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

THURSDAY, JUNE 10, 1976

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

The Board convened at 10:12 a.m., in room 2318 of the Rayburn House Office Building, Hon. George E. Brown, Jr. (member, Technology Assessment Board), presiding .

Present: Representative MarvinL. Esch; Emilo Q. Daddario, member ex officio and Director, OTA; J. M. Leathers, member, advisory council , OTA; and Dennis Miller of the staff.

Mr. BROWN. The Technology Assessment Board will come to order. This is the third day of hearings undertaken in an effort to clarify and improve the definition of the processes of technology assessment (TA) in order, we hope, to improve the utility of the Technology Assessment Board in its role of serving the Congress and helping to make better decisions on matters involving future technologies.

This morning we have a very distinguished group of corporate executives who are going to help us with some insight into the TA process as it operates in their own industries. We are looking forward to hearing their testimony.

I might *say* that the House of Representatives is in session—went into session at 10 o'clock-and we are in the midst of a quorum call, but we trust that there will be *some* additional members who may be able to show up during **the** course of the morning.

We are going to start this morning with Mr. Harry E. Teasley, Jr., vice president, corporate business development, for The Coca-Cola Co. You may come forward, Mr. Teasley. We welcome you here this morning and are looking forward to your testimony.

Mr. Teasley. Thank you very much.

[The biographical sketch of Mr. Harry E. Teasley, Jr., is as follows :]

HARRY E. TEASLEY, JR., VICE PRESIDENT, THE COCA-COLA CO.

Harry E. Teaslev, Jr. was elected vice president, corporate business development of The Coca-Cola Co. in May, 1975. In his present position, he is responsible for a group that focuses its activities on merger, acquisition, and divestiture analyses, new venture development and management, and internal product, package, equipment, and business system development.

Degree in industrial engineering from Georgia Institute of Technology.

Joined The Coca-Cola Co. in 1961 as a senior engineer with the technical research and development department ; has subsequently held positions of project engineer, senior project engineer, project manager in new packaging, and mananger of the snles equipment, packaging and distribution group of Coca-Cola USA, a division of The Coca-Cola Co.; was appointed vice president and head of marketing and business development department for the division in 1973; in March, 1975, was named manager of the newly formed corporate business development group of The Coca-Cola Co. ; and in May, was elected vice president, corporate business development.

STATEMENT OF HARRY E. TEASLEY, JR., VICE PRESIDENT, CORPORATE BUSINESS DEVELOPMENT, THE COCA-COLA COMPANY

Mr. TEASLEY. Mr. Chairman, my name is Harry Teasley. I am a vice president, corporate business development, The Coca-Cola Co., Atlanta, Ga. I am pleased to accept your invitation to participate in these hearings that seek to explore the methods used by both business and Government to lay plans for technological development, and evaluate the impact of such envelopment on our economy, the environment, our standard of living , and our institutions.

First, let me identify myself with respect to the activity on which I will report today. am an industrial engineering graduate from Georgia Tech and have been with The Coca-Cola Co.for 15 years in various marketing , technical, and developmental assignments. Between 1965 and 1974, I had functional and administrative management responsibility for the packaging activities of The Coca-Cola Co.

Today, I would like to report on a technology assessment (TA) activity for which I had project management responsibility during that period. I would like to describe briefly some of the decisions that we made as a result of that activity, and finally, I would like to discuss the use of TA with respect to a philosophy for managing resource usage and environmental impacts.

Let me begin by briefly describing the environment that led up to this activity. During the decade of the sixties, the SOft drink indus-, try underwent substantial changes in its packaging and distribution practices. There was a shift from small or individual size containers to large multiuse containers, warehouse distribution replaced store-door delivery in certain market segments, private labels were introduced and attained a market share, convenience packages became an important part of the packaging mix, and new packaging materials an containers were developed. These changes were brought about by a combination of events. There were changes in consumer lifestyles; there were changes in both wholesale and retail distribution patterns; there were new technologies; and economics played a major factor. For example. during the period 1960 to 1970, the cost of capit.al recovery increased by about 74 percent-that's a combination of change in cost of fixed assets and change in cost of money or interest rates-labor increased by about 65 percent in that period. while materials increased by only 21 percent. and energy by only about 10 percent.

