to meet the varied requirements for biological and health impact data for any new—or existing—facility. This biological assessment program has as its goal the ability to accurately model on a predictive basis the interaction of any of our facilities with the local ecosystems. In addition to the models themselves, there is a strong requirement for baseline data of a generalized nature to support the predictions. One hope is that this approach, once refined, will permit Southern California Edison to provide definitive data on the criteria on which to base a meaningful monitoring program. Currently monitoring studies are done on a piecemeal basis, thereby reducing the overall effectiveness of the TA process.

We hope that the statements above and the examples I gave will assist the Board in its deliberations. In today's world, any organization, be it governmental or industrial, having large impacts on society cannot continue without the ability to perform sophisticated TAs. I am sure that through discussions such as this, more meaningful methodologies as well as a better understanding of the process itself will result. Thank you for the opportunity to discuss this concept with the Board.

Mr. BROWN. Thank you very much.

I think, Mr. Moore, you have given us a very clear statement of the significance of technology assessment (TA) in your own operation. There are some questions that, arise about how you distinguish the TA process from those activities that take place before and after a TA. To clarify what I mean—an assessment is not a policy choice. It is defined as a tool to facilitate improved policy choices.

Mr. MOORE. I can certainly agree with that.

Mr. BROWN. You have indicated some situations in which you have made assessments and on those bases made policy choices; for example, powerplant siting or type of powerplant. Then you found these decisions disrupted by factors that developed subsequently. This raises a question about clearly defining the role of the TA assessment and its relationship to the policy-planning and policy decisionmaking activity. Then of course, after that decision is made there is the whole process of implementation, which is another more or less normal aspect of most management activities. You are accustomed to making decisions and implementing them, and I suppose there is always a small amount of confusion involved. How can we enter into this process a situation

such as you described, where a constituency in the high desert began to oppose you and erected roadblocks, which made it difficult to go ahead with your original decision ? Would you consider that such a factor made your original policy decision a bad or a wrong policy decision, or are you prepared to include in the process of assessment the attitudes that develop within a constituency that is concerned about a particular development on which you are trying to make an assessment ?

Mr. MooRE. Well sir, I certainly would say that the decision made to install a coal-fired plant in the high desert was a poor decision. That decision was made on an inadequate assessment of the situation. It was made on a, type of planning that we had done for many years in which the in-house understanding was that any type of industrial process or project because of tax base, is acceptable to the general public. We had not taken adequate steps or made an adequate assessment of the overall picture from a corporate standpoint.

We now have people on our staff who are qualified in many areas that 10 years ago were not included in a utility staffing. For instance, we have a doctor of terrestrial biology to understand the impact or look separately at the impact of a project on inland areas. We have people who are similarly qualified to look at impacts in the marine world. Today we have far larger staffing in the science fields than in the engineering fields, so that we can make what we believe is a full assessment of the impact of any program that we would start that would include facilities or would include changes in facilities. As I mentioned earlier, we are now staffed to do a broader TA. We view it as such before senior management will make a decision to sink large sums of money into a project that is fated for disaster before we can ever get started. As I mentioned, often the assessment doesn't necessarily give you the final answer, but it certainly opens your eyes to many areas that could cause problems as a program moves ahead.

Mr. BROWN. Well, I raise these questions because as a part of our own assessment activities on the Board, we are confronted with finding out the degree and type of public participation that should be an ingredient in this TA process. Presumably the Congress is a little different from the Edison Co. in that we have a mandate to represent the public interest in the assessment process, and the assessments undertaken are for the purpose of providing us with other kinds of data. On the other hand, it is essential to the whole political process that elected public officials who make decisions in them representative capacities, are highly moved by their perception of public attitudes to particular decisions.

In a larger perspective than your experience with the powerplant in the high desert. is the situation involving the whole of California on proposition 15. Here the question of public attitudes toward a technology or toward the full deployment of a technology becomes a matter of almost overriding concern if we are going to be able to plan for the future energy needs of the State. We therefore need to have some way of rationally evaluating the role of public opinion and public attitudes. As we evaluate any of these technologies, we need to have a mechanism whereby the public can assist and participate in the decision-making process.

The mechanism may simply be sophisticated polling. This is one way to a form of public participation. It may also include a wide range

of advisory committees. I don't know whether or not you have ever utilized the tool of public participation. It is subject to considerable criticism in Washington. we are trying to determine what is the proper role for hearing the public's voice in TAs, and how it can contribute to the overall value of an assessment.

Mr. MooRE. I believe we have a step process here. As we view a TA, the first step is to ask either our staff or frequently outside qualified people to make a TA such as the one we asked the Jet Propulsion Lab (JPL) to make in the case of solar energy. In that process we don't anticipate having input from the general public. We hope that we have picked the properly qualified people to make a study for us as to that. As I see the second step of the assessment process, it is to review the output of the first step of the TA in order to make adjustments, or to more clearly assess what is the public's general thinking.

I think in JPL or in any organization today we are all in the corporate part of the world more interested in and more conscious today of the questions that concern you; the need for social assessment and understanding of the impacts of pure technology such as apparatus and plants. I just view these as a series of steps, the first one being the generation of a scientific document using a bank of technical information that includes sociological input, just as we are doing now with transmission lines and similar technologies. Then in the second step of a hearing process we will be better prepared to understand what to expect in that second step.

Mr. BROWN. You have devoted several paragraphs to explaining the importance of the regulatory system on your planning for the future. I am continually puzzled in my own mind as to whether or not an analysis of regulatory system operations and anticipated or projected changes in the regulatory environmental mechanisms is a proper field for the Office of Technology Assessment (OTA). Obviously it is a part of your policy pattern or planning. Can we construe that an analysis of the impact of a given regulatory course on the development of our energy system is a legitimate problem for technology assessment ?

Mr.. MOORE, In my opinion it certainly is. This is cause the very foundation of the reformation, the answer to such a question as, "110 we have proper regulatory procedures?" starts with technology. Arriving at a decision based on purely sociological considerations gets you nowhere I think, because the base of the technology, including economics, must be established before determining whether we have proper regulatory procedures. I am certain you are aware that in general the electric utilities have fostered a one-stop regulatory process. This would have no hope of success unless it had as its foundation a TA of the full field involved in the generation and future planning for electric power or any form of energy in this country.

Mr. BROWN. Well, we have almost come to the point where TA is sort of synonymous with the whole field of futures analysis. We appear to be moving in the direction of looking upon our economy or maybe in a broader sense our entire culture as a technological artifact subject to whatever forms of assessment will survive some pragmatic test of usefulness That of course is not a very narrow boundary for the field. The concern of the Board is to develop a focused and operational definition of the TA process. If we take the broad definition that it is legitimate to engage in a TA of an-y aspect of future develop-

ment that will have an impact on society in a major way, then our problem becomes one of setting priorities rather than defining a field, and that is, of course, an entirely different kind of a problem. I gather you subscribe to a broad rather than a narrow definition of technology assessment.

Mr. MOORE. Yes, I certainly do. I recognize the size of the problem just from measuring the size of the problem that we as an individual utility have today. It is, because of its size, one of selecting priorities. But if you look at the tools with which any question is answered today-other than the human emotional tools that are used on many occasions—the people or the organization trying to find an answer usually turn to computer modeling; almost immediately you have stepped into the world of technology in just trying to get a simple societal answer. So I don't see how we can escape it,

Mr. BROWN. For many years you have had a phase of your operation that deals with load forecasting and with futures analysis or planning centered on the necessity of being able to supply the load that you forecasted. I gather from your paper that you are developing new and more sophisticated methodologies for improving your load forecasting capabilities. To what degree has your operation examined the possibility of whole new patterns in energy consumption? What assumptions do you make for example, about the impact of conservation or more energy efficient technologies?

I recently read Herman Kahn's book '(The Next 200 Years," in which the underlying assumptions are rather interesting. He postulates certain limits based on these assumptions. One of these is a fourfold increase in energy efficiency, which would have massive impact on energy consumption over any reasonable period of time. To what degree does the Edison Co. engage in efforts to project increased energy efficiencies and energy conservation over a reasonably long time frame?

Mr. MOORE. our system planning department, which as little as 3 years ago used to be called a generation planning department, and is now the system planning department because of a broader concept than we had 3 years ago, is made up of an environmental division and a conservation planning group. The man that heads up that organization today is on the officer level in the corporation. Our Edison Electric Institute (EEI), makes what I might call more global type of studies, as well as the Electric Power Research Institute, a separate division of that institute, they are also making studies, but these are more of a direct research type on technology applications.

I certainly have to agree with your comment about an increase in generation in the future, even from the viewpoint of a lack of the conventional energy sources we have had in the past. Because as there is a depletion of these energy sources I believe that you will see a greater usage of electric energy, but possibly more for things such as transportation than we have today with fossil fuel supplies. Part of this belief comes from projections of the type that are made by the EEI.

Something else that has had quite an impact on some of our thinking in the company is that about 4 or possibly 5 years ago, the Joint Committee on Atomic Energy asked for a projection into the future of energy supplies. It came as a surprise that such a study existed, to many with whom we had discussed the possibility of a cutback on fossil fuel supplies, but the document did exist. That made a major

input into our fuel purchase planning. So in order to determine whether we will be able to supply low-sulfur fuel to the combined-cycle plants that we will be building in the future, we do have to make more broad global type studies in-house than we have had to do in the past.

Mr. BROWN. Have your operations been impacted by the new institutional arrangements in California dealing with the environment? I am speaking here of the new energy corn-mission that also has a powerplant siting role. I gather that even the Public Utilities Commission, and I am not at all familiar with it, is pursuing a somewhat more aggressive supervision of your utility activities than it has in the past. Have these factors influenced your need to engage in futures analysis and TAs to any degree?

Mr. MOORE. They certainly have. We had hoped that with the establishment of the Energy and Conservation Committee in the State, we would come closer to a one-stop agency. We find that today all that has been done is a proliferation of agency involvement into some of the things we do. In fact, I would expect that that same energy commission from the land use charter they have will attempt to move very heavily into the nuclear field. They established hearings in August of this -year to study the movement of people in the event of a nuclear disaster, a study not of a generic nature but of a very specific nature, that has already been covered by the Nuclear Regulatory Commission (NRC). So we see the generation of additional paper and of additional information that is already available in the public record. We just completed hearings, as far ***as*** San Onofre is concerned, on the effect of the park that was established in front of the plant. I think that this has to be placed in our planning for the future, which comes back to the word assessment—what are our opportunities, what can be done.

Mr. BROWN. Just one final question. With regard to your futures analysis, to what degree have your forecasts of demand or your load forecasts changed in the recent past, that is over the last 2 or 3 years? Has there been a marked shift m your projection of what the energy demands for your service area will be 10, 15, and 20 years in the future?

Mr. MooRE. We believe that for our 20-year plan, we will see a growth rate on the order of about 6 percent on a long term basis. on a short term basis I can say that we are coming out of a period where the load growth was absolutely flat. I would expect that for the year 1976 we would see growth of about 1½ percent. In the next 5, 10, and 15 years this could go up to about 4 percent, and then in the 20-year period about 6 percent if the supply of natural gas dwindles as predicted and a change in the transportation mode occurs.

One of the unknowns here is the impact of certain industry oil well pumping with the possibility of seeing that it would be more economic to convert to electric power as the market improves for their product. We can see that there could possibly be a slowdown in certain building areas. The impact of solar has been cranked into the energy use, but those are short term.

Now you are surprised that I say solar is somewhat short term. Well, we will see that there is the possibility that with respect to the future development of solar today, the technology is highly dependent

on oil for example, for the construction of solar panels. So if we expect to really develop large amounts of solar power there have to be answers developed other than just continuing in the direction of oil, including coal and maybe fossil fuel.

Mr. BROWN. Regarding 6 percent annual growth rate that you have projected for the 20-year plan, is that a substantial lower rate than the past 20 years have been?

Mr. MOORE. Oh yes. We have projected 9 and 10 percent in the past, and we have had rates of growth such as that.

MID. BROWN. We very much appreciate your testimony here this morning, Mr. Moore, and we look forward to hearing more about the activities of the Edison Co. in the field of futures analysis and the TA related thereto.

We hope that if we would like further clarification of the points you have made, our staff can submit additional questions to you for your response.

Mr. MOORE. Thank you, sir. It was a pleasure to be here.

[The following questions were submitted by congressman Brown to Mr. Moore and his answers thereto:]

Question 1. **Would you say that technology assessment (TA) has influenced the manner in which Southern California Edison conducts its business? What is done differently now?**

Answer 1. The operation of a large electric utility system has always depended to some extent on the use of TA. However, in recent years this has become of greater importance with the advent of new technologies, environmental impact considerations, and economic limitations. In its planning for the future, Southern California Edison has taken into account 1'A in a number of areas. For example, the use, by Edison, of solid waste from the Southern California region has undergone TA, and the company has developed a program that we believe will be beneficial and responsive to the local social, environmental, and political situation. Similarly, a thorough review of solar heating and cooling identified institutional and technical problems that are the focus of Edison's actions in this area for the next few years. Here, the company has chosen to serve as the warrantor for a large number of solar water heating systems installed on new residences. This represents a new direction in Southern California Edison's conduct of business,

The use of TA early in the development of a technology has allowed Edison to develop a better research and development plan in several areas. A number of alternatives have been developed simultaneously for meeting air emission regulations, but at the same time the understanding of the effects of these emissions on the environment is being improved. In general, the use of TA during the planning and conduct of the complete research and development program as well as the siting and construction of generation and transmission facilities has improved the flexibility in responding to problems that arise. Where technical feasibility, and economic and political systems were considered previously, Edison now uses TA to add consideration of social and environmental concerns.

Question 2. **In a TA should the impact of a new technology on job structure be examined?**

Answer 2. From the standpoint of a single company, the impact of any of its operations on job structure is continuously being examined. The extent to which it is considered, of course, varies with the nature of the operation or new technology. In general, new technologies have to go through a maturing process before they reach commercialization. During this process the job structure may change several times. Only in the broadest sense can the final job structure be predicted. From a Federal Government standpoint, the impact of the development of new technology on employment in general, as well as job structures in particular, should be examined if major changes in the employment market or industrial structure seem to accompany the new technology.

Question 3. **What formal structure exists for doing TA?**

Answer 3. In considering a particular technology for installation, the licensing procedures represent the closest framework to a formal structure for doing

TA. The need to consider environmental impact as well as the requirement that new facilities be justified based on demand projections, including customer actions, inherently represent a TA by the electric utility. This process can take several years and involve several updatings of environmental, social, and political impact information. For new technology the Southern California Edison Company relies in particular on national organizations for any formal structure for doing TA. In-house efforts are conducted on a less formal basis as the need arises. In some cases, the TA is contracted to outside organizations (e.g., the solar heating and cooling assessment was done by the Jet Propulsion Laboratory of NASA).

Question 4. How do you incorporate TA activity into your reports?

Answer 4. Technology assessment activity generally appears in several formal reports prepared by Southern California Edison. If new facilities are to be constructed, a general TA is included in the environmental impact statement that must be prepared. The social aspects are considered in filings with the California Public Utility System for licensing purposes.

In addition, aspects of TA are included in status reports for recommendations for the development of new technologies. These latter reports are not prepared on a fixed schedule but on an as-needed basis.

Questiom 5. What is the most useful manner you have found for getting the public involved in your TA activities ?

Answer 5. The most common method for public involvement in Edison's TA activities has been the use of public hearings in conjunction with siting of new facilities. Since there are several different aggncies involved in the licensing of new facilities, the public involvement during hearings can be on a broad basis. Through the public inputs in these hearings, and the actions of the licensing agency, many of the social and political aspects of the TA can be developed and refined.

Question 6. Do you see any similarities or differences between TA and environmental impact analysis (EIS) ?

Answer 6. TA and impact analysis are closely linked concepts. As part of a specific TA, an impact analysis could be conducted as part of the overall feasibility evaluation. However, depending on the purpose of the TA, an EIS may not be required.

On the other hand, an EIS could be considered to be a type of TA. The impact analysis is in essence an assessment of the feasibility of a technology applied to a particular site and a particular set of environmental and political criteria. A technology that is feasible for one set of circumstances may not be acceptable in another. Accordingly, the technology must be assessed for such unique set of circumstances.

Question 6a. How do you handle EIS's? (The following answer assumes this question refers to how we interact with the process that results in lead agency completion of EISs.)

nswer 6a. Southern California Edison is involved in both State and Federal programs for the conduct of environmental impact analysis. California State requirements result in a document entitled an Environmental Impact Report (EIR) and Federal requirements result in an EIS.

These documents are developed in several ways depending on the agency lnvolved. Following are the general approaches used:

1. The Nuclear Regulatory Commission (NRC) and some other agencies require the applicant to prepare an Environmental Report in compliance with very specific guidelines. This document is used as a reference base for completely independent analysis by the agency of every environmental feature. From their independent analysis, an EIS is produced. This approach results in the most thorough impact analysis though it is quite time consuming.

2. Some agencies require the applicant to submit data not in the form of an analysis report. From these data and the agency's own analysis, an EIS is prepared. This is a relatively ineffective approach because the agency is trying to analyze and interpret data collected by the applicant.

3. Many agencies, including the California Public Utilities Commission, require the applicant to submit a data statement which also includes the applicant's analysis. This report is similar in concept to the report required by the NRC. The applicant's report is circulated by the agency for comments. Comments received and applicant and agency responses are bound with the applicant's report along with a summary evacuation by the agency responsible. This compilation is circulated as the draft EIS. This approach is quite effective because the final document can reflect several viewpoints.

Question 6b. Do *you* discuss impacts and educate the public ahead of time?

Answer 6b. As projects are developed, a public information plan is produced that serves as a basis for public contact Generally, most initial contacts are with civic leaders and others with probable interest The level of efforts in communicating with the general public usually depends on the magnitude of the project and the likelihood that people will be adversely affected.

Question 7. What value do you see in having closer relationships in regard to TA activities in the public and private sectors?

Answer 7. Closer relationship between the public and private sectors in TA activities should enhance these activities considerably. Information as to what is plausible and what is impractical from both points of view need to be included in TA activities but seem to be lacking in many cases. As an example, an assessment of on-site solar plants by a research agency under contract to OTA did not consider, initially, the availability of materials and the ability of industry to construct facilities in the quantity being suggested. With input from the private sector this matter was resolved without loss of credibility for the entire study. Continuing interaction of this type will result in more useful assessments. The same is true for the input of the public sector in terms of potential regulations and legislation. In private sector TA, this will result in more meaningful developments.

Question 8. What limits do you see to the concept of TA in its utilization and application in the government and private sectors?

Answer 8. Since TA depends in part on predictions of future actions by society, it is limited by the nature of the assumptions used for the future of the Nation and international relationships. Technology assessment as I understand it, is only a method for assessing alternatives and their impact, and should clearly be limited to this. The determination of direction must come from other simultaneous assessments of National, social, and economic goals in the governmental sectors, and industry goals in the private sectors. In terms of technology, the use of TA often pre-supposes success in the development of new concepts. As is evident from much of the history of science, success at research is not guaranteed. This must be recognized as a critical limitation on the utilization of the results of a TA.

Mr. BROWN. Our next witness is George E. Mueller, chairman and resident, System Development Corp. Dr. Mueller, we welcome you here this morning and I am sorry that we proceeded out of order with you. I hope it doesn't infringe too much on your time schedule this morning. I am pleased that you could be here this morning and help us to some degree refine the concept and process of technology assessment. This is the purpose of these hearings as they relate to our Technology Assessment Office in Washington, a new arm of the Congress. The Board hopes to make it as useful to the Congress as possible.

You may proceed with your statement in whatever form that YOU wish.

[The biographical sketch of Dr. George E. Mueller is as follows:]

DR. GEORGE E. MUELLER, PRESIDENT AND CHAIRMAN OF THE BOARD, SYSTEM DEVELOPMENT CORPORATION

B.S. electrical engineering, University of Missouri; M.S. electrical engineering, Purdue University; Ph. D. physics, Ohio State University.

Research at Bell Laboratories; electrical engineering faculty, Ohio State University (10 years). Early space projects on which associated include: establishment of the U.S. Air Force SPAN satellite tracking network; development of Pioneer I space probe; and design, development, and testing of the Atlas, Titan, Minuteman, and Thor ballistic missile programs. Senior vice president of General Dynamics Corporation prior to assuming present position.