It is obvious that the price of materials and energy. were stable relative to the cost of labor and capital during the sixtics. Since returnable systems are labor and capital intensive, there was an economic pressure on the returnable system. In addition, there were some internal economics that also affected the market structure during

that period. Within the soft drink industry, trippage on returnable bottles decreased from about 20 to 22 down to about 9 or 10. Concurrently, productivity gains were being made in the container-making industry. The combination of all of these events-changing lifestyle, changing economics-gave rise to a market and economic environment that put pressure on the returnable soft drink system, and provided an impetus for the development of a packaging and distribution system that was more like the norma
system.

However, by 1970, it was clear that the decade of stability that existed with respect to the price and availability of materials and energy was coming to an end. Corporations needed to have an understanding of the various resource inputs on which they base their business, even if these inputs occur at the supplier level. In addition, the environmental debate made it clear that corporations, as well as governments, need to have an understanding of the impacts associated with their products, their services, their processes, and their policies.

So in 1970, The Coca-Cola Co. commissioned what we believe was the first systems study (we know of no prior study) to evaluate the material and energy requirements as well as the environmental impacts for a class of products. That class of products was soft drink packaging. The conceptual model was developed by The Coca-Cola Co. and articulated and executed by Midwest Research Institute of Kansas City.

Simply stated, the objective of that study was to define and quantify total material and energy requirements as well as environmental impacts from mining and extraction through all processing steps to disposal, for each technological option that was available to the industry. And I might parenthetically add here, each package that was underdeveloped, that was not commercially available at the time. In addition, analyses were made on the impact of container reuse and material recycling. I have submitted a more complete description of this study.

[The material referred to above is found in Appendix C, Exhibit 1.]

Since this study was the first of its type, there were many complications associated with assumptions, data limitations on operations measured, and a number of issues of that type. However, I believe it was a "first-cut" attempt to get us in the right ballpark. The study provided us with *a* data base at that time, and an analytical tool for making specific analyses on the impacts associated with changes in our packaging and distribution systems. As a result of that study and in context with our more conventional economic analyses, our market and consumer studies, and our internal TA regarding package performance, this technology assessment that we made did have an impact on our business decisions. I would like to review some of the things that we did as a result of that study.

We determined that a plastic one-use container was competitive in energy consumption to the containers that it would replace with additional safety benefits. We therefore made the judgment to continue the developmental activity that had been in process since 1968 in cooperation with the Monsanto Co. In that particular project, there were a number of other areas that required TA, especially in the chemistry area. It is my understanding that Mr. Monte Throdahl of

Monsanto has testified on some of these earlier this week, and has provided the Board with written material on those tests.

We made some long-term procurement decisions regarding metal containers-that is, the percentage of our purchases that would be steel versus aluminum-and what types of containers we would use in different markets.

We recognized the long-term desirability of two-piece metal containers and have promoted their development.

We developed a clearer understanding regarding the environmental as well as the economic efficiency of large-size containers, and have promoted the development of large-size containers within the soft-drink industry.

We developed an understanding of the pros and cons of recycling various materials under various operating conditions, and were able to allocate our energies to recycling efforts that had the highest potential payoff.

We determined the "environmental break-even," a loose term that covers a comparison of energy, material, and impacts, between one-use containers and returnables. It is based on various trippage rates and various assumptions about such factors as transport distances. An outgrowth of this understanding has been an improvement in returnable trippage from about 9 to 10 in 1970 to about 14 to 15 in 1975 in our company-owned plants as a result of an improved segmenting of the market between economy buyers and convenience buyers. In essence, what this means is that in the late sixties and the seventies, consumers were buying returnable bottles, and in many instances, throwing them away. We segmented the market to get the consumer that was throwing the container away not to throw away the high-cost container.

It is my belief that studies of the type that I have described-they are now commonly known as net energy studies or net environmental impact studies—are useful analytical tools in much the same way that economic analyses and market studies are analytical tools. A recent article in Science magazine questioned their usefulness in public policy deliberations. It is my view that the are useful in providing background and understanding of a specific situation but are not suficient for decisionmaking, because net energy studies deal with only a single variable, that being energy, while business and transfer decisions within the economy are made on the basis of dollars.

I would now like to shift gears and discuss philosophy for a moment. I believe that society is in the process of developing a philosophical framework for addressing the management issues associated with resource utilization and environmental impacts. I have attempted to state m observation of the fundamental concepts that are being proposed and debated in the wide-ranging discussion regarding environmental issues. This is not a personal opinion or acceptance of each concept but is more of an observation.

I think it is appropriate to review. these concepts at this session, because ultimately the use of data and informatlon from TA activities must be applied with respect to some philosophical or ideological construct. There appear to be four basic concepts.

The first deals with acute public heath or environmental issues, and it can be expressed by the following statement: activities, opera-

tions, or products that have the potential to cause acute public heaIth or environmental problems should be controlled, related, or prohibited. This could be from informal control to absolute prohibition. Examples include the disposal of radioactive waste; the disposal and use of very hazardous chemicals; the amount of residual insecticides or heavy metals permissible in food; and operations where single events are substantial, such as a pipeline break. The objective of this management philosophy, or this concept, is to prevent disasters.

The second concept deals with the short- to medium-term use of the "commons"—air, water, land, resources, and governmental services such as national parks, road systems, et cetera,. It can be expressed by the following statement:

When the aggregate use of the "(commons)" begins to approach their natural carrying capacity, adverse impacts begin to occur. These impacts are costs to society. Products and services should include all costs direct, environmental and social, in their cost structure. Therefore, the externalities should be internalized by setting limits via standards, or by charging direct fees.

Examples include air emission standards-one car does not generate an impact, a million cars in the Washington area, as we noticed today, may generate an impact: water effluent standards; sewage charges based on volume of biological oxygen demand or chemical oxygen demand; operations where single events are minimal to trivial, but substantial in the aggregate: land use regulation?; restriction of open dumping; strip mining regulations; and littering fines.

The objectives of this concept are to manage the "commons" in a fair and equitable manner; to manage impacts not activities, operations, or products; to allow the marketplace to manage activities or products; and to achieve a balance between the detrimental and beneficial effects *on* the "commons" of their use. Limits and standards have been the most effective methods for dealing with air, water, and in some cases, land; while fees and rationing are more appropriate for services. To date there has been no major Implementation of a depletion cost into the system except as defined by marketplace direct cost, that is comparing the cost of depletion or use of materials with labor and capital.

The third concept is a different management concept. It deals with the use and allocation of resources, and is expressed by the following statement: Over and above the management implied in the first an second concepts, society, acting through governmental institutions, should allocate private resources by managing the cost, availability> or terms of sale, for products and services within the economy.

Examples include-and these are general kinds of examples-the prohibition of any product if that prohibition is not a prohibition for the acute reasons discussed in the first concept; and legislating internalization on one product that generates an impact but not on all other products or services that. generate the same impact.

The objective of this concept is to replace the three fundamental functions of the market mechanism-resource allocation, rationing, and justifying investment. Implicit in this concept is the view that society can best handle the allocation process and make determinations on what products should exist and what products should not exist.

The fourth concept deals with the long-term use and availability of resources, and societal value systems relating to growth, consumption, and life-style. It can be stated in the following manner: Over and above the management implied by the first and second concepts, society, acting through governmental restitutions, should control the overall use of resources, and search for a no-growth equilibrium economic system. In other words, put a cap on economic envelopment or resource utilization.

The objectives of this concept are to reduce consumption and to take a longer term view of the world. Implicit in this concept is the belief that society should be culturally intensive rather than use intensive, capital intensive at the consumer level rather than flow intensive, and labor intensive in many sectors rather than energy intensive.

These *are* my observations about the four concepts that I believe are being debated today with respect to how we manage resources. I don't say that they are mutually exclusive. I think they exist along a management continuum, but there are certainly nodes in that continuum. In making use of analyses arising from TA activities, I think it is essential that we debate not only specific controversial issues, but concurrently the broad philosophical concepts for managing resources and environmental impacts.