Professional affiliations include: a member of the National Academy of Engineering; a Fellow of the American Association for the Advancement of Science, the American Astronautical Society, the American Geophysical Union, the American Institute of Aeronautics and Astronautics, the Institute of Electrical and Electronics Engineers, and the Royal Aeronautical Society; and an Honorary Fellow of the British Interplanetary Society.

Honorary degrees received from Wayne State University, New Mexico State University, University of Missouri, Purdue University, and Ohio State University; and awards include three NASA Distinguished Service Medals, American Astronautical Society Space Flght Award, the Eugen Sanger Award, the American Academy of Achievement's Gold Plate Award, and the National Medal of Science, for his many individual contributions to the design of the Apollo System.

STATEMENT OF GEORGE E. MUELLER, PRESIDENT AND CHAIRMAN OF THE BOARD, SYSTEM DEVELOPMENT CORP.

Dr. Mueller. Thank you, Mr. Chairman. It is a pleasure to be here this morning and to address the subject of technology assessment (TA) as it is practiced at system Devclopment Corp. (SDC) ; its role, how we use it, and some of the results obtained from TA. In our business? which is the development and production of data processing systems and services, technology has very significant impacts. The data processing industry has grown, and will continue to ***grow,*** because of rapid technological changes and innovations that create new product opportunities and open new markets.

At SDC, our TA program is used to anticipate and plan for the impacts of technology changes on our products and operations. We evaluate technology trends with respect to basic customer needs to find new product opportunities. We examine technological advances in terms of our internal operations to look for better ways to produce our current products. In short, our TA program is an essential ingredient of our long-range business planning, investment policy, product planning, and market development.

Technology assessment is a continuous process that is quantified and documented annually as a part of our 5-year planning cycle. Some of the important technology trends listed in our current strategic plan are as follows:

First, rapidly decreasing hardware costs. This trend will have an increasing impact on SDC's business and products. It will keep intensive pressure on reducing software costs and will cause some functions now performed by software to be done by hardware. Software costs will respond to this pressure and decrease during the next 5 years. As this happens, pressure will build on the reduction of operation and maintenance costs, which like software are labor intensive. Our software factory program, which I will discuss later, is in response to this trend.

Second, is increased data communications capability. The availability of long-range communications links will be greatly expanded by communications satellites. The cost per bit per mile will continue to decrease. These factors, coupled with the availability of minicomputer and microcomputers will cause increased emphasis on computer networks and distributed processing.

Third, is the growth of minicomputers and microcomputers. The availability of small, inexpensive computers will open up new application areas. You will see one example of that later. Their use *will* continue to grow and expand both as small stand-alone systems and as an element of distributed processing networks.

Fourth, is increased requirements for protection of computer-stored data. As the applications of computer-based systems expand, both industry and Government become more dependent on these systems.

The data stored in them become more valuable and more sensitive. In addition, with the expansion of distributed systems, data in transit is more vulnerable to abuse in the shared communications systems. Current and anticipated privacy legislation will place additional requirements on protection, accountability, and system accreditation. These factors will increase emphasis on the application of computer systems security technology in both military and commercial systems.

Fifth, is the increased use of online systems. Online systems provide substantial improvements to users in terms of a system's responsiveness and the timeliness of data. However, they tend to be more costly in terms of hardware utilization. As hardware costs decrease, usage of these systems will continue to grow to the point where they will completely dominate the industry 5 years from now.

Sixth, is increased use of computer-based systems by nonprogramers. The use of online systems has removed the programer as the interface between the real user and the data processing system. As online systems expand, the number of real users interfacing directly through "smart" terminals will grow. This trend will demand that the systems we develop be much more secure, reliable, available, and usable, providing the user with a work station suited to his needs and training without assistance from programers.

I have chosen three brief case histories to provide examples of our TA program, and the results of applying this kind of a long-range assessment-m our business, 5 years turns out to be a long-range assessment rather than 20 or 200 years—to give you some idea of how we actually apply TA.

The first case is a product called Text II. In 1971 technology advances in three key areas were identified and assessed to have a significant potential impact on the manner in which material was composed for printing. The first important technology advance was the development of the phototypesetter that used photographic techniques to set type. This device was capable of replacing the hot metal linecasting machines and was much faster and more accurate.

The second important advance was the development of low-cost, highly reliable minicomputers. These devices had the processing power and storage capability to prepare copy for input into the phototypesetters, and in addition. automate many of the office and accounting functions of publishing houses.

The third area of technological development identified was the video display terminal. This device permitted the capture of the original keystrokes for direct entry of text into computers and the rapid display of entered text for editing, corrections, and review, thereby eliminating the need for time-consuming and error-prone retyping of the text.

These technical advances were evaluated in terms of the needs of the publishing industry. At that time, we found that the preparation of information for printing was costly, labor intensive, and error prone. The requirements for the industry has grown in direct relation to the '(information explosion" of the previous two decades. The methods employed in the composition of copy for printing had remained virtually unchanged for some 50 years after the invention of the linecasting machine in the late 1800's.

In the 1950's computers were first introduced into the publishing industry to prepare copy and to create paper tape to drive automatic linecasters. This was an important step. It did not, however, appreciably reduce the human effort required, since the original copy had to be rekeyboarded for entry into the computer.

Our assessment of the new technology available to provide an improved solution to the needs of an industry triggered the development of a new product-an all electronic publishing system we call Text II. Software programs were developed that linked video-display terminals, a minicomputer, and a phototypesetter into an integrate system for the entry, editing, and setting of text, as well as the automation of related office and accounting functions.

Our first system was installed in 1974. Today, we have five systems operational and a substantial backlog of orders. The most widespread use of these systems to date has been among newspapers. Virtually every newspaper in the United States with a circulation of more than 25,000 is planning to automate its production methods as a means of increasing efficiency in order to remain competitive with other media. In the next 10 or 20 years it is expected that electronic publishing systems will materially improve the efficiency of preparing material for printing in all areas of government and industry.

The second case is a software factory, and addresses quite different problems. Over the past 20 years the capability or power of computer hardware per unit cost has increased dramatically. A recent advertisement by a computer manufacturer stated that:

While the cost of just about everything has risen dramatically in recent years, the cost of doing things by computer has been a noteworthy exception. Although computers have become increasingly useful as their speed and capacity have multiplied. their cost per operation has declined sharply since the first commercial computer was installed less than 25 years ago.

For example, in 1952 it cost $1.26 to do 100,000 multiplications on an IBM computer. Six years later, the cost had dropped to 26 cents. By 1964. those same 100,000 multiplications could be executed for 12 cents and by 1975 for 5 cents. Today they can be done for a penny. All this against the current of inflation that has been seeing an $0 percent rise in the Government's Consumer Price Index over the past 20 years.

This astonishing reduction in a computer's perfunction cost has led to important savings in the overall cost of doing a given data processing task. It has been brought about by technological advances such as the miniaturization of computer circuitry. Such advances have made possible vast increases in computation speed-from about 2,000 multiplications a second on an IBM computer in 1952 to more than 2 million a second today.

Widespread and inexpensive availability of powerful computers has led to the development of ever more complex systems. As a result of these technology trends, our TA program concluded in 1973 that software costs would rapidly dominate data process systern costs, that intense pressure would be brought to bear on reducing software costs, and that we at SDC must find new techniques for producing software and reducing costs. Consequently, a program was initiated to develop an innovative approach to software production. This approach, called the software factory, consists of three fundamental components—a new organization concept. rigorous production standards, and production tools. The organization approach involves the use of dedicated organizations to perform key software production functions; for example, design, development, and test. Thus each new software system passes through a series of organizations that coincide with succeeding

phases of production, very much like a factory assembly line. This, when contrasted with the usual approach of one group of people performing all of the production functions from start to finish, has the advantage that increased benefits accrue over time if essentially the same people are responsible for specific activities. Familiarity and facility with methods and took is gained with repeated use; general purpose libraries of reusable software modules are built Up; and specialized centers of technological knowledge can be maintained and applied to all projects as needed.

Traditionally, software has been produced at customer locations, field sites. or wherever the system hardware is located. This new organization approach requires the software to be produced at a central location—the "factory" where the workers can easily move from one project to the next, and have ready access to all production tools.

The production standards constitute the software factory's methods component, and are embodied in a manual that provides a common definition of the software development cycle with detailed standards and procedures for ever-y required activity. The detailed procedures provide a consistent and highly visible standard production approach m which the system development process starts as a set of general requirements and production plans, and passes through standardized production phases to add more and more detail to the evolving system framework. Each phase, when completed, increases the degree of detail one dimension to establish the foundation upon which the next phase of the software system production cycle can proceed. This approach provides visibility and traceability to the developing system, both from a technical and management point of view, and exerts a strong and desirable structuring influence on the system architecture. It is the consistent and universal use of this concept that makes the software factory approach unique, and it is this concept more than anything else that will help achieve our goals of increased productivity, lessened risk, and more reliable products.

The third major component of the software factory is an integrated set of production tools that save programmer time and effort, and provide a framework for implementing the procedures -just described.

Work on the software factory was initiated in 1973, and is currently being completed and put into operation. We expect this program, triggered by TA, to provide major Improvements in our software production capability to meet the demands of our data processing systems for industry and Government.

The third case I would like to describe is a product called FOCAS, which is a quite different area, and represents a quite different application of computer systems. Here the technology trends of lowering hardware cost, and the increased availability of low-cost, online systems through the use of communication satellites and "smart" terminals are identified in our current strategic plan as I have indicated earlier. The world energy shortage has led us to assess these trends with respect to the transportation industry in a search for new information system products that would improve the efficiency and effectiveness of transportation systems. One of the results of this activity is a new product we call FOCAS.

FOCAS is a computerized system designed to meet the special needs of the shipping industry in its daily activities required for controlling the movements of containers and cargo. A typical shipping company has a number of locations at which important business is conducted,

each location developing and handling critical data. In Containerized shipping, the need occurs daily at nearly every location to obtain a consolidation of data from all locations. FOCAS addresses this need by creating and utilizing a single set of information; the data base. This avoids the creation of multiple, often conflicting files, at various locations.

The centralized information is made instantly available to all locations through the use of low-cost, simple-to-operate terminals at all of the locations, tied to the data base at a central computer with high-speed data communication links. Transactions that are performed at the terminal are the nucleus of the system operation. They keep the data base information up-to-date and provide immediate, consolidated information at the terminal in response to inquiries. Functions performed by the system include container management, ship management, lease control, sales and accounts receivable, tariff analysis, agent commissions, and intracompany communications.

FOCAS is now in operation providing service to two major shipping companies. Its effectiveness is illustrated by the fact that both of the companies have been able to reduce container requirements significantly.

In summary, we at SDC use TA as a way of survival. We have used it both to make an assessment in terms of a specific perceived requirement, and as a method to generate requirements of a customer's need in terms of our international operations. We are using it to identify new products and to define better ways of doing business.

Mr. BROWN. Thank you very much, Dr. Mueller.

How do you or do you identify the TA function as a separately identifiable organization unit or is it merely integrated into your management and policy-planning activities in general?

Dr. Mueller. We have felt that technology assessment is something each of the major line operations must participate in if we are going to have an effective cross section or view of trends of technology.

We do have an R. & D. organization, whose primary charter is to maintain us in the forefront of the applications of technology, and we do have a chief technologist, whose duty is to be sure that we are aware of and are following the trends in the development of new technology throughout the country. So we charge everyone with the responsibility but we have focused it in the office of our chief technologist.

Mr. BROWN. Since your company's business is technology in a general sense, and more specifically computer technology, what in another company would be ordinary production planning is technology planning for you.

Dr. MUELLER. Our supply literally depends u on our ability to maintain current understanding of technology anZ being right about our forecast.

Mr. BROWN. What most interests me about the examples that you have given of the impact of your technology developments, for example in the printing business is that they appear to substantially reduce the need for manpower, particularly the old skills---the craft skills and the printing trades—and possibly the overall manpower requirements. Obviously this reduces the costs and has other positive economic effects, but It has the negative effect of creating a problem

of displaced manpower. Is that a part of your overall analysis in these fields This is an externality that your company is not responsible for, but it is a kind of problem for which we in the political policy-making area think we have to be responsible. Otherwise we wouldn't have legislation like the Humphrey-Hawkins bill and other similar legislation before us.

Mr. MUELLER. You are quite right. And yes, we do consider that.

I would say that although computer-based systems are generally credited with increasing the efficiency and reducing the requirements for manpower, there are very few computer-based systems that have been installed either in industry or in Government which have actually resulted in the reduction of manpower. Computer-based systems have certainly provided efficiency in terms of producing more output for a fixed cost, but they have not resulted in significantly reduced manpower in any area in the information-based systems, which is the primary business area in which we operate.

On the other hand, in the case of the newspaper-publishing business, the skilled craftsmen necessary for carrying out the production of newspapers using hot metal can be reduced in number. 'The introduction of the new technology has helped sustain a reasonable growth in the publishing industry by solving problems created by increasing costs in combination with shortages of resources both in terms of men and in terms of material, and the increasing amount of printed material that we are experiencing in every year. Our experience has been that we have tended to improve the output rather than to decrease the manpower.

Mr. BROWN. I am not trying to advert to what used to be a very popular view that technology was reducing the number of jobs available in our society and at some point down the line people would not be required to do the work of society. That has not occurred in any area of technological development., but there has been, as you indicate, the increased efficiency coupled with a changed type of skills required to operate the system. This has created certain problems, which are sometimes exaggerated.

Dr. Mueller. I will say this. that it is a very good point that the skill mix has changed as a result of the introduction of new technology, and in many instances it has required a higher level of skill. I think that as we learn more about how to use computers, we are going to see a reversal of that trend. It is true that today relatively untrained people in the newspaper business are capable of using this Text II terminal. whereas a few years ago that would have been quite impossible.

Mr. BROWN. I seem to recall that in the area of transportation we have seen the development of new forms of labor contracts that recognize the inevitability of the decreasing need for longshoremen and similar types of skills. It has created a contract, that provided protection for employees during their lifetime but it has not been able to retard the employment of new technology.

According to my recollection of the new labor contract at the Washington Post, which went through a traumatic experience a few months ago, they developed a somewhat similar type of contract aimed at protecting the economic well-being of craftsmen too old to retrain and who the company don't want to throw out on welfare or something of that sort.

May I ask a question similar to the one I raised with the previous witness about the impact of the public in the TA function as we put greater emphasis on the communication revolution that is occurring and we see certain policy developments taking place. You made reference to the question of privacy, which arises because more and more computer files are being maintained. Some of these will contain personal information on individuals. The public will have a concern about access to these files. There is the possibility here that public reaction against new computer developments might arise somewhat similar to what we have seen with regard to public reaction against nuclear power or other energy technologies.

It is obviously important that questions of desirable public policy be considered in the deployment of these new communications technologies. Is there on element in your TA process that allows you to evaluate these possible reactions ?

Dr. MUELLER. We certainly try to anticipate problems. As it turns out System Development Corporation (SDC) was one of the organizations that recognized the problem of both privacy and security some 5 years ago, and has been working in this area for some time. We have a group in Washington working on privacy, and a group here working on computer security. We have just undertaken the development of an electronic transfer system for a group of savings and loan companies. One of the key ingredients is providing security for the data so that when the remote terminals access the data base they do it through a link that is secured and cannot, be penetrated without having some access to the actual keys. I believe that more and more of the data bases will have that kind of protection built into them as the use of online systems arise, in order to prevent unauthorized access to data.

Mr. BROWN. Do you have that built into the FOCAS systems that you described?

Dr. Mueller That is not secure in that sense. In fact, I know of no truly secure computer-based system, with online terminals in the country today. Now, there are various levels of security. FOCAS has what is called password security, which is also capable of preventing unsophisticated access to the data base, but—

Mr. BROWN. That doesn't help much when everybody is becoming more sophisticated, does it ?

Dr. MUELLER. I believe that is one of the key problems. As more and more people, as more and more college students learn how to use computer terminals, the challenge of penetrating private data bases becomes more and more intriguing to them.

Mr. BROWN. You did describe a system that is secure for the movement of cash for savings and loans?

Dr. MUELLER. Yes.

Mr. BROWN, That, is not what you call an online system?

Dr. MUELLER. It is an online system. It is secured using a new special security device employing the National Bureau of Standards data encryption standard.

Mr. BROWN. Could that same kind of device be applied to the FOCAS system if you felt it was necessary to do so?

Dr. MUELLER. Yes. It could. And I have no doubt eventually it will.

Mr. BROWN. It is probably not quite so important to maintain the security of the system when it just involves data having to do with Congress as it does with the actual transfer of funds. However, I can visualize the possibility that in an intense competitive situation a competitor might make an effort, for example, to get into a particular FOCAS system for whatever purposes.

Dr. Mueller. You are quite right. I am sure that eventually somebody will think of a way of using data improperly. On the other hand, I don't believe that the data we have now in the FOCAS system is one that lends itself to competitive advantage.

Mr. **BROWN.** The point that I was trying to make is the degree to which the public perceives these systems as having either beneficial or adverse public policy implications for whatever reason. This public reaction may pose a problem with regard to the deployment of these systems, in which case the attitudes of the public have to become a part of the TA process.

Dr. **MUELLER.** There is no question in my mind that more and more of our use of our a placations of new technology is going to be influenced by the way the public feels and expresses its concerns.

MR. **BROWN. It a pears already that we are going to have a technolo devoted to determining how the people perceive what is good for them and what to do about that. Of course, that will replace politicians when that comes.**

Dr. **MUELLER. 1 doubt very much if we are going to replace the political scene in the near future.**

Mr. BROWN. Dr. Mueller, we are very grateful for your statement this morning. It will **make a valuable contribution to the record of our hearings.** If further elaboration on some of your remarks is required, I hope you will allow us to communicate with you in writing about these and continue to cooperate with that in that respect.

Dr. MUELLER. By all means. It was a great pleasure to be here, and I appreciate the opportunity of addressing you.

Mr. BROWN. Thank you very much.

[The following questions were submitted by Congressman Brown to Dr. Mueller and his answers thereto:]

Question 1. What limits do you see to the concept of technology assessment?

Answer 1. Technology assessment (TA) is used as a forecasting technique at System Development Corporatlon (SDC) to predict requirements for new products. The accuracy of the forecasts is limited by our ability to forecast technological advances and to interpret the results in terms of product requirements and new product opportunities. When technology trends progress in a relatively continuous manner, the accuracy of the forecasts is quite good. When a technical breakthrough occurs, there are discontinuities created in the technical trends and the accuracy of the forecasts is degraded.

Question 2. Has the use of TA influnced the way SDC does business? How do you incorporate the results of your TAs into **your planning, decision-making and policy processes?**

Answer 2. At SDC, our basic business strategies and policies are established and updated annually through our long-range planning process. This process involves a series of planning, review, and presentation sessions conducted by the senior managers of the corporation and the corporate chief technologist. The end result of this process is our long-range plan that documents the basic strategies, policy decisions and results expected over the next 5 years. Our TA program provides one of the important inputs to the long-range planning process and is used to anticipate and plan for the impacts of technology changes on our products and operations. We examine technological trends with respect to basic customer needs to find new product opportunities. We examine technological ad-

vances in terms of our internal operations to find methods of increasing productivity and product quality.

Question 3. What formal structure exists for doing TA? What steps are usually taken in the TA process? How do you decide when it is necessary to do a TA?

Answer 3. Our TA program is focused in the office of our chief technologist. He, in conjunction with the manager of the research and development division, determines the 5 or 6 key technology areas that are likely to have the largest impact on our business over the next 5 Years. A senior technical specialist is appointed Technical Area Manager (TAM) for each key technology, and charged with the responsibility to conduct our TA program and plan the technology development in his designated area. The TAMs provide inputs to the line managers for the long-range planning process near the end of each year, and for our annual operating plan at mid-year.

Question 4. In your opinion, in a TA should the impact of a new technology on a job structure be examined?

Answer 4. One of the more significant impacts of the introduction of new technology is to change the skill mix required of the organization involved. Therefore, I think an examination of the impact on job structure is an important aspect to be examined.

Question 5. When you do a TA on a certain problem, how do you involve the public?