In summary, I believe that TA activity, both within industry and within Government, is a valuable means for providing decisionmakers with a good look at an issue. Furthermore I think the specific concept of net energy analysis is a good example of a new TA mechanism that will prove useful in many decisionmaking environments. Finally. I think that there is a need to develop a philosophical framework for dealing with these issues.

I would like to thank the Board for the invitation to participate. If you have any questions, I will be happy to attempt to answer them.

Mr. BROWN. Mr. Teasley, it is not often we have witnesses up here who refer to net energy analysis or net environmental impact analysis, particularly if they are not in the energy business. I imagine Coca-Cola is concerned about energy, although not exactly in it, and I am wondering how you developed a concern in this area. I know that Professor Odum, who has done a good deal of work in this area, is from Georgia.

Mr. TEASLEY. Professor Odum is at the University of Georgia, that's right.

MR. BROWN. **Did you have some consultation with him?**

Mr. TEAsley. I have read two of his books. I guess the concept is one whose time has come. It has naturally evolved from the following activlties, input-output analysis in economlc terms, and general systems analysis. Net energy analysis is not new to the biological area—biologists have been doing net energy analyses for a number of ears-or to the process engineering area, where a single process may be studied to determine net energy impacts.

What we saw happening to us is that, our world was changing and we were getting criticized at times for the direction that it was taking. We had to understand not only the economics that were bringing about that change, but the environmental and market impacts that were associated with that change. Our studies were simply to provide

management with an additional tool that they didn't have before. With that tool we could make R. & D. judgments about whether we ought to pursue a certain kind of development or not, and we could make procurement decisions. From a business standpoint it has also been extremely useful to us because now that we know how much energy or how much diesel oil or how much gasoline is involved in a specific option, we can make long-term plans about what is going to happen to the cost structure of that option vis-a-vis another option. So we have improved our planning capability substantially by developing that data base and that analytical tool.

Mr. BROWN. I am going to ask my colleagues here if they have any questions. We have Mr. Daddario, who is a member of the Board and Executive Director of the Office of Technology Assessment, and Mr. Leathers, who is a member of our National Advisory Council. Mr. Daddario, do you have any questions?

Mr. DADDARIO. Just one quick question, Mr. Chairman. Your various concepts and the objectives you derive from them, Mr. Teasley, are very interesting. In the second concept you discusssed, the second of the three objectives was to manage impacts not activities, operations, or products. You allow the marketplace to then perform its function. In the fourth concept you say that society acting through governmental institutions should control the overall use of resources and search for a no-growth equilibrium economic system. It seems to me that these are mutually contradictory.

Mr. TEASLEY. I am not trying to say that these are all possible. They are four distinct concepts that I believe are being publicly debated today. It is my observation of the environmental debate. Let me give you my personal view. I think the first concept is generally accepted by most people. There are always questions about what is an acute problem and how you implement and manage this concept. I think the second concept is a natural extension that as you begin to have an aggregate set of impacts, and manage the impacts, then the marketplace, under that broad umbrella, is allowed to determine how resources are allocated.

Now, the third and fourth concepts are very different. They move away. from the market mechanism as a major allocator of resources and justifier of investment, and move to some other arena and some other philosophy decisionmaking. The second and third concepts are at odds and so probably is the fourth. I am just trying to state the concepts because I think that a number of legislative issues can be addressed if we can sit down and characterize them and say it's a second concept issue or a third concept issue. Then we can ask whether we philosophically agree with the concept.

Mr. DADDARIO. Your fourth concept deals with controlling the overall use of resources and searching for a no-growth equilibrium economic system. When the limits-of-growth concept came through with the study from the Club of Rome some time ago, it developed considerable discussion in the public sector and so served a very valuable purposes.

But I attended a Club of Rome meeting in Philadelphia recently, and it seemed as though they were beginning to question their own data and approach to this concept. There might be more room to move around in insofar as growth in the overall society was concerned.