Answer 5. Our internal TA program does not usually involve the general public directly, however we encourage our TAMs and other technical specialists to participate in professional societies, industry associations, government study panels, and similar activities that involve a broad cross-section of opinion, and consider technology progress from the public point of view.

Question 6. In the TA process, do you discuss with the public possible positions or negative impacts ahead of time?

Answer 6. Yes, in the professional societies, industry associations etc., mentioned above.

Question 7. What value do you see in having closer relationships between the public and private sectors?

Answer 7. At SDC, technology advances are a basic ingredient of our business. New products and better ways of doing business are created by new technology. These changes often create problems too; problems for our customers using a new product; problems of standardization across an industry; and problems of changing skill requirements in our internal operations. I believe a closer relationship with the public sector would help us to better anticipate and plan for these problems, and in some cases, avoid them.

Question 8. How do you incorporate your TA activity into reports?

Answer 8. As indicated above, our TA program results are reflected in our long-range and annual operating plans.

Mr. BROWN. Our next witness is Prof. Don E. Kash, who is director of the science and public policy program with the University of Oklahoma. Professor Kash has been active in the field of technology assessment (TA) for a considerable period of time and has been of great value to the Technology Assessment Board. We are very pleased that you could come here today all the way from Oklahoma in order to contribute to our hearing record. You may proceed with your statement in whatever fashion you wish, Professor Kash.

[The biographical sketch of Dr. Don E. Kash is as follows:]

DR. DON E. KASH, DIRECTOR, SCIENCE AND PUBLIC POLICY PROGRAM AND GEORGE LYNN CROSS RESEARCH PROFESSOR OF POLITICAL SCIENCE, THE UNIVERSITY OF OKLAHOMA, NORMAN, OKLA.

Born, May 29, 1934; married, two children. B.A., 1959; M.A. 1960; Ph.D. 1963; political science, the University of Iowa.

Instructor, Texas Technological University, 1960-1961 ; assistant professor, Arizona State University, 1963-1965; assistant professor, The University of Missouri at Kansas City, 1965-1966; associate professor, Purdue University, 1966-1070; visiting professor, the University of Oklahoma, Advanced Programs, 1967; visiting associate professor, Indiana University, first semester, 1969–1970; professor, The University of Oklahoma, 1970-present.

Director, Purdue University Graduate Education Project in Science and Public Policy funded by the National Science Foundation; Purdue Coordinator, Joint Indiana University Purdue Project for Curriculum Development in the Study of Science and Society funded by the National Science Foundation; Director, Program in Science and Public Policy, Purdue University; Director, Science and Public Policy Program, The University of Oklahoma, 1970-present.

A member of: Review Committee on Energy and Environmental Systems Division of the Argonne Universities Association (AUA is the university consortium that governs Argonne National Laboratory) ; Office of Technology Assessment Panel on Outer Continental Shelf Oil and Gas Policy Advisory Group; Committee on Science and Public Policy, American Association for the Advancement of Science; and Marine Board, Assembly of Engineering, National Research Council.

Congressional testimony on: Technology Assessment before Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, December, 1969; on A National Science Policy submitted to the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, August, 1970; before U.S. Senate Committee on Interior and Insular Affairs, May 8, 1974; with Michael D. Devine, testified on energy R&D needs associated with offshore petroleum development before the subcommittee on Energy Research, Development, and Demonstration of the House Committee on Science and Technology, July 11, 1975.

Panels on which served in 1974-1975 were: "A Report on Technology Assessment of of OCS and Gas Operations," presented at the American Political Science Association, Chicago, Illinois, September 1974; "Lease Management and Resource Conservation," presented at John Wesley Powell Federal Building Dedication, U.S. Geological Survey Symposium on Earth Science in the Public Service, Reston, Virginia, July 10, 1974; "Government Stimulated University Research Organizations for Carrying Out Social Problems Research," prepared for Symposium on Application of Science to Society's Problems, AAAS annual meeting, San Francisco, Calif., February 25, 1974.

Membership in: the American Political Science Association; American Association for the Advancement of Science; American Association of University Professors; Southwest Social Science Association; and International Society for Technology Assessment.

Over 20 articles in journals and books on such topics as science policy, science and public policy, energy resources, and technology assessment.

Grants received for: *The Politics of Space Cooperation* from the Kansas City Association of Trusts and Foundations, 1965; Curriculum Development in the Study of Science and Society, to Indiana University from the National Science Foundation, 1960; the support of program in science and public policy at Purdue UniverSity from IBM, 1907; Educational Project in Science and Public Policy to Purdue University from National Science Foundation, 1907; a Technology Assessment of Offshore Oil Operations from National Science Foundation, 1971; A Technology Assessment of North Sea Oil and Gas from Council on Environmental Quality, 1973; a study to develop a methodology and documentation for consistent analysis of energy alternatives for environmental impact statements from Council on Environmental Quality, 1974; an Energy Systems Analysis of Alternative Resource Options from National Science Foundation, 1974; a Technology Assessment of Western Energy Resource Development from Environmental Protection Agency, 1974-present; Support Services for OTA Analysis of Federal Energy Research and Development from Office of Technology Assessment, June 1975-present.

STATEMENT OF DON E. KASH, DIRECTOR, SCIENCE AND PUBLIC POLICY PROGRAM, UNIVERSITY OF OKLAHOMA

Dr. Kash. Thank you, Mr. Chairman.

I appreciate the opportunity to testify before the Board.

My comments today are derived from the experience we have had in the Science and Public Policy program (S. & P. P.) at the University of Oklahoma. The program is an interdisciplinary research organization established at the University of Oklahoma in 1970 for the express purpose of doing technology assessment (TA). Organization-

ally, it is located under the Assistant provost for Research and has the equivalent standing of an academic department. S. & P.P. has a hard-money budget sufficient to support its permanent faculty and support staff. Large-scale research efforts depend on external funding that currently averages about $500,000 per year. Although the S. & P.P. has a present staff of 16—and that staff, by the way, includes five engineers and a biologist, a systems ecologist, and various and sundry social scientists—the expertise of the entire university is tapped as needed by bringing in individual faculty members on a consulting basis.

The capabilities of S. & P.P. in TA are best measured by the results of three previous studies: (1) Energy Under the Oceans: A Technology Assessment of outer continental shelf oil and Gas Operations; (2) North Sea Oil and Gas Implications for Future United States Development; and (3) Energy Alternatives: A comparative Analysis.

Energy Under the Oceans and North Sea, Oil and Gas were TAs of offshore oil and gas development. As such, they included descriptions of the physical and social technologies for developing these resources. Both also included problem and issue identification and descriptions, the identification and evaluation of policy alternatives, and an extensive policy implementation analysis.

Energy Alternatives, which was supported by the National Science Foundation (NSF) and an interagency committee describes the coal, oil shale, natural gas, nuclear fission, nuclear fusion, tar sands, geothermal, solar, organic wastes, and hydroelectric energy resource systems as well as the electric power generation and energy consumption systems. This study also proposed procedures for calculating and comparing the residuals, energy efficiencies, and economic costs of technologies or strings of technologies. It also suggested procedures for relating residuals to ambient conditions, expanding energy efficiency analysis to the level of determining energy balances, and extending the economic analysis to include economic impacts.

In addition, S. & P.P. is currently completing an energy R. & D. study and recently prepared a draft report entitled "An Analysis of Energy Supply R.D. & D. Options." This study, sponsored by NSF, describes alternatives for supplying various forms of energy, and identifies and assesses physical. environmental, and social issues and constraints. Particular attention is focused on identifying R. & D. priorities. Finally the program is also 9 months into a 3-year TA of Western Energy Resource Development funded by the Environmental Protection Agency (EPA).

S. & P.P. was one of several organizations asked to participate in the, OTA's review of the Energy Research and Development Administration's (ERDA) fiscal 1976 budget. Subsequently, program personnel have participated in reviews of ERDA's revised plans and budget.

By definition TAs are a class of policy studies. They are distinguished from other policy studies primarily by a central assumption. It is that a set of activities covered by the label technology, cause or have significant influence on social change. I might note as an aside from the testimony here that my own view of TA is that it starts with hardware. I am uncertain about starting from other assumptions.

I don't want to write it off, and some of my colleagues disagree with me on this, but it seems to me it is the hardware that holds these studies together. Technology assessments give technology a much greater role in influencing change than is common in other policy studies.

Technology assessment then, is distinctive in its perspective. Put in figurative terms, what technology assessors do is stand on the technology and look out. They ask, What are the impacts, consequences, or effects that will result from the use of a technology, in addition to the impacts that are being used to justify its development?" For instance, what happens in addition to the production of energy if we develop synthetic liquids from coal ? In general, the goal is to determine not just immediate first-order impacts, but also the domino or higher-order impacts.

The answer to the first question is then followed by a requirement to ask a second question. It is, do the various impacted parties or groups see themselves as affected beneficially or adverswly? And the effort is made to determine how intensely they feel about the impacts. I make a note in this connection, I don't think you can do assessments without involving the interested parties from day one.

The answer to this second question must be followed by a third question. What can be done to enhance beneficial impacts and to mitigate adverse impacts? Answers to this question provide the main grist for the policymaker. That is, assessments may identify alternative technologies or technology modifications that offer a more attractive balance of beneficial and adverse impacts. Or assessments may identify a plethora of legislative. management, financial, and so forth, alternatives that can modify impacts.

In fact, the most successful assessments identify packages or mixes of technological-social options that can modify impacts. This point deserves special emphasis because technologies need to be viewed in the context of their interaction with the physical. biological. and social environment. It is this process of interaction that is the central concern of assessments. Trchnologies make certain demands on the environment for inputs. They also produce outputs that affect the environment. The consequences of both of these are the foci of an assessment.

Our experience in carrying out assessments suggests that several points need emphasis. T might note in this connection. Congressman. that I spent some time writing around in circles and decided what I wanted to say required making several points. These points are that assessments: (1) are inherently interdisciplinary, and that means they involve engineers, natural scientists and social scientists and perhaps people in the humanities; (2) involve dealing with people's preferences or values; (3) are neither scientific activities themselves nor are there any demonstrably successful methodologies available for carrying them out; and (4) special efforts are required to insure that their findings are usefully communicated to policymakers.

When I use that term I am talking about more than just Congressmen. I am talking about the people from whatever the particular technology area, who are involved in making decisions. In the case of a utility company—utility companies are policymakers also.

Based on the characterization of TA that I have just sketched, and our experience in carrying out these studies, I would like to build the rest of my testimony around three recommendations to the OTA Board.

First, any proposed assessment that is characterized as being primarily dependent on a formal methodology should be rejected.

Second, all draft papers reduced as a part of OTA-funded studies should be widely circulated, and such circulation should not require Board approval. That is, you should not have to sanitize these papers before they are floated to the interested parties.

Third, the Board should make every effort to assure that the Congress undertakes a self-conscious program of long-term institutional support for TA research organizations. That is what you call a vested interest recommendation, but I also think it is the case.

Recommendation 1: My first recommendation results from two conflicting sets of facts. The first set is that there is a very weak record of useful assessment coming from studies organized around such techniques as input-output analysis. Delphi simulation, and the 200 types of cost-risk-benefit analysis, The second set of facts is that both within the research community and the executive funding agencies there is an almost compulsive attraction to such methodologies. The reason for this attraction is that by general agreement TA requires interdisciplinary work but no one really understands how to do it.

It is inherently high-risk research and, therefore, may create a lot of political flack. That is, without a guiding theory or methodology this policy oriented research can easily become little more than unsubstantiated special pleading. Methodologies allow the value issues to be hidden one level below the surface and they therefore offer safety in this very uncertain research situation.

In fact, TAs need to focus on the value or preference questions. The way. to insure quality and protect against special pleading is to insure that the research is truly interdisciplinary, and that. it is subjected to continuous review by the potential parties-at-interest. That is a second check, In summary, useful credible TAs depend on organizational and procedural arrangements not on methodologies.

This is why an interdisciplinary team approach, including the extensive use of external reviewers, should be stressed. Both are a means of attempting to insure that all germane factors are considered and that appropriate criteria and standards are applied. In short, the proredural approach, which I argue is essential, is basically a substitute for the lack of established TA theory and/or methodology.

Reviews by both an interdisciplinary team and external reviewers are necessary to overcome inherent limitations such as bias, narrowness of perspective, and insufficient knowledge. The goal is to see to it that these limitations are not allowed to go unchallenged, When team members are drawn from a. variety' of disciplines and encouraged to develop an intellectually challenging working environment!, the team as a group is less likely to permit the limitations of individual team members to shape the assessment. But, since there is an upper limit on the number of persons that can be included in an interdisciplinary research team, limitation in terms of perspective, bias, and knowledge cannot be completely overcome. This, together with the possibility that

the team has an institutional bias, is why a variety of external review mechanisms are an integral part of a good assessment. external reviewers should include consultants, and a advisory committee, and a broad range of persons chosen to represent the interests or values that are at stake.

Consultants should be selected to perform two primary functions: to provide perspectives and expertise not available within the interdisciplinary team; and to provide in-depth critiques of various papers and reports produced by the team.

An advisor committee should be constituted for each assessment to provide for balanced representation of the interests and values at stake. In energy resource development, for example, these might well include representatives of industry, labor, Indian tribes, various levels of government, and so forth. Members of the committee also provide a communications link between the interdisciplinary team and the community of interests that the committee member was chosen to represent.

To be manageable, the size of the advisory committee must be limited. Therefore, it is unlikely that all interests or values that the team should consider get represcnted. Consequently, on the basis of its own knowledge and the advice of the advisory committee and others, a broad range of other external reviewers should be asked to critique the interdisciplinary team's papers and draft reports. Many of these should be parties-at-interest, but some of these reviewers should be selected because they possess expertise that the team wishes to utilize.

The procedures to minimize bias broaden perspective, and overcome knowledge deficiencies described above are displayed in figure 1.

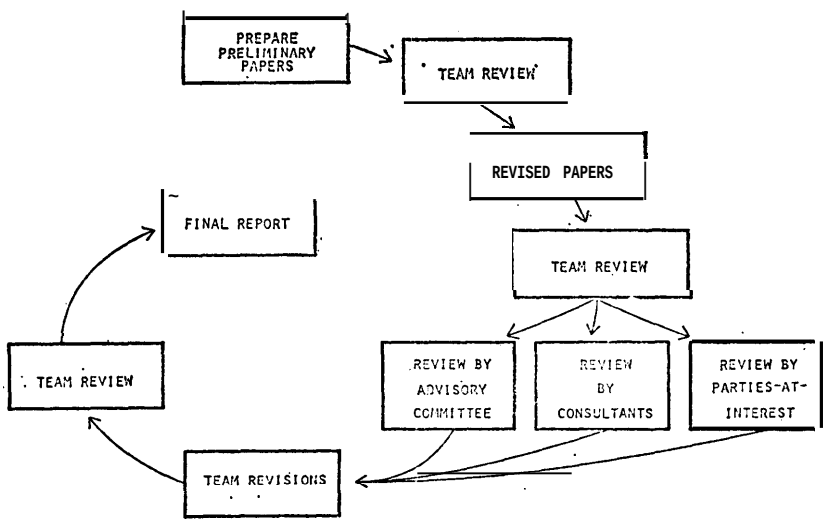

FIGURE 1

Recommendation 2: The reason for my second recommendation, which calls for the wide circulation of even early draft papers produced by OTA studies, are Implicit in my comments on the first recommendation. To extend those comments, however, it is important to note that policy is usually evolved within policy communities. Assess-

ments should be used to inform the diverse interests in these policy communities at the earliest stage possible. The requirements of many Federal a aencies that high-levelfformal approval be obtained before wide circulation takes place impedes that process. In sum, I am arguing that every step of the assessment process should be open.

Recommendation 3: My third recommendation, which calls for institutional support for an OTA research organization, is linked to the previous two recommendations. These have said that there is a need for a particular kind of interdisciplinary research capability and a need to make its research credible and useful to a diverse range of interests.

In practice, there are very few organizations that can produce both competent and credible assessments. The competence problem is heavily the result of the addiction to methodology. The need is to focus on organizations that can put together interdisciplinary teams that will make prudent judgments and subject their work to continuous review by the range of parties-at-interest.

Credibility requires the same recognition. Since assessments must be broadly credible, if they are to have major utility, those who do them must be free of any economic or regulatory interest in the outcome of their research. Unlike scientific research, where performance standards are widely agreed to, assessment standards are unclear. There is substantial disagreement over how to measure the social impacts of technology. Under these circumstances the biases of the researchers must be a ma "or source of concern.

At present. most of! the organizations that do TAs are heavily funded by Federal agencies with promotional or regulatory interests in the technologies, or alternative y by industries with economic interests. Regardless of the quality of the research, it is open to serious challenge when it comes from such organizations. Only a new sustaining funding structure will assure the availability of research organizations with characteristics necessary to provide the Congress with the kinds of assessments it needs—that is credible assessments.

That is the conclusion of my statement. I would be happy to respond to questions.

Mr. BROWN. Well, I find that to be a very direct and useful set of recommendations, Professor Kash.

I am not quite clear with regard to the emphasis you put on the interdisciplinary nature of the assessments. I understand the significance and importance requiring a number of disciplines but you seem to be saying that it goes beyond that. You indicate the need to have a point of view with respect to technology assessment (TA) that rises above special interests, disciplinary, economic, or any other kind of special interests. What is that interest that. rises above these?

Dr. **KASH. Well,** I don't think it is possible to identify that interest. I think you have to go at it from a negative point of view. That is, if you ask me to identify what that ideal set of interests is I can"t tell you. I can tell you that at this stage of the game those of us who are practitioners of the various disciplines have built into our perspective a bias that is every bit as serious as that of the AFL--C1O. the National Association of Manufacturers (NAM), or Southern California Edison. One of the things that is necessary is to have an interdisciplinary group to challenge the conventional wisdoms of the particular disciplines . Those biases are terribly serious.

One of my concerns at the present time is with the addiction to methodologies. As the man from System Development Corp. indicated, there is this tendency to plug every study into a computer. What you do is convert all the variables into a common unit of some kind. In the process you make a fundamental value judgmen& one that is as dangerous to informing complex political decisions as if the study were written by NAM,.What I am saying is, if you don't know what the danger is you at least try to adopt the traditional wisdoms of this political system. You build counterpoints in from day one.

Mr. BROWN. You appear to be lending great weight to what in the legal system is referred to as the adversary process.

Dr. Kash. I am, and I guess the difference that I would emphasize is-and you understand now that I am an observer from a substantial distance-that most of the decisions made in this society are really made by evolving a consensus. A number of policy decisions are made in the Congress, where issues are joined, and you fight them out. YOU make them by majority vote. But those decisions represent a very, very small part of policymaking.

Most decisions percolate upward through an agricultural community, or a defense community, or a nuclear community or a biomedical community. Those communities evolve a consensus within a group of people who share a common interest. They may fight among themselves, but they grab hands to protect themselves from outsiders. I think you have to have some outside looks into these communities, and that is one of the things that TA does.

Mr. BROWN. I am trying to develop this thought as fully as possible. From a theoretical standpoint, if a number of biased parties are brought together in the hopes that the interdisciplinary nature of the group will overcome their individual biases, you may end up merely with what is an amalgam of biases; Such a product is the 1east unsatisfactory to all of the parties, and does not reflect either any substantially different interest or a new result, which would have some different criteria for its achievement.

Dr. Kash. I understand your point, and I think it is a sound one. First. it may very well be that the best you can hope for is that amalgam of biases, bad as it may be. There is no ideal, but I would make a difl'erent point.

I think that TAs are of marginal utility if the issues they address are already joined. One of the advantages of doing assessments is to identify issues before people have chosen up sides, and it seems to me that the few instances in which assessments have worked well have been because they helped to identify both the issues and the options. The assessments got their early. Once it has become an issue on the floor of the House of Representatives it seems to me the ballgame changes a bit.

Mr. Brown. To again seek to refine this by example, a situation ma-y exist where there is a policy community within the business community and a policy community within the labor community. These communities arrive at different policv decisions or views as thev involve a matter of common interest. This has happened over find over again. What sometimes evolves is accommodation between those two communities, and the public be damned.

Dr. KASh. Those who aren't part of the communities.