Herman Kahn has taken the opposite approach, saying that with the projected, technological advances in the utilization of world resources and the better balance of things throughout the world, we could probably sustain a considerable amount of growth. There is, therefore, some question about whether in fact we should be putting so much emphasis on control of overall uses by governmental institutions, when perhaps at this time, by improved resource use we might have greater opportunities. By setting arbitrary limits at this time, we ma prevent ourselves from taking advantage of these opportunities. No one knows which side of this argument is correct, but these are points that conflict with each other.

Mr. TEAsley. No question about that. I would certainly agree with you that it would probably be premature for societ, to be setting up absolute limits in any area. obviously, you also have to consider your position with respect to other world-trade countries at the same time. Again, it is an attempt to express the concept because it is being promoted by some people. I think I read the article by Mr. Kahn in the latest issue of Futurist magazine in which he takes the very optimistic view that we have a lot more room to move around in than the earlier Club of Rome study projected.

Mr. DADDARIO. Thank you.

Mr. BROWN. Mr. Leathers, do you have an questions?

Mr. LEATHERS. I just have one short one, Mr. Teasley. In the switch from returnables to the plastic bottle, did you make a net energy analysis to see where the break-even on energy would be?

Mr. TEASLEY. We have not switched. The plastic bottle that we have introduced in the marketplace did not substitute for returnable bottles; it substituted for already existing one-way glass containers. A net energy analysis on that move indicated, in the size range that we introduced, which was a 32-ounce size, that we were equal to glass in energy consumption. So it was a washout. Probably the assumptions and error one way or the other would tell us which one was really the lower energy consumer. We had determined that we had improved safety factors, and that we had very high market and consumer acceptance; and we introduced that in New England.

Mr. LEATHERS. Have you made one versus the returnables as to how many trips the returnable—

Mr. TEASLEY. OK, you are talking generally one-trip containers versus returnables.

Mr. LEATHERS. Let's say the plastic.

Mr. TEASLEY. Well, it will turn out to be roughly the same for plastic or glass one-trip containers, versus returnables. The break-even based on trippage for returnables depends on a number of factors including package size, shipping distances, specific production-distribution facilities, et cetera. On balance, break-evens occur somewhere between 3 and 5 trips or at return rates on returnables of 67 to 80 percent. These trippage rates exist in some markets. Trippage is the most important variable. In 1970 to 1971 industry trippage was at an all time low with very low trippages in major eastern urban markets. Since that time, the market has been segmented more efficiently between economy buyers who purchase returnables and return them, and convenience buyers who now buy one-trip containers and no longer discard the more costly returnables. In fact, since l970, energy con-

sumption per gallon of finished product has decreased due to this more efficient market segmentation, the shift to larger sizes, weight reductions in one-way containers, and recycling of used containers.

Mr. LEATHERS. Thank you.

Mr. BROWN. Mr. Teasley, getting back to your philosophical concepts, I am concerned about how tfe commitment to a philosophical concept might bias the results of a TA, and whether this is a possibility in the operations of the Technology Assessment Board in its own studies, as well as with TAs in general, as conducted by industry. For example, if we were to assume that those engaged in making a TA had adopted your fourth philosophical concept, it seems to me that might lead to a bias in terms of a particular attitude toward a new technology. I haven't thought the details of this through, but I can conceive of, let us say, a slight bias toward energy- and materials-intensive technologies, toward what you describe as cultural rather than use intensive--

Mr. TEASLEY. Skill intensive.

Mr. BROWN. Yes. Do you perceive this as having an impact on the TA ?

Mr. TEASLEY. I think you run the risk in any kind of study that somebody comes to the study with a biased point of view. They don't really pursue an objective, scientific approach to describing a situation and developing and analyzing the data. It just means that you have to be able to recognize the propagandist when he comes.

Mr. BROWN. Well, one man's propaganda is another man's wisdom, you know.

Mr. TEASLEY. Sure.

Mr. BROWN. I think the scientific process here would be to make the effort to at least fully disclose the underlying biases or concepts under which the operation is being conducted, whether it is by the manager of the TA or the various people who are providing the inputs. Would that be your estimation of a reasonable way to at least cancel out to some degree the effects of any of these biases ?