Mr. BROWN. Yes.

Dr. Kash. I think that regularly happens

Mr. **BROWN.** This does happen and It is possible to suggest of situations. I am not picking on labor and maria

point was made by that distinguished philosopher, van IlliCh, in his latest book dealing with the medical community. In it he contends that we are now subject to a new form of disease, which he calls iatrogenic disease, created by doctors. He claims this stems from a policy consensus on the part of the medical community probably in combination with sick people, that they need fantastically expensive medical capital equiqment and medical processes in order to provide assurances of goohealth. Illich's point of view is that this is absolutely wren , but it is the consensus that society has evolved with regard to health. How do you get out of such a trap, if indeed it is a trap? How does TA, or the-interdisciplinary approach as you seem to imp y, provide a method for getting out of this trap?

Dr. **Kash.** Well, I think it can provide a method. There seem to me to be two schools of thought with regard to TA. One of these schools is that what you do is bring in people who are expert in the particular area and then try to counterbalance them with other sorts of interests

The other approach and the one that we have adopted is to try to take people with different or diverse educational and experience backgrounds who really don't know anything about the technology, who aren't a part of that community. We have done this on four different occasions. A couple of things impressed me.

One is that moderately intelligent people given a year or so can learn a good deal about even relatively complex technologies. That ***is,*** it is not beyond the ability of people to get a handle on most of these technologies or at least it "isn't beyond their ability to get enough of a handle so that they can read the literature and out where the problems are. My own perception, and one of the reasons that I argue for distinctive TA organizations, is that I think if you are golng to get meaningful assessments, you have to get people not Imbued with the values of that technical community. For example, you don't want a bunch of people that have grown up in the nuclear community and who understand all that jargon and can tell you about everything down the line.

Now that is a problem in almost every area. So I think what you have to do is get organizations that aren't a part of that community that don't live and breathe it. You understand that what I am suggesting here is not just a concern with economic vested interest. A man who spends hls time going to graduate school and working within a community develops a real commitment at a gut-level professional commitment. You have to get people who are from the outside, and I think professionals who are f rom the outside.

Mr. BROWN. Going back to the medical example, there was an interesting recent article in the press about a study done in England that indicated that cardiac patients receiving intensive **care** in hospitals have a higher death rate than people with heart diseases who are at home without 'acute cardiac care. In a TA of intensive cardiac units, using standard methodologies, I wonder how you would come to a conclusion that this might be a desirable ***way*** to develop. As a practical matter, I think that the study reported in the press is in

fact a form of TA that will probably lead to some basic policy changes within the British health system.

Dr. KASH. Well, I notice that two or three of the people who had testified in these hearings in Washington had identified that TA wasn't a decisionmaking process.

Mr. BROWN. Right.

Dr. KASH. Now, there are a couple of things that strike me. One is that technology is now by definition something that is managed. If it is understood at all, it is understood by organizations, not individuals. I am inclined to think that I can understand about as much about things as most people can, and what strikes me after working in the energy area for 5 years is just how I don't understand it. I don't believe anybody else, any one person, understands it.

So what you have are organizations that manage. They manage knowledge; they manage technology. We do not have similar organizations that try to look at what happens with the technology in addition to those things that the organizations that are promoting the technologies say is going to happen. I think we have got a real organizational question on our hands. We have to recognize that there are no technological renaissance, men who can have a total understanding. You have to have an organizational capability. It seems to me that the reason you want that organizational capability is to alert the Congress and other interested parties of consequences that, have simply not surfaced before. lt is really an information-providing mechanism, but it provides information generated from a different perspective.

Mr. BROWN. Well, I want to go back and emphasize the point that you made about TA not being a decisionmaking or a policy-articulating process. Instead it is a prior step that provides data for decisionmaking. At the subsequent step, where the decisions are made, the assessment has to be combined with value judgments. It is the TA that enables one to make a policy decision. I think it is important to recognize that TA is not a panacea. We have a very human tendency to look for panaceas as some magical tool that will allow us to do something without hard work and without plugging values into the equation.

Dr. KASH. Well, there is the statement by one of those Yngoslav emigres who is in Sweden now, who talks about activities of this kind, and he says the purpose is to reduce the present irrationality from 99 to 98 percent. We are talking about pretty small ranges. I would make one other comment. It would seem to me that TA ought to be thought of as being particularly important in informing decisions about that set of activities covered by the R. & I). budget. We are spending some $20 billion a year now of the Federal money to buy R. & D. My perception is that you can look at that $20 billion and say that is the design money for the future of this society.

If you want to have some control over the design of this society what you have to do is make some discriminator-y jndgments about which technologies you buy and which ones you don't buy. I don't know how in the hell you do that. And so we are really talking about a new kind of information that we self-consciously go after. We don't wait around for a few happenstance people like Ralph Nader to come along and put their fingers on this or that.

This is an organizational societv. The problem is that most of the organizations in society are committed to developing technologies. There is very little organizational capability that is geared up to ask, "What happens in addition to ?" There is in most organizations a fairly shaky professional future for people who do TA. If you think you can go out and buy this capability by a lot of one-shot contracts or grants you are wrong. It takes a kind of organizational capability that is just damned rare at the present time, and I am suggesting that the capability ought to exist in all the sectors; that is, it ought to exist in Government, industry, the nonprofits. and universities. We ought to use the same kind of mix of organizational skills that we have used so successfully developing technologies, and I guess now that I am on my platform I think it important to emphasize that while we know how to do technology wc don't understand it.

There is an old story about a medieval blacksmith who had a knight come in and say, **I hate been out trying to lop off the heads of my opposing knights, and every time I hit them the damned sword bends. I want. you to do something about this." So the blacksmith stuck his sword in the forge, and he heated it up, and he beat some metal in, and he said, "Take It out and try it." The guy came back and said, "It still bends."' They went through the process three or four times, and he came back in and said, "It took the head off nicely." The blacksmith said, "That is great. I am going into the headsword business." He didn't understand the metallurgy, but he understood how to beat a chunk of this and a chunk of that in.

Now that it is the way in which we have developed complex technology, and that is the way in which we are going to develop meaningful TA. The idea that you are going to understand this process in the same way that you understand quantum mechanics is just poppycock. I mean maybe someday, but if it is available at the present time, I haven't been able to find it.

Mr. BROWN. In addition to this interdisciplinary focus that you stress, we may be reaching a point where we need a new discipline to be included in the equation. We may need, for example, to include someone who has a greater background in general problems of philosophy or the philosophy of values. Do you think that is completely unrealistic ? There are people who are spending more time looking at the way people set priorities and establish values, and this is something that is normally not a component of most interdisciplinary teams of any kind that I know of.

Dr. KASH. Well, Congressman Brown, I think that kind of person is an essential ingredient in any TA, but I don't think you ought to talk about developing a new discipline. That new discipline requires that the guy understand physics, mechanical engineering, biology, presumably sociology and philosophy and there just aren't that many people in the worId who are that much more able than I am. I have one heck of a time getting my head around very small parts of this.

So if you want TAs what you have to do is take disciplinary apples and oranges and put them together. We have a great story that we like to tell in our organization, about a hell of a battle that went on for 2 days over a down-hole safety valve. It finally came down to a confrontation within the group between a political scientist and a me-

chanical engineer, and they were arguing over whether it would work. Finally, the mechanical en engineer said," amen it you are wren ˢ and the political scientist said, 'Why?) The en gineer answered, Because I am a mechanical en " engineer an I know.)' And the political scientist said, "That won't sell. Now, what I am saying is that these disciplinary communities are just like my hometown in Iowa. They are full of little conventional wisdoms, which when you mouth them, everyone nods his head.

The design of offshore structures to withstand a 100-year storm is a case in point. Our first question was what is a 100-year storm. It turns out that somebody put together a 100-year storm out of clouds, and thought, and computer runs. All of that is perfectly fine, and is a reasonable basis fordesigning a platfom, but an implication that you are measuring 100-year storms is not correct. You have to build into these things people who don't buy the conventional wisdoms—philosophers, la era, all sorts and types.

Mr. BROWN. There is a professional meeting scheduled here in a few weeks, composed of architects, planners, and various others, that is focusing on the design of the energy conserving city or community. This is a technological problem in a sense, and one can assess the characteristics and impacts of an energy conserving city. It is a rather large problem in some ways, particu l arly if it is a large city; but I bring]t up to raise a question. In the earlier part of your statement you said you preferred to narrowly draw the line around TA basically starting with the hardware aspects of it. A technological city, which is an energy conserving city, is a hardware concept. Yet the immediate impacts will be very, very broad in terms of various aspects of sociology, psychology , and economics. Can you really draw a line that would limit TA to hardware In the process of analyzing the domino effects, second, third, and higher order, aren't you immediately drawn into much more than the hardware aspects of technology

Dr. Kash. Yes. And I think clearly the purpose of the assessment is to go beyond that, but the difficulty if you are looking at terribly complex systems of that kind is where do you start, and w at track do you follow.

The reason that I ha pen to be particularly attracted to looking at the hardware or the physical side of the. city as the starting point is not that this is the most important ingredlent, but it is the one tangible thing that you can start with. If you look at an energy-conserving city, what you do is look out and see what sorts of impacts and what sorts of demands a city of that kind makes on people or on the surrounding environment. If you are going to get together people as diverse as mechanical engineers and political scientists, they can't talk to each other. Now, what they can do however, if they spend some time, is share a common physical reference system. It is]ust about that crude. It is like that medieval blacksmith. If I were going to do a study of that kind I would start with recognizing that what -you are really interested in is what it means for man and his values. But you know the difficulty is that we deal with a conceptual system that is the system of science. This is a cause and effect system. I don't even know how to think in other terms, so I have to start someplace, and I say this is the cause.

1 think that the reason OTA exists, and these hearings are being held, is that there is a growing perception that something called technology, a physical thing, has become causal. Technology assessment says the way you approach society is different from the way an economist approaches it, which is as a relationship between labor and capital, and sometimes natural resources.

Mr. BROWN. You can look at this both ways. It is possible to start with the technology and say how this is going to affect or impact human systems, procedures, and health and welfare. You can also start with the other end and see how the development of human systems, values, methods, and styles of life affect technology. Let me give you an example.

During the 1930's we developed the Federal Housin~ Administration and a system of insuring home loans, which made It possible for middle income people to move to the suburbs. This led to t e development of transportation schemes, suburban centers, and other things, technologies you might say. The net effect of this host of events was the decay of the inner city. We are now trying to take a technological approach in our attempt to figure out **how to reverse** the decay of the inner cities. Maybe we need a kind of assessment that looks at human value systems and how they impact technology rather than starting with technology.

Dr. **KASH.** Well, I think that we need that. You made the point earlier that TA is no panacea. You also asked the previous two witnesses, where should you start, what should be the boundary conditions ? My reason for sticking with hardware is a very pragmatic thing. It Isn't that 1 wouldn't like to be able to do the other thing; it is just that I think lt is potentially possible to do assessments if you start with the hardware. I just don't know how to deal with those others. It isn't that they are not needed. I just think that they are less dual.

Mr. BROWN. Well I have reached the same conclusion, but I don"t like it.

Dr. KASH. No, I don't either.

Mr. BROWN. Because it seems to me that policy decisions ought as a matter of course, to contemplate a much broader base than just technology. What I like about TA is that it gives us a handle on these other things. I have supported it for that reason, but I really would like to see the concept on as broad a base as possible.

This has been a very stimulating discussion, Professor **Kash,** and we appreciate the contribution you have made to it. We hope that if we would like further clarification of the points you have made, our staff can submit additional questions to you?or your response.

Dr. KASH. I thank you.

[The following questions were submitted by Congressman Brown to Dr. Kash and his answers thereto:]

Question 1. How does technology assessment (TA) compare with the environmental impact analysis process?

Answer 1. Technology assessment differs, in two ways from the process normally associated **with** preparing environmental impact assessments. First, TA has as a perspective the assumption **that it** is the causal **factor or force. Technology assessment is a process of policy analysis that figuratively involves etand-@g on the technology and looking out. The causal assumption is not a necessar~**

ingredient in environmental impact assessments. The second major difference is that TA generally takes a broader perspective. In particular, it carries the investigation for the analysis to the point of identifying alternative policy options. This point is regularly lost in the debate. A meaningful TA will not only assess the impacts of a given action but it will attempt to identify and assess alternative ways of accomplishing the action. In substance, it will attempt to identify alternative policy options.

Question 2. **What should be the basis for deciding to do a TA instead of some other kind of analysis?**

Answer 2. My view differs from that of many people who are involved in doing TA. I think that TA is distinctive because of the causal assumptions that underlie it. Those causal assumptions are a set of phenomena labeled technology, which cause or drive social change or have social impact. A TA then is required when one wishes to control the social consequences of a situation in which technology is going to have a major influence.

Question 9. **What is the best way to get the public involved in the TA process?**

Answer 3. I believe that two routes are most fruitful. One is to insure that a representative group of the interested public be included on oversight or review committees put together for each individual assessment. Second, the group doing the research for the TA must view the interested public as a major source of information and data. This means that the research group must seek information, counsel, and criticism from potentially interested parties at every stage in the process. The pursuit of information from the interested public means **that you don't just ask them what they are concerned about. It means that you get the interested public to review and critique every draft of the papers prepared in connection with the TA. We found that you usually need to hire representatives of interested publics or consultants. Essentially you pay them to critique your work, to tell you where you are wrong, and to tell you where your emphases are right. An important point is that there is not a single public. For each T.A there are specific interested publics.**

A TA is a failure if the investigators do not identify those publics. It is also a failure if those publics are not an integral part of the research process. If they are an integral part of the research process the people doing the TA have covered 90 percent of the distance necessary to disseminate their results. That is assessors can't separate their research from the people to whom they will communicate their research.

Question 4. **What value do you see with respect to TA in closer relationships between the public and private sectors?**

Answer 4. In a technological society it is extremely difficult to maintain the distinction between the public and private sectors, particularly in areas of rapidly evolving technology. The interdependence of the public and private sectors is given. In practice, my view of the policy process assumes a decision is made in seemingly public, private policy communities. Energy Policy is a result **of a combination of public and private decisions. It is inconceivable to me that a policy study such as a TA would not have to be as concerned with the decisions in one sector as they are in the other. My view is that most legislation is only the result of complex evolution through these policy communities.**

Question **5. Do you think the concept of TA has affected the way the government and corporations are now doing business in comparison to their practices 6 years ago?**

Answer 5. I think the answer is pretty clearly, yes. One needs to emphasize that TA is really a label that covers an effort to respond to a broad set of societal demands. These demands are the result of a growing recognition that the use of technology exerts a major influence on the character of the society. People now want to know what happens when a technology is utilized, in addition to those things that proponents of the technology use to justify its development. Corporations as well as government now have no choice but to attempt to answer those questions. The environmental movement is only one manifestation of the demands for such answers. That demand is so pervasive and has developed so rapidly that I find it difficult to believe anyone could answer this question other than you.

Question **6. When conducting a TA do you think a corporation should look at the impact of a new technology on job structure?**

Answer 6. Sure, yes.

Question 7. In your opinion, how do human value systems affect technological development? What role should the analysis of value systems have in assesing impacts of technology on society and the environment?

Answer 7. I can't separate the answers in two parts. I don't know how one can label TA as a kind of policy study without recognizing that value assessments are implicit Policy choices include questions of fact and questions of value. In practice what an ideal TA does is tell you what values the development of a given technology will promote in the future. TA can't tell you which values ought to have social priorities. It can tell which values are likely to he promoted and which are not likely to be promoted. The traditional democratic political process must make the choices among the values.

Question 8. **What limits do you see to the utilization and application of the TA concept in the government and in the private sectors?**

Answer 8. I would repeat a comment I made in connection with an earlier question. I differ from many of my colleagues in seeking that TA should start from a physical or hardware base. I do that because I think TAs are inherently interdisciplinary. What one can do is use a common hardware or physical system as a glue to hold an interdisciplinary research group together. My own thinking—and I emphasize that for the moment—is that TA should be carried out around physical or hardware systems.

Mr. BROWN. Our next witness is Dr. R. Rhoads Stephenson, systems analysis manager, Jet Propulsion Laboratory, California Institute of Technology.

You wish to bring your colleague with you?

Dr. STephenson. Yes; I would like to have one gentleman, Mr. Thomas A. Barber with me here. I think he will primarily participate in the question and answer period.

Mr. BROWN. We welcome both of you. You may proceed with your statement in whatever fashion you wish.

[The biographical sketch of Dr. R. Rhoads Stephenson is as follows :]

DR. R. RHOADS STEPHENSON, MANAGER OF THE SYSTEMS ANALYSIS SECTION, JET PROPULSIO N LABOR~TOBY, CALIFORNIA INSTITUTE OF TECHNOUMY (JPL-CALTECH)

Ph. D. mechanical engineering, Carnegie Institute of Technology, 1961.

Worked in plasma physics and magnetohydrodynamic (MHD) power generation research, energy conversion laboratory, Martin-Marietta, 1961-1962; military service U'.S. Army, 1962-1964, assigned to JPL to work on nuclear electric power generation, thrusters, and mission analysis. Joined JPL 1964, worked on Blariner and Voyager planetary missions; as assistant manager of The Tracking and Orbit determininaticm section conducted research and developed computer programs in astronomical, space navigational, and mathematical areas related to planetary missions; since 1970, manager Systems Analysis Section, which performs mission analyses for advanced space missions and systems analyses of civil sector projects in the areas of biomedical engineering, transportation, law enforcement, energy systems, and environmental analysis; and from December, 1973 to August, 1975, was Principal Investigator for a $500,000 grant study from Ford Motor Company to study alternative power systems for automobiles in the 1980's. The broadly based study included engine technology, vehicle design chanxe% fuel and energy consumption, patterns of automobile use, and industry practices.

Advisory activities: appointment as a member of the Advanced Powerplants Committee of the Society of Automotive Engineers; and NASA representative to the Vehicle Design Panel of the Interagency Task Force on "Motor Vehicle Goals beyond 1980."

STATEMEI?T OF R. RHOADS STEPHENSON, MANAGER, SYSTEMS ANALYSIS SECTION, JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, ACCOMPANIED BY **THOMAS A.** BARBER

Dr. Stephenson. Thank you, Mr. Chairman. It is a pleasure to be asked to testify before the Board.

I am Dr. R. Rhoads Stephenson, manager of the Systems Analysis Section at the Caltech Jet Propulsion Laboratory and principal investigator of the recently completed automobile power systems evaluation study or so-called APSES.

I have asked Mr. Thomas A. Barber, who prepared the industry practlces **portion Of the study, to** accompany me em to **Participate** m the question-and-answer period.

The topic under discussion today is the 'practice and uses of technology assessment in industry, Government, and other sectors." To this end, I have been asked by your staff to use as a case study the evaluation of alternate automobile engine technologies, which is documented in our two-volume report, "Should We Have a New Engine? An Automobile Power Systems Evaluation."[1]

I do not intend to repeat here the technical basis of the evaluation or the specific recommendation-these are documented in the report and in other congressional hearings. Instead, four topics will be discussed: (1) the background reasons for conducting the study; (2) the lessons learned about how to conduct such studies; (3) the post-report-publication activities; and (4) the possible impacts of the effort.

I. BACKGROUND

The concept for the study was established during the spring of 1973 within t e Ford Motor Co. They, along with the rest of the auto industry, were encountering a long and continuing series of adversary interactions with the Government-primarily in congressional hearings and Environmental Protection Agency (EPA) emission control suspension hearings. They were frequently confronted with questions 1" e "why don% you use this new carburetor development?" or "Why don't you intro duce a steam (or electric, or gas turbine, or* *) engine order to meet the 1976 emission standards ?" They would answer these questions. However, the credibility of the industry was very low because, in part, they have a vested interest in the outcome.

Someone within the Ford organization proposed the idea that one way to break out of this defensive position would be to give a substantial study grant to an outside, competent, nonprofit research organization that did not have a vested interest in the outcome. An internal steering group was formed to develop a statement of objectives and to select the study organization. Letters to solicit interest were sent to half a dozen research or animations thought capable of performing the work. After a two-phase elimination **process, cal**tech's Jet Propulsion Laboratory (J L) was selected to perform the stud .

After some very minor negotiations, the statement of objectives and grant agreement was signed off. It is documented as appendix A of volume I of the final report. The important of the form of this agreement cannot be overemphasized-it establishes: (1) the core question Should there be a new engine and when (2) the **Concept** of a moving baseline of Otto engine technology; and (3) the charge to consider the national point of view. A broad charter was established that allowed us to examine any topic that we felt was relevant. I

1 Available through the Society of Automotive Engineers, 300 Commonwealth Drive, Warrendalq P& 15096.

do not feel there were any arbitrary ground rules or limitations in scope that would bias the results.

The rant agreement also established a hands-off relationship between Ford and JPL. Obviously, their purpose would not have been served if there were an suspicion that JPL was influenced by their position. There were to be no progress reports or technical direction b-y Fordoral, nor were they to review the final report. The final report was to be totally public, widely distributed, and released to al interested people at the same time as Ford received their copies.

We feel that this agreement was very important to the conduct of this effort, and the reception of the resul ts. It is also rare, and in retrospect we realize that we probably would not have been able to publish our final report in its current form, with its specific recommendations, if it had been sponsored under a typical contract with a Government agency o, private **company we recommend that the office of** Technology Assessment (C)TA) and other Federal agencies seriously consider a similar grant approach to beet serve the interests of an o n, unbiased public forum. Certainly, if *a* private institution can a fford the risk of such an arrangement, the F ederal Government should also be able to. The Ford Motor Co. must be recommended for this most unusual, enlightened, and venturesome approach

II. LESSONS LEARNED ABOUT THE CONDUCT OF SUCH STUDIES

There are various aspects **about the way in which the study was conducted that allowed** us **to grasp an extremely broad and complex problem, and derive conclusions and s specific recommendations which in the large, have held** up to scrutiny. t hey are Iisted and commented upon below.

No. 1, team selection: The initial selection and formation of the team (and formulation of detailed task breakdowns) took 4 to 8 weeks, and drew from the skills of JPL and the Environmental Quality Lab. over the next 6 to 8 months the composition of the team evolved as we learned more about the **problem and focusd** on the key issues. With a few exceptions the staff worked full-time on this project.

No. 2, team recess: The project acquired a set of contiguous offices and most members were colocated for the duration of the effort. We also had a project secretary, a library, and reproduction machines in the same office complex. The importance of this physical integration cannot be overemphasized in terms of promoting interaction among the various task areas and **facilitating the synthesis and** integration of the final product. We did use subcontractors, but, in a limited way. and as consultants to specific team members. We could not identify pieces of work that could be successfully **performed in** isolation. The lack of integration is one of the major shortcomings of large studies that are broken down at the outset into separate panels, or farmed out to separate contractors.

No. 3. getting immersed in the problem: Most of the team **members** had only limited knowledqe of the automobile industry—mainly that of the interested technical layman. To achieve quick exposure to technical and nontechnical aspects of the problem it was necessary to quickly build a comprehensive library covering all relevant subject areas, read a lot, establish contacts, and conduct visits to key people within the auto industry, regulatory agencies, research agencies, and independent research organizations. Initial contacts were used to ex-

plain what we were up to, solicit cooperation, gain perspective, and to acquire background information.

Subsequent contacts, usually at a working level in the organizatio~ covered details of analysis, test data, potential solutions to problem areas, and further established trust and o en communications. The trust and mutual respect that developed al owed us to gain access to some proprietary data, which have us confidence in certain of our statements even though we cou8 not reference the source or supporting data. Later in the study when the topical chapters of volume II were drafted, these same contacts provided us with valuable technical review and comment.

No. 4, getting the technology right: This seems Iike an obvious rule for a technology assessment (TA) but, frankly , many of the TAs I have seen suffer from an inaccurate or incomplete characterization of the technology .

Gatheringdata and opinions, as discussed above, was a necessary first step, but inadequate if one is to assess a technology 10 to 20 years into the future. To do this, it was necessary to perform independent technical analyses and make self-consistent projections based on physical and thermodynamic principles. Of course, engineering judgment is still required, but usuaIy at a component or materials-technology level where experts can communicate and usually agree. The technology must then be viewed and evaluated in an economic and institutional framework.

No. 5, providing flexibility in scope and depth of analysis: Any complex subject, like automobiles, which affects many people's lives, is essentially boundless. You can start with automobile engines and be led to almost any other aspect of our society-all of which are interesting. However, all of these aspects of the problem cannot be addressed competently in any reasonabl, sized, fixed-duration study. We had to keep continually refocusing on the core question, "Should we have a new engine ?," and explored impact areas far enough to determine their relevance and importance, and then to study only the key issues in depth,

For example, we found very earl-y that organized labor was not likely to be an impediment to the introduction of a new engine technology, and somewhat later, that it was not essential to have an accurate estimate of car sales or vehicle miles traveled in 1990. Fairly wide bounds on such variables would lead to the same conclusions. Conversely, the automobile's role in the air quality of our cities, its energy consumption, the industry's ability and time-scale to convert, were all key issues on which the conclusions are quite dependent. This adaptable, variable-scope, variable-depth approach stands in contrast to some TA methodologies that attempt to examine systematically and exhaustively all potential impacts upon and from a given technology. Such a general approach borders on a model of our entire economy and society, and would be a mammoth (and probably ill-fated) undertaking. If such models are attacked, perhaps they should be done independently and made available to researchers working on specific TAs. Related Points are that such studies must be adequatel, funded to get a quality product. and flexibility must be provided on the schedule as well as the directions to be pursued, and their relative emphasis.

No. 6, review process: Because of our unusual, hands-off relationship with the funding source, our need for an external guide led us to invent our own sponsor-surrogate in the form of a review board. This group was composed of senior JPL managers and Caltech campus faculty members. It was formed at the project's inception, and met with the team an average of once a month. They provided an important management and technical review function, served as an additional source of ideas, and kept the team oriented to the study context and progress that is all too often lost in the day-to-day grind of " getting the work done."

&e did not form an outside oversight committee made up of representatives of all affected interests. It was felt that such a group would not be able to come to consensus (which is true, but not necessary). I personally feel we should have had such an oversight committee, but there is not full agreement on this view. The likelihood for frequent changes of emphasis and extensions of scope would probably result in wasted effort and the inability to maintain schedule and budget. Without such a group we identified and contacted individually the various affected interests. The report critiques and followup activities now serve the oversight function starting from a well thought-out and documented position.

The technical meat of our report, the topical engine chapters of volume 11, were reviewed by selected industry and other outside experts. However, volume 1, which contains all of the intercomparisons, synthesis, and recommendations was not reviewed outside the Caltech/ JPL family. This was done to insure that outside feedback and pressure would not be brought to bear to try to change the recommendations, and to maintain a credible separation from the position of Ford, the rest of the auto industry, and regulatory or R. & D. agencies, consumer groups, or any other advocate.

No. 7, synthesis and final report writing: We brought together various pieces of the study and drew our conclusions and recommendations as a team process. Each member came with his particular information and point of view, and interacted in long and sometimes painful meetings. It seemed very inefficient and frustrating at times, but out of this grew an appreciation of different aspects oft e problem, and members gradually identified with the total team product-not merely their own pieces. After several early drafts the shape of the product began to take form, and one of the team members, Mr. Gregory Nunz, drafted the summary volume. This draft then formed the core which was carefully reviewed and revised by the team and converged to the final product.

The summary was virtually complete befor all of the pieces of the supporting material (volume II) were in final form. It was decided not to publish the summary until all of the backup material was finished, which, while it caused a delay of several months, greatly increased the credibility and impact ofti e final product.

III. POST-REPORT-PUBLICATION ACTIVITIES

one frequently thinks that the project is over when the report is completed. In this case where we were studying a topic of great interest to the general public, motorists, the industry, and government, there

was an immediate and intense interest in the report. We initially printed 2,000 copies of the report-about half of which were distributed immediately to a distribution list of individuals known to be interested that was compiled during the study.

A short press release was prepared and sent through normal channels. That initiated widespread articles in newspapers and requests for radio interviews, news interviews, and for more in-depth articles. Within 3 weeks it was clear that we would need a second printing of the report. As the second printing was completed, we made arrangements for the Society of Automotive Engineers to handle subsequent distribution. They are now into a third printing, and the report set is one of their most highly demanded reports ever-despite a price tag of $16.50 a set.

The team also gave 3-hour verbal briefings to the organizations most directly concerned with the results of the study, the Big Three auto manufacturers, the Energy Resource and Development Administration (ERDA), the Department of Transportation (DOT) (with the Federal Energy Administration (FEA), OTA, and other Federal agencies), and at the Society of Automotive Engineers National meeting. Shorter presentations were given to the Office of Management and Budget (OMB), university seminars and at local meetings of professional and service organizations.

Testimony was solicited and given to three congressional committees and one State of California committee, and four of the APSES team members provided advice to OTA in setting up their technology assessment of "Changes in the Use and Characteristics of Automobiles," which is currently getting underway. In short, there has been a strong demand for the written report as well as verbal presentations ranging from one-half to 3 hours in duration.

We solicited and received critiques of the final report from the auto industry, government agencies, and anyone interested. As you might imagine there was not universal agreement or endorsement of our findings. The loudest complaints came from the manufacturers, who felt we overstated the near-term potential of the conventional Otto engine to meet the statutory emission standards with no loss (even a small gain) in fuel economy, and from the independent developers of those engines that we did not assess as having an attractive long-term future.

The ERDA Transportation Energy Conservation Division has contracted with JPL to digest and respond to those critiques, to extend the scope of the study in specific areas, and to ultimately updata the report to incorporate these changes and additional test and development results that will be forthcoming over the next year or two. This is a unique opportunity to respond to these very constructive critiques and thereby provide a dynamic, rather than a static, report that will continue to be of value to government and industry planning. The Energy Resource and Development Administration should be commended for its foresight.

One of the lessons learned is the large magnitude of activities that took place after the report was published. Some of these were initiated by ourselves but many were
It would have been inappropriate, and reduced the impact of the report, to turn these requests down. Yet it put great strain

on us personally, since we all had other assignments to carry out. A suggestion is that this post-report interaction phase be recognized as an integral and legitimate part of a technology assessment, and that it be provided for in both the plans and budget.

IV. POSSIBLE IMPACTS~ AND USES OF THE REPORT

It is presumptuous of us to attempt to assess what the impact of our report has been or will be. First of all, we are obviously biased since we are proud of our effort. Second, it is premature to make such an assessment. A third observation is that the very process of asking about its impact can affect (positively or negatively) its real impact (observing a social system affects its behavior). Finally, any change or decision is obviously. based on a wide variety of data, intuition, strategy, and considerations (properly) beyond the scope of our effort. At best we could hope to illuminate only a small portion of the rationale or data for a complex decision by a regulatory agency, Congress, or a large industry.

The report has certainly caused a reexamination of the case for, and role of, an alternate engine for cars. The huge potential payoffs and justifiable levels of R. & D. expenditures are perhaps realized by many more people. Professional interest in new engines is expanded, perhaps **giving new hope and stature to those involved in automotive** R. & D. Some colleges have considered using the technical material from volume II as graduate school course material on alternate engines. The possible revitalization of automotive engineering has the interest of some engineering schools.

Our report and congressional testimony may have had some small effect on the mandatory fuel economy bill, some of the pending emissions legislation (although our emphasis was farther out-the mid-80s and beyond), the proposed electric vehicle R. & I1 bills, ERDA's budget in automotive engine R. & D., and the Automotive Transport Research and Development Act of 1976, which was passed by the House on June 3. Both DOT and ERDA have testified that they agree that the recommended Brayton and Stirling engines are the best longer term choices, and ERDA has partially refocused its program on three alternatives.

The effect on the industry is less certain. They certainly have studied our report very carefully and objectively at engineering as well as at top management levels. In this process they have reexamined their previous positions on new engine technologies What specifically has happened, or will happen, is unclear. I do not know if oompany R. & D. budgets or priorities for alternate engines have increased. The industry does seem to be publicly more receptive to an expanded government role in automotive R. & D.—provided the program stays far away from production prototypes

Three of the team members anticipated as National Aeronautics and Space Administration (NASA) representatives to three of the panels of the DOT-led Government study on "Motor Vehicle Goals Beyond 1980." Some of our data was used, but the final recommendations are expected to be rather different than those of APSES. I feel that the differences we fundamentally due to their emphasis on the short term and a very conservative (more conservative than in the auto

industry itself) view of the rate of development of alternative engine technology.

It is important to note that the major product of the study is not its final report but rather the interaction, discussion, and followup by a team of people thoroughly involved in the subject matter of the study. We have also found that we have credibility in both Government and industry circles, and have been able to facilitate communication and understanding between these frequent adversaries.

I have summarized how we did the study, what we learned, and some of the potential impacts of having performed the study. I hope from these observations t at we have contributed to the state-of-the-art of technology assessment. Mr. Barber and I will be happy to answer any questions you may have.

Mr. **BROWN. Thank you very much,** Dr. Stephenson, for that detailed analysis of your experience, which I am sure will be of great value to the Technology Assessment Board. May I ask you if you can spell out in a little more detail the disciplinary backgrounds of the team that prepared the report? Also, have you used to any extent, other than the review processes that you mentioned, inputs from university community consultants or other resources?

Dr. STEPHENSON. Yes. Most of the members of the team had an engineering background, and were either from JPL or from the Environmental Quality Lab at the Caltech campus.

We sought to have an economist involved in the transportation projection part of the task. When we were unable to 1ocate the right type of person, one of the engineers took on this responsibility. We felt that the use of a consultant or a subcontractor in that area would not be a productive way of proceeding. It was also at this time that we realized that our conclusions would not be sensitive to the precise estimate of future transportation usage.

The second part of your question related to use of subcontractors and consultants. We did this on a limited basis. We had three such individuals involved. One was involved in the industry practices, manufacturing, and costing substudy. Another was an expert on air quality and emissions, and the third was a general consultant on engine studies and related previous work to us.

These consultants were paired on a one-on-one basis with one of our internal team members, worked directly for that person, and helped prepare the material for which that particular team individual was responsible.

Mr. BROWN. Can you give me an idea of the man-years involved in the team work Is that possible?

Dr. STEPHENSON. I think it is in the range of 12 to 15 man-years.

Mr. BROWN. I was struck by your statement that you can proceed from an analysis of a problem of this sort to an analysis of almost the entire problems of society. Hence you have a boundary definition problem. Can you elaborate on that a little bit? It seems tome that this same process will occur as you grapple with almost any problem of any magnitude in our society. And there needs to be, if it is possible, some rational way of determining boundaries. I suppose ultimately the scope and depth of problem analysis is resource limited, Because resources are limited the boundary is defined in such a way that the problem can be covered fairly well with available resources. Is that a gen-

eral principle that can be applied, or are there other kinds of principles that you can use in making these limits?

Dr. STEPHENSON. Well, I agree with your point that a characteristic of any broad problem is that you can get to almost any aspect of society from it. Thus, it becomes fundamentally a resource limitation problem and also a problem of keeping relevant focus. I am not very optimistic about trying to set those boundaries at the beginning of a technology assessment (TA) project. I think that the team doing the effort has to be given the freedom to explore those paths that are identified initially as being important and seeing where they lead. Then the primary and secondary impacts can be examined in an appropriate amount of depth, depending on their relevance, rather than trying to uniformly cover all possible outcomes.

Mr. BARBER. Mr. Chairman, if I might address this?

Mr. BROWN. Yes, Mr. Barber.

Mr. BARBER. I believe that although there may be no specific content you can identify previous to a study's start, there might be at least one methodological, if I maybe so bold to use the word, way of going at it. I am referring to the principle of affected interests. This is a method that is well known to the politician and one that is being discovered by us TA neophytes. I recall that we found out what was important by finding out the first thing that was important from someone, anyone, and that person steered us to another thing that they thought was important. We essentially worked our way through the whole web of involvement in that particular kind of a problem, in this case the automobile engine. We received much assistance from all of the people who were truly involved in the solution of the problem. Then it is a matter of understanding how to set priorities for those things that you find out.

Mr. BROWN. Yes.

Mr. BARBER. And to deal with them. .

Mr. Brown. A significant element is finding the boundary of a problem which can be extremely broad. Hence you need to set priorities for the elements within these boundaries. Then using resource limits or whatever, establish certain levels of priorities and concern that are needed to deal with and rationally dispose of the lesser priorities in a cursory fashion. That decision frequently can only be made after you have gotten well into the problem.

I am very much interested in the point that arose earlier this morning about the development of the Volvo technology as an extension of the Otto engine technology. This is going to have a substantial impact upon the course of the deliberations of the Congress, it seems to me, dealing with the extension of the Clean Air Act and other matters relating to environmental pollution in the near future. I am wondering how we deal with this matter.

Could either one or both of you deal for a moment with how you perceive this development as it relates to the findings of your own study, and its impact upon these policy issues with which we are going to be grappling in the next few weeks?

Dr. STEPHENSON.. Well, I will say a few things. We tried to assess the potential of the Otto engine from fundamentals and predicted a mature technology that is very similar to what was recently announced by Volvo.

Mr. BROWN. Was this done on theoretical grounds!

Dr. STEPHENSON. Yes. With the major judgment being relative to the question of the durability of the catalyst for 50,000 miles. A great deal of progress has been made there, and our assessment from a materials point of view was that that desired durability would be achieved within the next few years, and would result in a viable technology.

Mr. BROWN. Did you make this conclusion in the absence of knowledge that the catalyst manufacturer was probably developing a three-way catalyst at the same time that you were preparing your report?

Dr. STEPHENSON. We did not have specific information on the Volvo development at that time. However, we did have interaction with several of the major catalyst manufacturers, and were led to the view that these problems would be overcome with development. I think the thing that is most surprising about the Volvo technology is that it came sooner in a production vehicle than many of us would have presumed. They also went further than they needed to go to meet the 1977 California standards and actually came within, well within, the statutory limits that were set for later on. But this is technologically very predictable and not surprising. It is an example of the kind of technology toward which we feel the Otto engine will evolve.

Mr. BROWN. If it wasn't surprising to you standing outside of the industry, do you think it should have been a surprise within the industry?

Dr. STEPHENSON. I am not sure it was a surprise to them except perhaps that the Volvo catalyst and system durability demonstrated improvements that had not been demonstrated on the fleet tests of the U.S. manufacturers. Perhaps Tom Barber would like to elaborate on some of these questions.

Mr. BARBER. I would like to go back over and relate our experience and our interaction with the automobile companies on the catalyst issue. First of all, it was one of the bones of contention when we published the final report and was directly challenged by several members of the automobile industry. Their statement was that they did not now have a catalyst that will do what we projected. In fact, they went into great technical detail and to great lengths, in highly revolved technical discussion. They indicated precisely how far they had been able to go with their catalysts and precisely the problems that remained. These facts agreed substantially with what we knew to be the facts at that time.

The crux, the basic bone of contention, was our willingness to extrapolate that set of facts based on our experience in technology development. All of us have had a large amount of experience in hardware and other areas of technology development. We had the willingness and the char to extrapolate these facts to a success within a given time period. We said it is our judgment that it is a matter of development, not an invention, that no discovery is required and no basic law of physics needs to be violated, in order to have the emissions system work; it is a matter of just putting enough time, money, and manpower into the issue, and it will be solved. The industry kept saying that they didn't have the answer at hand, and I think that puts the difference between our statements and their statements in a nutshell. I don't know if it is a matter of surprise. It is just a matter of point of view. They kept saying, "We have to build them. You don't." Both

points of view are legitimate when viewed in context. However, for the purpose of illuminating future possibilities, our view has proved to be richer.

Mr. BROWN. Well, there are some important aspects of this which go beyond TA. I think we are going to be having a large amount of continuing discussion on this. We had Ford and General Motors as witnesses last, week in Washington. I saw no indication that they have changed their point of view, that they can meet the current standards even with this Volvo technology, or that the accept the Volvo technology as a valid production-read technology to accomplish the goals. So I am sure that there will be some debate over this as we go along.

Getting back to the methodology of assessments, you have suggested that this unique project on the automobile engine might provide a desirable model for other kinds of TAs. You referred to the relative autonomy that you enjoyed in making this assessment, as well as the internal methods that you utilized here. Is it your view that these can be readily carried over to a broad range of assessments, and that they didn't have some particular or unique utility because of the nature of the problem you were working with?

Dr. STEPHENSON. I think the principles are general and can be used in man different situations.

Mr. BROWN. The methodology used by the Technology Assessment Board, and I am not contending that it is by any means ideal, has relied more heavily on external review or review committees, fairly carefully selected to represent the various contending interests. The panels have provided some input during the course of assessments and may even actually do a considerable amount of work on the assessment. Do you see that methodological approach as an equally valid, less valid, or more valid method of approaching some of these problems; or is there any way of determining without first looking at the problem itself?

Dr. STEPHENSON. Well, there are different views on that general topic of how and how much to involve the affected interests and what the boundaries should be. I would not suggest that you go to the last step that you listed of actually having such a board do the assessment. I don't see how that can be competently done. I think the value of such committees is in making sure that you identify the affected interests and the key problems, and are addressing them.

Mr. BROWN. And the key impacts?

Dr. STEPHENSON. Yes; the key impacts and the interactions that you might overlook. I think if on went into a brand new area that has been relatively unstudied, the need for external review committees might be considerably greater than for a problem that has been looked at a great deal such as the automobile and the engine. People who are familiar with the literature have a pretty good idea of what are the affected interests, key problems, and the issues. So I think how much of an oversight committee or affected interest type of committee you would want to have should depend on the area in which you are doing TA. The problem of going too far in that direction is; how do you keep the stud bounded in scope, and how do you get done an where near within budget, or within the schedule that was originally established.

Mr. BROWN. You get involved in a selection process when you want to do a major assessment. You have to in fairness examine pretty much the universe of capable performers in this area.

Dr. STEPHENSON. Yes.

Mr. BROWN. In order to get one that is at least near the to in the ability to give the results that you want or give the quality of results that you want.

Dr. STEPHENSON. Yes.

Mr. BARBER. Mr. Chairman, if I may. I think for the issue of public review there is more of a distinction in when the review happens rather than whether or not it happens. For example, in the case of the Automobile Power Systems Evaluation Study (APSES) report, one of the reasons we put so much emphasis on the post report activity is due to the fact that we didn't have the policy review and oversight committee incorporated into the actual performance of the study. It is a matter of when these issues are addressed. It is my opinion that the policy issues are best reviewed publicly after the study has had a chance to amass the facts and folklore on the subject at hand.

Mr. BROWN. I think that was a useful procedural observation. It is helpful to recognize the extended life of these studies and provide for, at least to some degree, the post-report analysis and followup, including distribution, review, and comment. If a report truly performs a vital informational service, it needs to be utilized as an educational tool by a very broad public, which may be a hard requirement to work into the assessment process. Apparently you shifted this problem over to whomever wants to take it on, in this case the Society of Automotive Engineers, for the distribution of the report, and to various institutions that may want to incorporate it in their educational recesses.

I suspect that you have to put some definite limits on how far you go into post-report activities, just as you do in preparing your report itself, but it is obviously a very, very useful component of the total process.

Thank you very much, gentlemen. I would like to explore this at considerably more length in view of the additional repercussions that you have pointed out in your statement. We still ho e to et that R. & D. bill through the Congress in the next couple of months. You may be called upon for some further activities. However, this is as much as we have time to go into this morning, and we again express our appreciation to you for your help. There are a number of additional questions that we will be submitting to you and we would appreciate your written responses.

Dr. STEPHENSON. Thank you very much.

[The following questions were submitted by Congressman Brown to Dr. Stephenson and his answers thereto:]

Question 1. In the conduct of your study did you feel that it was important to have a truly interdisciplinary team? Please explain. Did you have a sociologist and psychologist on the team? Why or why not, ?

Answer 1. I Welcome the opportunity to elaborate on my testimony relative to the question of team composition. The appropriate team composition is dependent upon the problem being addressed and the approach taken to the technology assessment (TA). For example, the core question in the Automobile **Power Systems Evaluation Study (APSES) was a technical one relating to**

new engines for automobiles-and it was essential to get the technology right in order to address that question. Also, in our methodology, we based our comparisons on Otto Engine Equivalent cars-that is, vehicles powered by alternate engines that were functionally indistinguishable to the consumer. We were also studying a time frame for introduction of the new technology in the 1980's and an impact-time horizon up to the year 2000. For these reasons, we appropriately needed a team heavily oriented toward engineering skills and it was not appropriate to have sociologists or psychologists to assess the acceptance of or impacts on individuals.

The composition of the APSES team was multidisciplinary, primarily in engineering and science (Mechanical Engineering, Chemistry and Chemical Engipeering, Electrical Engineering, Metallurgy, Physics, and Operations Research). Some of the team members had additional degrees in Business Administration and Policy Science. Many had extra schooling in social sciences, and several had previous experience in working on applications of technology to societal problems. For TAs where there is not a close analogy or example of the technology currently used in society, it is necessary to have a much broader, and different set of disciplines on the team.

Question 2. How did You involve the public in your assessment? Was the study reviewed by consumer and public participation groups? In general, what kind of reactions were received?

Answer 2. The public was not involved in a formal way in our study, but they were represented by each of us on the team and review board through our experiences and reading. We also acquired books and public literature in relevant fields including air pollution, energy conservation, role of the automobile, dealers publications, highways and transportation, and publications of consumer advocates. Personal contacts were also made with several consumer groups who have studied the automobile and/or environmental questions.

As stated in my testimony, no pre-publication review of volume 1 (which contains the comparisons, synthesis, and recommendations) was made by anyone outside the Jet Propulsion Laboratory-California Institute of Technology (JPL/Caltech) community. The final report was distributed to known consumer and public participation groups and to my knowledge we have not yet received any comment—positive or negative-from them.

Question 3. What limits do you see to the utilization and application of the concept of TA in the Government and in the private sectors?

Answer 3. I see two kinds of limits-one in terms of what can be done within a TA and the second in terms of what TAs will be requested by the Government and other funding sources.

The first limitation—the state-of-the-art of TA—is very severe. As I suggested in my testimony you can start with almost any problem and be led into nearly all aspects of society. It is hard enough to get the first order effects "right," and nearly impossible to determine the response of our "open system," and then the secondary and tertiary effects. Another problem is that it is often difficult to label an effect "good" or "bad" even after having described it.

The second limitation is the willingness of funding sources to support TAs. This results from the fact that such studies are very expensive (as studies go), take a long time and as indicated in my testimony, don't end when the report is published, and frequently will lead to a negative or cautious result. It seems that many technology assessors are primarily concerned with "impacts" and that the harder and further we look the more that are found. Frequently there is an implicit assumption that the status quo is fine and any change is bad, or that the natural environment in the absence of man is the ideal. More emphasis is needed on the benefits side. In some cases change itself may be beneficial.

Question 4. With respect to TA, do you see any value in a closer relationship between the public and private sector?

Answer 4. Yes, in many TAs it is the private sector that has the detailed information on the technology, including marketing and manufacturing. It has a great deal of data, and in many cases, will become the implementor of the technology being assessed. Thus it is essential that the private sector be closely involved with the assessor and the Government agencies that may be involved in the regulation or funding of the technology.

Question 5. What should be the basis *for* deciding to do a TA instead of *some* other kind of analysis?

Answer 5. Other types of studies that come to mind include cost-effectiveness, cost-benefit, and environmental impact studies. These are usually done for a

specific technology, frequently at a specific location, and usually are limited to the intended effects of a given technology. A TA would be a more appropriate type of analysis when it is expected that the application of the technology may become very widespread (e.g. automobiles), or its effects may be very large or perhaps irreversible (e.g. nuclear waste), or it is expected that there may be very important, unintended (or secondary or tertiary) effects.

Question 6. How do human value systems affect technological development? What role should the analysts of value systems have in assessing the impacts of technology on society and on the environment?

Answer 6. I expect the major ways that human value systems affect technological development is through the political process (in terms of what gets funded or regulated) and through the value systems of those actually doing the technology development (and their associated decisionmakers). For TAs in which people's values are very important and unknown, then a specific analysis of values is needed. I am not sure whether a generalized analysis of value systems would be beneficial to any specific TA.

Mr. BROWN. We have one additional witness this morning, and I would like to complete his, testimony if we may. He is Mr. Selwyn Enzer, Associate Director, Center for Futures Research, University of Southern California. We are very pleased to have Mr. Enzer here, and I hope to learn more about what the Center for Futures Research is doing, and how it incorporates technology assessment (TA) as a component of its activity. Without objection, the full text of your prepared statement will appear in the record and you may proceed with our oral statement in an way that you wish.

[The biographical sketch of Mr. Selwyn Enzer is as follows:]

MR. SELWYN ENZER, ASSOCIATE DIRECTOR, CENTER FOR FUTURES RESEARCH, GRADUATE SCHOOL OF BUSINESS ADMINISTRATION, UNIVERSITY OF SOUTHERN CALIFORNIA

B.S. civil engineering, The City College of New York, 1951. Additional courses completed in: advanced mathematics, economics, operations research, statistics, and quantitative business models at Brooklyn Polytechnic Institute and the University of Southern California.

Professional experience prior to 1969: the design and analysis of commercial and industrial structures, powerplants, steel mills, chemical plants, and related projects; structural engineer, Republic Aviation Corporation; determination of mission and systems requirements for future space programs, Advanced Systems Division, Space Division, Rockwell International ; technical director of space studies, McDonnell-Douglas Astronautics Company.

Professional experience from 1969-1975: Senior Research Fellow and Treasurer of The Institute for The Future, research on development and application of forecasting methods for assessing the long-term social impacts of changing bankruptcy laws, no-fault insurance, and exploring alternative future issues for corporate clients; and Chairman (2 years) of the National Advisory Board Committee on Technical Aspects of Critical and Strategic Materials.

Professional experience 1975-present: at the Center for Futures Research, preparation of long-term transportation scenarios for the State of California (CALTRANS) ; director, 2nd annual 20-year forecast of world food problem sponsored by NSF: principal investigator for research on interactive modeling techniques sponsored by CALTRANS; and member of the National Materials Advisory Board Committee on Contingency Plans for Chromium Utilization.

Numerous publications and papers presented at conferences on various aspects of technology assessment and futures research between 1970-1976.

STATEMENT OF SELWYN ENZER, ASSOCIATE DIRECTOR, CENTER FOR FUTURES RESEARCH, GRADUATE SCHOOL OF BUSINESS, UNIVERSITY OF SOUTHERN CALIFORNIA

[The complete statement of Mr. Selwyn Enzer is as follows:]

STATEMENT ON SOME PROGRESS AND PROBLEMS IN TECHNOLOGY ASSESSMENT BEFORE THE CONGRESSIONAL BOARD OF THE OFFICE OF TECHNOLOGY ASSESSMENT BY SELWYN ENZER, ASSOCIATE DIRECTOR, CENTER FOR FUTURES RESEARCH, GRADUATE SCHOOL OF BUSINESS, UNIVERSITY OF CALIFORNIA, LOS ANGELES, CALIF., ON JUNE 14, 1976.

Technology assessment (TA) is an old idea whose time has finally come. The need for TA is as old as the story of Adam and Eve, because if Eve had assessed the full range of consequences associated with apple-eating, we might all still be in the Garden of Eden. Yet how could she know of the consequences ? The apple was sweet and its rewards were immediate, while the future, then as now, was distant and uncertain, notwithstanding the fact that she was advised of the consequences by a Prophet with impeccable credentials.

In the intervening centuries, technological progress has been a truly irresistible force. Neither individuals nor their social institutions have been able to hold back the forces of technology no matter how perilous a future the technology portrayed. Immediate needs and the promise of further technological progress always seemed to win out. So we went from stone to iron, from arrows to bullets, from horses to machines, and from wood to coal to oil without excessive concern over the indirect consequences of those changes.

Now after centuries of experiencing undesired, unintended consequences of technological change, the inevitability of the technological imperative is being challenged. The challenge is coming not from the TA movement alone, but also from informal and concerned citizens in general. It appears under such names as consumerism and environmentalism, but all address the same basic weakness in our system of checks and balances. As a result, technology will no longer be evaluated on the basis of immediate needs alone: the full spectrum of alternatives and their consequences will have to be considered.

No *one* opposing a new power plant, highway, or oil pipeline argues that the development does not respond to some desire or satisfy some need. Environmentalists recognize the need for more energy, more food, etc. The questions that they raise are concerned with whether or not we have considered all of the alternatives and whether our choices appropriately assess the full range of consequences we face. Decisionmakers similarly recognize the need for these assessments. The issue is not one of disagreement as to what has to be done, but rather concerns what can be done and how to do it.

The founders of TA recognized that formal program analysis was based exclusively on immediate needs. With coats and benefits based on immediate needs, program analysis reduces exclusively to the consideration of technical feasibility and economics, and on this basis technology indeed becomes an irresistible force. Therefore, they expanded the issue to ask about what else may happen, and whether or not we would welcome those happenings. This gave rise to a new type of analysis that some have called a new discipline. What distinguishes TA from previous analyses is that TA stipulates the desirability of the innovation with regard to immediate needs, and systematically explores the longer range consequences that may follow from the successful implementation of the proposed innovation.

Even though they recognized that TA was an art form that could never be handled in a truly scientific manner, the early technology assessors were generally *systems* analysts schooled in operations research, and the methods of scientific inquiry. They attempted to use methods of scientific inquiry to assure comprehensive coverage of the issue and its impact areas, Of course the application of scientific analytic procedures to TA is at once a paradox, Scientific analysis depends upon positive data and a complete understanding of underlying processes of *change*, whereas the future is fraught with uncertainty and non-scientific issues involving human values. As a result, the sciences have always avoided decisions on the desirability of technology, relegating these choices to the political process. The early technology assessors recognized that this dichotomy had grown too large. Technology affects all aspects of society, and if the political process was to be effective in making technological choices, a more cooperative posture between the physical and social sciences had to be developed.

Now, after a number of years in which many TAs (and many so-called TAs) have been performed by government agencies, industrial organizations, think-tanks, and universities, it can be useful to take stock of the progress made in

developing TA into a useful analytic tool. However, we must remember that we are dealing with an ancient problem and are reviewing only our initial efforts. Hence, we must not be too hasty in judging what is success and what is failure. Yet we must be able to discriminate positive findings from spurious conclusions. To do this, there are several caveats that should be borne in mind.

Much of what is reported as TA, is really not TA at all. The reason for this confusion is partly definitional and partly due to a misunderstanding as to what TA really is, or more precisely what it is intended to be, and how that differs from conventional Investigations of possible new technological applications or even market studies. After all, most market researchers investigating the business potential of a new technology regard their activities as assessments of the business potential of that technology. Similarly, many systems analysts regard their studies as TAs because systems analyses are typically concerned with all possible technological options and outcomes. And while it is true that these analyses are similar to TAs in many ways, they differ in a number of key aspects. Hence, the first caveat is that many of the so called TAs are frequently something else, and it would be erroneous to evaluate TA on the assumption that all analytical efforts that are called TAs are true TAs.

There was and still is considerable *disagreement* as to the specific nature and understanding of TA even among those who are fairly well in tune with the goals of TA. This is the sort of evolutionary situation that one would expect with a new analytic tool. However, the lack of early definition and understanding led many assessors to adopt analytic procedures in the conduct of TAs that ultimately proved unsatisfactory. In post-mortem reviews of many TAs, the assessors can frequently identify assumptions or constraints that were introduced in an attempt to improve the analysis, but that proved counter productive in the end. A TA workshop sponsored by the Academy for Contemporary Problems and the National Science Foundation (NSF) in 1974, cited many examples of this situation. Thus the second caveat is that many TAs contain basic deficiencies that the researchers recognize but that may not be evident in the final report. These weaknesses should be identified, and care should be exercised in evaluating the utility of the results of assessments containing such weaknesses.

The final caveat is concerned with the expectations of the sponsors of TAs, and the impact these expectations have had on the research itself and the recommendations that followed from the assessments, Although it is obvious that the only value realized from a TA is in the program changes it promotes, change is always resisted by incumbent interests. Furthermore, when the recommendations for change are basin on indirect and higher order impacts, the need for change is easily attacked on the basis of uncertainty. This is amplified by researchers engaged in TA who are generally conditioned in the scientific method, and regard making recommendations based on value judgment as sinful behaviour. As a result, specific policy recommendations, which are so important in political circles, are meticulously avoided by the usual cadre of personnel involved in TAs. Instead. TA results generally present a menu of alternatives and possible impacts, which in attempting to be exhaustive and objective, include considerable trivia and avoid the value judgments that in the long run are most important.

This problem is still very much a part of the current state-of-the-art of TA. In order for this condition to improve, sponsors will have to expect recommendations that are controversial and that may run counter to their ongoing programs. Technology assessors must recognize that the value sought from their deliberations necessitates stimulating the forces of change and that these changes will be resisted.

The need for TA as a constructive tool in guiding forces *of* change in our society is obvious. It is reinforced every time we observe undesirable side effects from programs intended to satisfy a societal need. But just as it is hard for a child to see a stomach ache in ice cream and apple pie, it is difficult for a technocrat, government administrator, legislator, or business leader to see problems emanating from socially needed programs to which he or she is dedicated. Therefore, we must develop a greater appreciation of the fact that the best laid plans can go astray, and that collaborative efforts between innovators and assessors can reduce the frequency of these undesired outcomes.

WHAT IS TECHNOLOGY ASSESSMENT?

If people familiar with TA were polled, a surprisingly large number of different definitions of TA would be found, and an even greater variance in how a TA

should be conducted. The definitions generally boil down to a search for unintended consequences that may follow from the successful fulfillment of a technological program--so that we can deal with unintended consequences before they become social issues themselves. This distinguishes TA from other forms of 'technological investigation and it also increases its complexity enormously. Ideally a TA team must be able to assuree that a particular program (in say energy, transportation, etc.) is completed as planned, and must then proceed to investigate what further consequences may occur as a result of that success, while still retaining perspective on other changing societal conditions. There are no constraints or guidelines telling the assessors where to look. On the contrary, identifying such higher order, indirect impact areas, is an important part of the "l'A. There are no constraints or guidelines as to how far ahead the assessors should look. Generally the technological change being assessed will take years to reach its successful fulfillment and the indirect consequences may take many more years to manifest themselves. Hence, TA is inherently future-oriented, and as a result involves considerable uncertainty.

Technology assessment is not limited to physical or biological techniques. Many social innovations have been responsible for unintended impacts of immense societal consequences. Legislation creating the land grants colleges, social security, and no-fault automobile insurance are a few examples of social technologies that have been the subject of assessments or have been suggested as candidates for assessment.

Each of these innovations poses different methodological problems in the detailed conduct of a TA, but they share two common characteristics that present enormous complications—they are entirely open-ended and they do not have any singular "right" answer. By their very nature, problems of this type defy rigorous solution. Understanding them involves imagination, conjecture, and judgment applied in a way that is in opposition to the way we were trained to think and to solve problems.

These considerations, more than any specific methodological problems, are responsible for the difficulties in promoting the development of the discipline of TA as an art form. They also represent a major source of difficulty on the part of policy makers who generally look for more positive conclusions from analytic -results.

THE CRITICAL NEED--AN ASSESSMENT ORIENTATION

Our educational system teaches us to think along discipline structured lines and to solve problems that have precisely determinable answers. Technology assessment demands that we think in an interdisciplinary fashion, and that we are able to appreciate not only the different outcomes that can result, but also how differently these outcomes are likely to be viewed by various social groups. Not only are we ill-equipped as analysts to cope with this type of problem, but also *as* users of information we find that such results can often increase rather than reduce our uncertainty.

It has been said that the more we know, the more uncertain we become. This is certainly true in TA. Yet the situation is not hopeless. On the contrary, with the proper orientation, we will recognize that the improvement we seek is not easy to obtain, and cannot be relegated to a group of planners who will tell us what should be done if we wish to avoid undesirable indirect social consequences from technological progress.

It is self-evident to say that we are surprised only when things we did not expect to happen actually occur. (This also includes the converse, that is, when things we did expect actually do not occur.) Generally however, not all of us are surprised. Frequently, there was some minority viewpoint that did anticipate what the majority regarded as unlikely. General Billy Mitchell of the Air Force has often been cited as the leading modern example of such minority opinions. The problems we face as analysts and users of TAs are how to nurture these imaginative minority viewpoints, and how to deal with them in a socially responsible manner.

Several responses are possible. One is to study this minority viewpoint further, an approach that some contend is a death sentence, an alternative to action. Another response is to assume the minority viewpoint to be correct, and to evaluate possible policy responses and their timing. It may be that key early warning signals can be identified and monitored to determine whether or not the situation anticipated by this minority opinion is developing. It may even be possible to make some policy adjustments that retain the original objectives while also accommodating the minority viewpoint.

The point is that conventional attitudes seek unique optimal solutions to problems that do not lend themselves to such simplification. In order for TA to be effective, we must expand the range of options, and our understanding of the full range of consequences these options contain. If this orientation is achieved, TA mechanisms and public debate will elevate to a point where more effective management of change will become a reality.

METHODOLOGICAL PROGRESS AND PROBLEMS

Many **methods have been developed in the past few years that are useful in pursuing the goals of TA. These methods address both the macro- and micro-aspects of the** assessment; that is, they describe a sequence of steps that must be taken to assure comprehensive coverage of all critical aspects of the assessment, and offer detailed procedures that can be of value in the conduct of one or more of the individual steps.

The macro-procedures have been presented with as few as 5 steps and frequently with more than 10 steps. On close inspection however, all of these procedures contain 5 essential tasks. These tasks and the subtasks they include are presented in Table 1. A detailed review of these tasks is not appropriate for our purposes, but some points are worth noting. First, these methods are structural rather than substantive. That is, they provide a systematic sequence of steps to be taken, but they provide no specific formula, the application of which would be sufficient to assure high quality results. This is consistent with the contention made earlier that TA is an art form, not a science. The application of these methods does not replace the need for highly creative and imaginative deliberations. These are necessary to produce quality results. It is important to note however, that there is general agreement about the steps that are essential for the proper conduct of a TA.

TABLE I—GENERAL TASKS IN TECHNOLOGY ASSESSMENT

1. DEFINE THE ISSUE AND **ITS CURRENT** STATUS

issue characteristics (problems, opportunities, alternative innovations, key questions, etc.).
Factors affecting the issue (stakeholder groups, values, external changes, etc.).
Goals and objectives.
Scope (impact areas to be included, time period).
Indicators (performance, effectiveness, satisfaction, criticality).
Current status, trends, and expectations.

2. **DESCRIBE THE NOMINAL FUTURE COURSE OF THE ISSUE**

Projections of issue trends and indicators.
External changes that may affect the issue (probability, time, impact).
Interactions among external changes and issue projections.
Alternative issue scenarios (exclusive of societal intervention).
Initial impact projections.

8. IDENTIFY POTENTIAL ***ACTIONS***

Alternative actions,
Conditions that might dictate actions.
Resource needs (economic, institutional, human).
Timing.
Impact on alternative issue scenarios.

4. **DESCRIBE AND** EVALUATE SCENARIOS

Candidate action programs.
Resulting scenarios.
Changes in expected impacts.
Assessment of outcomes (from viewpoints of stakeholder groups).
Preliminary identification of attractive alternatives.
Key branch points, milestones, monitoring signals.

Indirect and higher order consequences.
Stakeholder groups affected by consequences.
Action programs that enhance indirect impacts.
Program recommendations.

NOTE: **Frequent iteration among all of these tasks is an essential feature of** TA. **Aside from expediting the assessment process, this agreement facilitates communication between the assessors and the sponsors (or users) of the assessment.**

It should also be noted that some assessors emphasize certain tasks and minimize others. The issue over which there is the greatest disagreement is the degree to which the assessment team should seek to make value judgments and policy recommendations. This is partly the result of the unscientific nature of such evaluations, and partly to preserve the sense of objectivity with which the assessment was conducted. While the hazards associated with making value analyses are real, and do tend to crystallize the assessor's position, they are essential to some degree if the assessment is to confine itself to meaningful options and avoid theoretically possible, but trivial alternatives. More importantly however, recommendations are an important means by which the findings of a TA are communicated to decision makers and interested parties in general. Of course all recommendations must be supported by the analytic results. These must show which choices were considered at each step in the assessment, the assumptions, and the evaluation criteria used in selecting among the choices. An exhaustive menu of alternatives and their impacts presented without preferences can easily be disregarded by political forces.

The nature of the subtasks is likely to vary considerably to suit the issue being evaluated. In certain cases, only qualitative evaluations may be possible, while in others highly quantitative analyses may be needed. A wide variety of methods are available to insure comprehensiveness in each of these steps. These methods range from complex simulation modeling techniques to exploratory brainstorming sessions. Considerable progress has been made in these methods over the past few years, but as with the macro-techniques, all of these methods are structural rather than substantive. While it is not appropriate to present a detailed review of the micro-techniques available for each of the tasks in the assessment process, Figure 1 gives some indication of the variety of different methods, and their utility for each of the five tasks presented earlier.

Figure 1 - METHOD / ANALYTIC TASK MATRIX

METHOD	ANALYTIC TASK: 1. ISSUE DEFINITION	2. NOMINAL FUTURE COURSE OF ISSUE	3. POTENTIAL ACTIONS	4. ALTERNATIVE SCENARIOS	5. IMPACT ASSESSMENTS
1. MULTIDIMENSIONAL SCALING	**				
2. MORPHOLOGICAL ANALYSIS	*		**		
3. RELEVANCE ANALYSIS	***		**		***
4. POLLS	**				
5. BRAINSTORMING	**		**		***
6. CONFERENCE & SEMINARS	**	*	**	*	*
7. INDIVIDUAL INSIGHT	*	*	*	*	*
8. DELPHI	**	**	**	**	**
9. SCENARIO WRITING		*	**	***	***
10. EXTRAPOLATION	**	**			
11. QUANTITATIVE MODELS	*	***	*	***	*
12. QUALITATIVE MODELS	**	**	*	***	
13. SIMULATION & GAMING	k	*	*	***	***
14. CROSS-SUPPORT MATRICES	*		**		
15. CROSS-IMPACT ANALYSIS		***	**	***	***

* = USEFUL

** = VERY USEFUL

*** = KEY METHOD

Notwithstanding the structural nature of these techniques, their value in TA should not be underestimated. A relevance analysis, for example, is an extremely powerful tool for developing a systematic definition of the issue involved in the assessment. Not only does it promote comprehensiveness, but it also facilitates interdisciplinary collaboration among the assessment team because it

highlights those areas where the social, physical, economic, and other aspects of the issue interact.

Similar experiences have been realized with the other techniques described in Figure 1, although many of them tend to be more specialized and hence less flexible than relevance analysis. Indeed, one of the areas of greatest progress has been in the development of methods that aid in the investigation of the open-ended problems found in TA.

The principal problems currently associated with the conduct of TA and some thoughts on how these may be approached are discussed below.

1. BOUNDING THE ASSESSMENT

This problem has 2 components. The first is concerned with the definition of the technology itself, while the second is a methodological problem that occurs in all TAs. A good example of the first type of problem is the energy crisis. A complete assessment of that issue would be far too large to be practical for any one organization to handle. Breaking the subject into small components, for example by energy sources, may introduce wasteful overlap and possible inconsistencies. However, this problem is generally manageable by the sponsoring agency's project monitoring team.

A more difficult problem comes about during the conduct of the assessment itself, and is concerned with the systematic identification of indirect and higher order impacts. In a world where everything is said to be connected to everything else, this is truly an open-ended problem. Furthermore, since the search is intended to include higher order impacts-which are the result of the interaction of different impacts emanating from different causes-the critical elements of this aspect of the search may be only peripherally included in the basic assessment.

Current methods for systematically screening possible areas for important impacts simply do not exist. All approaches to this critical problem are based exclusively on judgment. Most current approaches are variants of brainstorming sessions involving people from different disciplinary backgrounds and varying points of view. This approach may overlook not only important, obscure, indirect impacts, but may easily overlook important higher order impacts that may not have been difficult to pin-point if a systematic screening procedure were available. Basic research into procedures that can be used to screen possible impact areas can be of immense value in assuring comprehensive identification of important indirect and higher order impacts.

2. *INTERDISCIPLINARITY* IN TECHNOLOGY ASSESSMENTS

As indicated earlier, our education system and hence our intellectual orientation is structured along disciplinary lines. On the other hand, most of the impacts that concern us in TA are the result of a change in one discipline acting on other disciplines--e.g., the effect of the use of persistent pesticides on wildlife, the impact of spray propellants on the upper atmosphere, the impact of new communications devices on social lifestyles and regional development, etc. Aside from our disciplinary orientation, communication difficulties and the lack of incentives work against the establishment of interdisciplinary cooperation.

Successful TAs have employed teams composed of experts from the key disciplines involved in the technology being assessed. These team members act as spokesmen for their disciplines obtaining appropriate data from the literature and other experts in their fields. These data are then integrated for the purpose of the TA by the team members. However, the creation of such interdisciplinary teams are quite time-consuming and Institutional incentives to encourage such efforts are often lacking.

In a university where a broad range of skills are generally available, competent experts in such fields as economics, law, political sciences, find that multidisciplinary research contributes very little toward their career development. Tenure and promotions are largely based on individual achievements along disciplinary lines that receive peer group acclaim. This situation makes it difficult to entice young faculty members into TA teams. (Senior faculty are generally too immersed in their specialties to be reoriented for interdisciplinary work.) And, in those cases where it has been possible to create interdisciplinary teams, the team was generally short-lived because of the lack of discipline-oriented recognition these efforts received.

To encourage interdisciplinary research, The Center for Future Research at USC has attempted to establish part-time interdisciplinary teams so that each member retains some contact in his basic field. We have also supported the individual preparation of discipline-oriented position papers on the various aspects of our assessment studies. These position papers provide the research products needed for faculty career development as well as the input data necessary for the TA.

Institutional changes that will enhance interdisciplinary research within a university are occurring, but at a very slow pace. This process can be accelerated if support for TA efforts were available on a more continuous basis. This unfortunately is not the case in the current environment where TAs are generally awarded against Requests for Proposals (RFPs), and are structured to match annual funding cycles. (Responding to RFPs is particularly difficult in universities where often there is no proposal preparation budget and no means of recovering the cost of such efforts in overhead rates.)

Another reason interdisciplinarity often suffers in TA is because eminent research personnel frequently hold such efforts in low regard. Much of the resistance to engaging such people in interdisciplinary research can be overcome by governmental agencies than sponsor substantial amounts of discipline-oriented research. If for example, the United States Department of Agriculture (USDA) were to encourage personnel (whose research they typically support) to cooperate with TA activities, these personnel would find it difficult to refuse. This can prove quite valuable if the researcher in question has unique insights of importance to the TA.

In summary, the problems of interdisciplinarity in TA are both institutional and intellectual. The problems can be overcome, but there are considerable start-up costs that must be borne in creating effective interdisciplinary teams from scratch. Because the university contains a broad spectrum of skills, it provides an ideal setting for such activities. However, because of the degree to which universities are institutionalized along disciplinary lines and because of their funding constraints, they require special consideration regarding continuity of support to attract and retain their team members.

3. POLICY RECOMMENDATIONS THAT MAXIMIZE THE DESIRABLE CONSEQUENCES OF TECHNOLOGY WHILE AVOIDING UNINTENDED NEGATIVE SIDE EFFECTS

Technology assessments frequently avoid value-laden issues that do not lend themselves to objective analysis. It is a difficult task to accurately assess the "social costs and benefits that accrue to various interest groups within a society, but this task is clearly part of a TA, and most assessment teams will accept this responsibility. It is far more difficult to choose a set of actions that distributes these costs and benefits equitably, yet some assessors regard this as an essential part of the assessment process. We at The Center for Futures Research consider it an important aspect of any assessment. However, converting these recommendations to operational policies that are implementable within governmental and industrial institutions is another matter.

In an assessment of no-fault automobile insurance, in which I was the principal investigator, it would have been easy for the assessment team to analyze the costs and benefits of the various schemes that could be devised and to present recommendations as to the desirable alternatives However, we could not draft the legislation, nor could we identify the institutional adjustments that would be required to. implement our recommendations. This is not within the competence of a TA team, and any attempt to move too far along those lines is likely to produce naive results that can only serve to discredit the entire effort.

What is needed for the policy formulation is an interdisciplinary effort that differs somewhat from the one presented earlier. This interdisciplinary effort should be between the assessment team and the staff of the Office of Technology Assessment (OTA) or other sponsoring agencies. The point is that the institution that sets policy is best qualified to draft the appropriate policy mechanisms. The assessment team can only advise in these matters.

This approach presents serious difficulties when the sponsor is not the policy setting agency per se, such as is the case with NSF-sponsored assessments, or when implementation of the appropriate action requires a policy change on the part of a third organization. Here too, actual policy information should not be attempted by the assessment team alone, but with the involvement of the spon-

soring agency, even if that involvement consists of negotiating for the cooperation of the appropriate third parties for this purpose.

4. LIMITATIONS IMPOSED BY DIFFERENT TYPES OF SPONSORING INSTITUTIONS

Technology assessments are currently being sponsored by various government and industrial organizations. In some cases the sponsoring organisation performs the assessment in-house and in some cases all or part of the assessment is contracted to outside institution--profit or nonprofit think tanks, or universities. In any case, the sponsoring organization is primarily concerned with meeting the needs of its stakeholders or customers, rather than any idealized version of society. When the sponsor is a government agency, the dichotomy between the sponsor's constituency and society in general is less than when the sponsor is an industrial organization. This is not intended to imply that industrialists are anti-society, but rather that their operating goals are motivated by profits. rather than the commonweal or the quality of life, and these goals are not always entirely the same. A similar argument could be made for government agencies with special interests such as the USDA, the Federal Aviation Agency,. or State and local governments. These agencies have considerably narrower charters than that of the Congress, which OTA serves.

The point is that the sponsor exerts considerable leverage in scoping the effort. Industry-sponsored assessments will respond to interest groups that affect their profitability. These typically are the consumerist and environmentalist groups. (Industry has always been concerned with meeting existing regulations and product safety requirements; hence these are not singled out as anything new that has to be covered by a TA.)

IN CONCLUSION

The objective of TA, namely guiding change on the basis of a complete understanding of alternatives and their consequences, can be found in many social demands including the consumerism and environmentalist movements. As a result many government and industrial organizations find themselves having been engaged in TA activities before they had any awareness of TA. The demand for better guidance *of* change in our society is now so pervasive that despite the methodological, institutional and intellectual difficulties, TA will continue to grow and expand although it may do so under a variety of different names.

Technology assessment is inherently open-ended and hence will never be amenable to closed-form rigorous analysis. It is an art, not a science. Methods have been developed that greatly facilitate the practice of this art-form, but they are no replacement for imaginative and creative inputs. We must promote the orientation-divergent thinking and interdisciplinarity--necessary to maximize our TA talents. This is as important for the assessors as it is for the users of the results of the assessments. The assessors must be able to think in terms of expanding sets of possibilities and impacts, whereas the users must be able to cope with unlikely impacts. After all, it is only from the occurrence of unlikely outcomes that we get the unexpected side effects that TA attempts to control.

The difficulties associated with trading off immediate payoffs for low probability future possibilities, are of both an institutional and an intellectual nature. The tendency is to discount undesirable future impacts even if the probabilities. of their occurrence are great. After all Adam and Eve made the wrong decision even after being given perfect information. Technology assessment will never provide decisionmakers with perfect information, but with the proper orientation on the part of the decisionmaker he will make better use of it than Adam and Eve did.

Mr. ENZER. I would just like to skim through my statement, highlighting some of the more important points. The concept technology assessment (TA) really addresses a very old problem. What we are concerned with is changing or even compromising present needs or present objectives or goals, in light of uncertain possibilities or consequences that may occur in the future. This is a very difficult task for society to undertake. Our history shows that we have traditionally deferred the future; that the present has driven the future out. It has often been said that we have moved from technology to technology

without really worrying about the longer term consequences, trusting -that future generations or future technologies will take care of these consequences. But today we have come to regard these consequences as a challenge. Technology assessment is a formal response to that challenge; that is, it is the formal mechanisms by which we can look at the indirect consequences of change, to explore our alternatives more carefull-Y rather than to gravitate to one that is most readily at hand or most easily applied to the situation.

We see what in essence are TA demands coming from many social groups--from the consumerist's movement, from the environmentalist movement, and so on. These people don't oppose electric power plants, highways, pipelines, or the like because they feel they are not needed. The grounds on which they contest these changes are always their indirect and higher order consequences. This, of course, is the thrust of TA. Hence these demands are the result of TAs of a sort. There is really no disagreement between the environmentalists and the technology assessors on what has to be done. Any disagreement is more the result of differences in approaches rather than substance.

I think the founders of TA recognized the open-ended nature of the assessment problem, and built the search for alternatives into the analytic mechanism that we are trying to evaluate now. Technology assessment explores problems that have no unique answers. Since there are no right answers the analysis cannot be scientific, but rather has to be an art form. It is really not a scientific discipline even though its initial practitioners were trained as scientists and operations researchers. This posed an immediate paradox in the design of TA methods. We are trying to analyze situations for which there are no data or certainties, and only partial understanding of the system that is shaping the possible consequences. There are many, man-Y difficulties associated with problems of this type, but if we bear in mind that it is an art form rather than a science we can develop the orientation that I think is ‘essential for coping with TA.

My written statement elaborates on some of the questions concerning how an evaluation of TA should proceed. But I would like to highlight several caveats that should be kept in mind. One of them is that many TAs aren’t really TAs at all. The-Y are called TAs because it was the “in" word to use, Occasionally the term was used to obtain the funds for the investigation and occasionally to give the results a title that made it sound as vital as possible.

The second caveat I would like to caution you about is that there was considerable disagreement over what TA is and what it should do, especially in the early assessments. The early assessors experimented with methods that occasionally proved counterproductive. So we may occasionally be looking at results where fundamental mistakes were made, and even though we may have learned from the mistakes, we may not have had the wherewithal to correct the results.

The final caveat, perhaps a little bit more important, is that the interaction between the user or the sponsor of a TA and the assessor was not clearly defined, particularly in the early TAs. This led to misunderstanding regarding what an assessment should produce, and what the -sponsor should do with the results. This weakened the impact of the TA as measured by the changes it promoted. We know that changes are often resisted by incumbent interests. These forces that tend to resist change were nurtured by the lack of understanding between

analysts and sponsors, making the assessment vulnerable to attack. And such attack was relatively easy to muster on the basis of uncertainty, **because** the consequences to be avoided were always in the future-that elusive time zone about which we can never speak in factual terms. Another factor that has made TA most vulnerable to criticism and perhaps contributed to its lack of utility, is the degree to which the assessment teams have avoided the value laden normative issues of what should be done. This is largely a result of the scientific conditioning of the assessors.

In TA we are talking about subjective choices that are not really amenable to scientific analysis, so the assessors prefer to avoid these issues. Therefore, the results of a TA often read like a menu of alternatives that is extremely long and nauseatingly detailed. Value judgments (preferences), which in the long run are most important, are generally avoided. This is a problem that is still with US. It is very easy for the political process to ignore a document that really doesn't take a stand, especially when it is extremely detailed and voluminous. Notwithstanding these problems, the TA movement is almost certain to grow. Whether this growth comes about under the rubric of TA or some other rubric, is unimportant, assessments are going to be with US. Furthermore, they are not going to be limited to physical or biological technologies. We are going to assess all innovations that have large social consequences, The big problems that we are faced with are the complexity of these innovations and the open-ended nature of the assessment process-the fact that assessments pose problems that do not have unique "right" answers.

The critical need in making TA work in our society is to develop an -assessment orientation. This ma sound like motherhood, and it is in a sense. But it is easier to cope with the thought of an assessment orientation than it is to put it into practice. Our educational system teaches us to think along discipline lines. We have to solve problems that have precise, determinable answers. If you look at the modern textbooks you find the answers to most problems in the back of the book. We are taught to think convergently to a single answer. Technology assessment demands the opposite from us. It demands that we think divergently, and in an interdisciplinary fashion. It demands that we explore the myriad of alternatives and their consequences, and that we understand how these might be viewed differently by different interest groups, rather than trying to identify the "best" answer. With the proper orientation we can do a far better job of TA than we can do without it, but we are fighting our entire educational system. 1 think this is a very key factor.

An orientation that helps us think about alternatives will also help us cope with uncertainty, and thereby help reduce the occurrence of unwanted and unexpected side-effects. It is obvious that we get surprised (or we incur undesirable side-effects) only when things we didn't expect actually happen, or when things we did expect don't happen. But we never get surprised when things that we expected 'happen. Therefore, if we are going to avoid these unexpected unwanted consequences we are going to have to deal with assessment results that are alerting us to things that we don't expect will occur. Our system really does not know how to co e with criticism of that type. The warning of Billy Mitchell of the Air Force is probably the

most frequently cited example of this particular situation. He stated the need for air supremacy as he saw it. He was heard, but his opinion was contra to the majority, and we didn't know how to deal with it. At least today we recognize that minority opinions can be most important, and if we can develop the right orientation we can perhaps nurture these opinions so that we can deal with unwanted consequences before they are fully manifested as problems.

The interesting part about this problem of orientation is its dual nature. It is not just a problem that the assessors face. It is a problem that the users of the TAs also face. A policymaker, a decisionmaker, has to be able to cope with low probability occurrences--occurrences that he may not expect and, as a matter of fact, that the assessor also doesn't really expect. It is from such eventualities that we are going to get unintended consequences, and unless we can deal with these in a proper manner, TA will prove highly ineffective,

Regarding methodological progress and problems, the text cites some of the macro and micro aspects of the TAs that have been developed over the years. I think there is considerable agreement as to the general approach to an assessment. Many detailed variations exist, but all of the variations cover the same steps. Some may put greater emphasis on certain steps, use a different sequence, but they address the same tasks. Furthermore, these methods are procedural rather than substantive. This reinforces the contention that we are dealing with an art form. There are no formulas such as are found in physics or chemistry, which if employed guarantee that the answer is true. There is no truth. We are dealing with open-ended questions. We are exploring unbounded issues. The development of methods means trying to come up with procedures that we can follow that insure that we are as systematic and as creative as we possibly can be. None of these methods will replace creativity. We have to have imaginative creative, interdisciplinary persons working in these tasks if we are going to get useful results. I don't by that statement mean to belittle the significance of the techniques. They are extremely powerful when carried out properly.

For example, one of the methods listed in Figure 1 of the text is called a relevance analysis. This method has invariably been proven to be an extremely powerful technique by promoting interdisciplinary considerations of complex subjects, and by virtue of its applicability to a wide rangeof subjects. Further development and application of techniques like this will improve the quality of TAs enormously.

I **won't dwell on any particular methodological problems here, but I would be glad to answer any questions that may come up later on regarding any of these techniques. I would like to address myself to a number of basic assessment problems for which no satisfactory methods exist. One problem is that of bounding the assessment. I don't mean defining how to breakup a complex TA, such as the energy problem, which is too great for a single assessment to handle. Technology assessment can handle this aspect of the bounding problem quite well. The problem I am concerned with is the one** the assessors **face when they sit down and try to identify where** they **should look for** indirect and higher order impacts.

Everything has been accused of being connected to everything else, and I am afraid that that statement may be true. If we try to look

under every stone and turn every corner we are likely to identify a larger number of obscure impact areas, but we are also likely to end up doing little more than merely identifying them. We do not have any systematic procedures for efficiently pursuing this problem. It would be very useful if we could have some basic research that could identify methods that could screen a large set of candidates for possible indirect impacts so that we can focus on our attention areas that are likely to contain these higher order impacts. Right now what we do is conduct brainstorming sessions with people with different backgrounds. We also use oversight committees. These approaches are useful indeed. They are the best things we have, but I don't think we should overlook their deficiencies in identifying impact areas. We have an important need for an approach that could perhaps do this job better.

Another problem that requires a significant amount of attention is to improve our skills at making TAs more truly interdisciplinary. I alluded to part of this problem earlier. In addition to orientation problems, there are substantive problems, and lack of incentives for interdisciplinary work. It is common for a TA to begin by creating a team made of people from different disciplines. These people presumably have an orientation toward interdisciplinary work, and make a sincere effort to communicate more effectivefy with each other. Development of such teams is very time consuming. It also is very difficult to provide the institutional incentives for creating interdisciplinary teams, particularly in a university, which is an ideal setting for an interdisciplinary team because of the variety of skills that are generally available there.

The reason for the lack of institutional incentives is that career development at a university is structured along disciplinary lines. "The key components used to determine promotions and the granting of tenure are individual contributions that receive peer group acclaim. Hence disciplinary research is most important for university people. This makes it difficult for us to entice young faculty members into teams, and when we get them into assessment teams we find it very often hard to retain them. To encourage Ion term associations we try to share our research personnel with discipline-oriented functions. By so doing, the team member is half professor and half researcher. We support efforts by the individual in the preparation of discipline-oriented position papers even though such efforts may only be marginally useful to our projects. If we have an economist doing an economic analysis for a food study we encourage him to document his results for peer group presentation; that is, in economics journals that can give him the kinds of acclaim that he ***needs.***

Another factor that presents difficulties in a university is the fact that TAs are generally procured on a competitive basis on annual or 18-month cycles. This cyclic nature inhibits team stability, and creates recurring proposal costs. Both of these aspects are very difficult for *a* university to cope with. At the University of Southern California (USC), for example, we have absolutely no budget for proposal preparation. Since we have no way of covering these costs preparing proposals are entirely ad hoc functions performed during limited personal time.

Another factor that constrains TA activities is that eminent specialized research personnel very frequently hold interdisciplinary activities in low regard. Specialists typically are very much into their thing whether they are physicists, economists, lawyers, what have you, and they are generally not too interested in pursuing interdisciplinary research. I would think this is an area where the government can use its influence to insure people who have unique insights make themselves available to TA teams. For example, if we were dealing with an assessment in agriculture I would think that the U.S. Department of Agriculture (USDA) could see that some of the researchers whom they support on a regular basis make their services available to a TA team when needed. I don't think they would have to do this very often. After stimulating such collaboration I think they would find it becomes self-sustaining. In total, our ability to perform open-ended interdisciplinary research is extremely important. We are presently not very good at it, and we are not making satisfactory progress along these lines.

Another concern I have with TA is the lack of a precise definition for the kind of policy recommendations that assessment should produce. Here the community of technology assessors is very much divided. Some assessors don't want to make any recommendations at all. Some of the users would like TAs to develop detailed recommendations, and even implementation procedures for policy changes. I don't think that TA teams ought to be responsible for drafting implementation procedures or legislation. I think that is an area where they are eminently unqualified. Perhaps this is an area on which the TA team and the Office of Technology Assessment (OTA) ought to collaborate. At the end of an assessment they can get together and in an interdisciplinary manner combine the insights available from the assessment. Administrative insight available at OTA should be used to develop policies that would be rational and implementable, and that would promote the type of change that should follow from assessment.

As a final thought I would like to point out the kinds of imitations that frequently result from different sponsoring institutions. An obvious example is the difference between the results when the sponsor is government in contrast to industry. Here I think we will find that the degree to which the results of assessments sponsored by these different organizations fulfill the noble goals of TA is related to how closely the goals of the organization overlap or are congruent with societal goals. In the case of OTA and the Congress, I think the overlap is very close. In the case of business organisations, this overlap is not very close. It is not that businesses are antisocial organizations, but that they are not attempting to respond to the same set of stakeholders. When an industry conducts an assessment on a new product for example, these stakeholders are the groups that affect their profitability. These used to be consumers alone. Now they include other activist groups as well. But they will not be concerned with the quality of life in the same terms as Congress. To this extent we could expect substantial differences in the kind of assessments on the same subject that would be performed for industry versus for a sponsor like the OTA.

In conclusion, I again remind you of the importance of developing the proper assessment orientation for policymakers who have to learn

how to cope with this tradeoff of immediate payoffs to avoid low probability future impacts. We have both institutional and intellectual problems in developing this orientation.

Mr. BROWN. We thank you very much for this extensive presentation, Mr. Enzer.

I wonder if you could tell us a little bit more about the Center for Futures Research. I have not been familiar with its existence. I presume it is a relatively new development on the campus. What were the factors that led to its creation, and where does it play its most important role?

Mr. ENZER. The Center for Futures Research has been in existence for over 5 years. It is situated in the Graduate School of Business at the University of Southern California (USC). Like most things that take place on a university campus, it is a product of need as perceived by certain key people on the campus. The leading figure in this regard is Burt Nanus, who is the director of the Center and who is also its creator and founder. He saw the need for it and went through the necessary procedures to convince others that this was an important activity for a university-and in particular for a business school to have—and here we are.

What we do is conduct interdisciplinary research primarily into the methods of understanding future alternatives and long-term change, as well as adapting these methods to business and social problems, which are after all quite similar. We apply these methods in the areas of social and business concern. We don't do business consulting or perform research with a narrow focus. We have had a large number both of business and Government sponsors. We have done research for example, for the California Transportation Department in helping them develop their long-range plans. We also hold seminars to teach this art form to practitioners and potential practitioners from business and Government. We have such a session going on today, we have 30 people that we are putting through a 3-day crash program.

Mr. BROWN. In other words, it has a close relationship to the need for policy planning in the business community, and it relates to what you might call futures analysis or research as an aspect of planning?

Mr. ENZER. That is correct.

Mr. BROWN. I was struck by a statement earlier in your paper that led me to believe that you felt that it was important to include value judgments in the technology assessment (TA) process, and that there is a value in coming out with policy recommendations. I think you commented in a point or two, that there seems to be a difference of opinion here. 1 am not sure how real it is. I don't think you can avoid having value judgments in any policy-planning processor any aspect of it, but it does seem to be a fact that many technology assessors want to minimize the overtness of my value judgment within the study. They want to present options rather than policy recommendations. Do you see any fundamental conflicts in these two points of view?

Mr. ENZER. I did refer to this briefly as an area of difference that has polarized the assessor community. I feel that to some degree value judgments can't be avoided. In order to avoid them you have to put in all of the nonimportant alternatives, and then you end up with something that is extremely large and extremely boring.

Mr. BROWN. Now you are talking about a priority-setting process here, rather than necessarily making value judgments. We were talking about this with previous witnesses. You can identify universal impacts and then discard those that are less significant, not necessarily trivial, but obviously everything isn't equally important. That does involve a value judgment.

Mr. ENZER Precisely.

Mr. BROWN. In order to establish priorities.

Mr. ENZER. That may be a lower level value judgment than those involved in assessing benefits and drawbacks. But a number of assessors begin at that level because they feel if they are going to be objective they have to be fully objective, and the list gets very long. I think many assessors are willing to take value-laden analysis and make recommendations from the points of view of various interest groups or stakeholder groups, so that they can then say that group A would regard this as a negative impact, whereas group B would find it a positive impact. These ratings are easily quantified . I don't think you would get too much objection from the assessors if evaluations of this type were part of the assessment itself. There would be a big disagreement however, if given all of these individual group analyses, the assessor were asked to recommend what course of action should be pursued. Given that group A would like it, say, plus 10, and group B would not like it by minus 3.5, what should I recommend that society do? I believe that the assessor ought to take a stand here, as well. He should evaluate options and state his choices.

The reason I feel this way is because I went through an assessment that specifically did not do these things. It was an assessment of no-fault insurance. After the assessment, I was called upon, as would be expected, to speak to a number of groups about the results of that assessment. While I could discuss the consequences of the assessment and its significance to various groups, I had to beg off on the issue of recommendations. I was always challenged at that point. Some people even demanded that I take a stand. I felt very uncomfortable having to indicate that I really had made no attempt to evaluate no-fault insurance from a benefits-disadvantages point of view, and was not really in a position to offer such a recommendation. This had the effect of weakening the significance of the assessment results.

Mr. BROWN. You make reference to the postreport phase, which we were discussing with the earlier witnesses regarding the auto engine study conducted at the Jet Propulsion Laboratory at the California Institute of Technology. From your experience you obviously feel that an assessment is not completed when you submit the reports but that there is an ongoing process that should be considered when funding the assessment or whatever other considerations are given to it, if it is going to have a full utility.

Mr. ENZER. I agree with that. That is something that is difficult to put into place, but I have always felt that perhaps 10 or 15 percent of the resources assigned to an assessment should be earmarked for post-assessment dissemination. I think that the time period between the completion of the assessment and the implementation of policies with regard to that assessment, is not zero. In this time the results of the assessment should be used to elevate the level of public debate. I think one of the key factors achieving general consensus on policies where

not everyone can be a **winner, is greater public awareness and greater public debate over the consequences. I don't envy the decisionmaker who has to make a choice between a program or a nonprogram, or keeping an airport or closing it, or putting in a powerplant or shutting it down. He knows he is satisfying some interests and not other interests. This process is lubricated by public debate, and one of the most important roles of TA should be to enrich that public debate. That takes time.**

Mr. BROWN. I think that is an extremely important point. It needs to be emphasized over and over again, particularly in our own environment in this country where the public decisions generally are the final decisions. It must be as a process of encouraging informed public debate so that we reach decisions that have stability to them. I have frequently felt that people who feel that they can present a series of objective professional judgments or options? shall we say, and then wash their hands of things are missing the key element of the social process that exists in this country. Most of these options, whether we call them TAs or whatever, are ***culturally bound, that is*** they are enmeshed in the particular background of the individuals making them, whether they think they are objective professional or not. The key to their success is input to a decisionmaking process on a broader basis.

Mr. ENZER. There is an approach that we have used in the past and I think will continue ***to*** use, that you might say is a form of interdisciplinary analysis, in which we stipulate that there is no such things as objectivity. But we can identify the key biases and then try to reflect these in the assessment by repeating the assessment from the perspectives of the different biases. In other words, saying that the best approach to objectivity is to see each of the biases separately side by side so that the areas of commonality and differences can be highlighted.

Mr. BROWN. There is also this concept of webs of abstraction. You **can look at a** problem, analyze the biases, see who **wins** and loses amongst the stakeholders, and all of that is postulated upon a certain framework. Then you move to a higher objective, to a higher or different, shall I say, framework, and the picture becomes completely changed. Some of the winners become losers, and some of the losers become winners. We sometimes are unable to move from one level of abstraction to another in any helpful way, and it makes our policy decisions somewhat limited.

I would enjoy pursuing this further, but" in the interest of time, I think that we had better bring this to a close. If there is a need for you to clarify any aspects of your testimony or to answer additional questions we hope you will respond within the limits of your time and ability.

Mr. ENZER. Be glad to.

Mr. **BROWN. Your contribution** this morning **is** appreciated, and is a very valuable input toward helping us to do **a more effective job in the TA process in the Congress.**

[The following questions were submitted by Congressman Brown to Mr. Enzer and his answers thereto:]

Question 1. Based upon your experience, what is the best way to involve the public in technology assessment (TA) ?

Answer 1. Involving the public in TA has proven to be a difficult task to accomplish. It is obvious that the public has a role to play in the issues involved in TAs. They are the stakeholders and are often immediately impacted by the decisions, but perhaps even more importantly, support for policy recommendations that follow from a TA depend upon public consensus. Thus, as a minimum, the public should be involved in identifying critical areas for an assessment and in discussing the alternatives and the policy recommendations that result from a TA.

To make this process more effective, it would be desirable to promote direct involvement of the public in those aspects of the assessment concerned with structuring the issue and establishing priorities. However, present channels of communication are woefully lacking when applied to this type of interaction. Perhaps the best means of obtaining such inputs is through citizen interest groups, although these may not always be locally available for a particular assessment, and it may not be appropriate to involve remote national citizen organizations. Perhaps the best that can be done at this time is to have the assessment team conduct hearings on the preliminary definition of the issue early in the assessment. These hearings should be less formal than those held here, and should be kept as free of technical considerations as possible to promote general public participation. This will probably encourage the post-assessment discussions since they are apt to be found more relevant to public interests. It may also lead to the development of better means of interaction as the public becomes more aware of the assessment process and the utility TA can serve in protecting their interests.

Question 2. Do you see any relationship between the TA and environmental impact analysis process?

Answer 2. Methodologically speaking, environmental impact analysis is a subset of the TA process. There is considerable commonality between the two activities in that both are concerned with long-term indirect consequences, but since environmental impacts are entirely physical, the nature of the analysis is structured along scientific and economic lines. The difficult issues **of psychological, social, and emotional impacts and the degree to which society should intervene in these processes are part of a TA, but rarely come into play in environmental impact analysis.**

Question 3. What value do you see in closer relationships with regard to TA between the public and private sectors?

Answer **3.** The concept of TA has been adopted by both governmental and industrial organizations. Assessments performed by industrial organizations are generally concerned with new products, the important considerations being the identification and analysis of indirect consequences that can affect the profitability of the new ventures. Governmental assessments tend to pursue broader social goals, and are interested in the complete spectrum of impacts that might affect the various sectors of society.

Notwithstanding these differences, there are two benefits that can result from closer relations with regard to TA between Government and industry. First they can share methods and experiences. Second they can assist each other **by** serving as advisors to each other in their respective assessments. The two-way nature of these relationships is very important. It is as crucial for Government to be involved in industrial assessments as it is for industry to be involved in governmental assessments, if we are to move closer to an even-handed view of the consequences of change.

A substantial portion of the benefits sought from TA are likely to result from the change in our institutional approach to evaluating technology. The change in approach will be enhanced by the interdisciplinary aspects of the assessment. A two-way relationship between Government and industry in the assessment process will provide those benefits in a most effective, low-key manner.

Question 4. Do you think that technology is the limiting factor in TA? What limits do you see to the utilization and application of the TA concept in Government and in the private sectors?

Answer 4. There are more potential candidates for TA than there are resources available to perform the assessments. A critical need exists for screening these candidates down to that set that is most sorely in need of assessment. There as a potential trap in screening on the basis of importance. The trap is that we tend to focus on the most pressing current problems. The ease with which we can fall into this trap is increased by virtue of the fact that OTA is a congressional service agency, and Congress, of necessity, must spend the major portion of its effort in addressing current needs.

An absolutely essential ingredient for a TA is the ability to maintain an even-handed posture during the interdisciplinary analyses involved in the assessment. Such an even-handed posture is virtually impossible with issues that have been fully tempered by the pressures of urgency. Experts, like other citizens, take stands on current issues and can no longer be counted on to perform the deliberations necessary for effective TAs. Therefore, issues that demand immediate solutions should be addressed via conventional political methods, reserving limited assessment resources for emerging problems.

The current issues trap also leads to a second trap, that of attempting to add insights into issues that have already been "studied to death." Technology assessment is intended to identify macro-alternatives and to discriminate among the indirect consequences of these alternatives, This task is almost impossible once we have become so immersed in the details of an issue that we no longer can see the forest for the trees. There currently exists a large number of trend monitoring activities that focus on emerging issues. The following table lists a few of these:

Project	*Institution*
Corporate Associates Program	Institute for the Future
Important for the Future	UNITAR
Prospects and Scout Programs	The Futures Group
Trend Analysis Program	Institute of Life Insurance .
Twenty Year Forecast Project	Center for Futures Research--USC

These and similar activities could be a useful starting point for initiating a search for assessment candidates, Part of the OTA function should be to screen these emerging issues to select potential candidates for assessment. By so doing the assessment process will be able to concentrate its limited resources on issues that it is most qualified to address **and will thereby be** able to make an important contribution to congressional farsightedness.

Question 5. **What role do you see for TA in the decisionmaking, policy, and planning processes in both the Government and in the private sectors? Do you think TA will have a significant impact on the way the private sector does its business?**

Answer 5. As indicated in my response to the previous question, the greatest contribution that TA can make to the decisionmaking process is to increase its foresight. While it is difficult to create good plans, it is easier than trying to redirect poor plans. Once resources and institutions have been mobilized in a specific direction even modest adjustments are difficult.

In addition, we often find many members of society are disenchanted by having been offered too few choices regarding important issues. As the pace of change increases we find that we have less and less time to consider our options. Just as invention is the offspring of necessity, planning is the offspring of early detection. TA will be most effective when there is time for study and time for broad **public** debate. There is no shortage of issues that have yet to emerge as urgent national problems. These issues should be the focus of TA.

Mr. BROWN. Thank you all **very much for being with us.**

This hearing is adjourned subject to the call of the Chair.

[The hearing in the above-entitled matter was adjourned at 1:30 p.m.]