Mr. TEASLEY. I think that the man, the decisionmaker, who gets the results of a study or a TA has a responsibility to understand the assumptions that were made, their impact and implications. It means some hard work. You simply cannot just read a set of conclusions in a report.. You have to sit down, work hard at it, and participate, I think, in judging the quality of the work.

Mr. BROWN. It's a little premature to refer to it, but in our next presentation, from the Ford Motor Co., reference is made to their cornmissioning a TA by an outside institution. They had the Jet Propulsion Laboratory do an assessment for them. I presume that this was in part to separate out any potential biases that might exist or that might be attributed, even though nonexistent to the Ford Motor Co. It seems to me that this is a commendable way to approach the problem that exists here.

I have one last question. I am a little hooked on philosophical concepts myself, and I was very interested in your presentation along that line. The fourth concept you described is a matter of considerable ongoing political controversy, because it relates to the whole argument around growth. Reference was made to Herman Kahn's philos-

ophy, as it is reflected, I guess, in his latest book—I don't think I saw the article to which you referred.

One of the noteworthy ideas that I perceived in Kahn's recent book, "The Next 200 years,') is that he postulates explicit limits--a global population limit of 15 billion, a global energy-use limit of five quints- and certain postulates with regard to energy efficiency and use, and some other things of that nature. I don't want to accuse Kahn of accepting the limits to growth concept, but it seems to me that he has established limits here. Under these circumstances, if we work to move toward a philosophy closer to your fourth concept, do you consider this to be incompatible with a competitive free-enterprise system?

Mr. TEASLEY. If a society faces a set of circumstances requiring some kind of capstones and some kind of limits, it does not necessarily have to affect the marketplace, as long as they are very broadly stated limits and people can stall make individual choices that are arrived at by allocating labor, capital, energy, and materials the way the marketplace wants to allocate them. If, however, these limits restrict the kinds of activities and products that are going to exist, then there is, I believe, a direct conflict.

Mr. BROWN. But you are suggesting in this concept that, in effect, we move backward toward a labor-intensive rather than a capital-intensive--

Mr. TEASLEY. I am not suggesting that, I am making the observation—

Mr. BROWN. Yes, I recognize that you have been very objective about it. But isn't it also true that our free-enterprise market system flourished in a much healthier fashion in the past, when there was not so much capital intensity, not so much Government regulation, and not so much of the other things that are the bane of corporate existence today?

Mr. Teasley. I don't really have a good enough historical perspective to comment on that.

Mr. BROWN. Well, you have done very well so far. I want to thank you for your testimony, Mr. Teasley. We would like to submit some additional questions to you in writing, answers to which will help us complete the record.

Mr. Teasley. Thank you very much.

Mr. BROWN. And I hope we will have a chance to see more of -you.

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

Question 1. **What limits do you see to the utilization and application of the** TA concept in the Government and private sectors?

Answer 1. Of necessity, TA activities are based on assumptions and subject to a number of limitations. The quality of the assessment will vary directly with the quality of the assumptions and the completeness of the model. The findings, therefore, from a TA activity should be viewed as an input but not as a total basis for making a decision. Managers making use of TA studies in the deeisionmaking process should have a background that will allow them to understand and judge a specific TA and not rely simply on the conclusions drawn **by the** preparer.

Question 2. Has a formal structure for conducting TAs been institutionalized since the early successes with this type of analysis?

Answer 2. No formal structure has been institutionalized within The Coca-Cola Company for conducting TA **activities. Assessments are conducted on an as-needed project basis when there is an indication that the specific technology has the potential for bringing about major change in some area. The Corporate**

Business Development Department of The Coca-Cola Company has been established to evaluate and manage major business projects. This department will conduct a TA if it is deemed advisable, and is able to call on other corporate resources such as engineering, *corporate* marketing, and corporate research, if specialized expertise is required.

Queution 3. Would you describe how it is currently decided what problems should be examined with TA? What kind of a decision-planning process is gone through in the conduct of a TA from its inception to publication and final utilization?

Answer 3. As a general rule, projects that involve new technologies and substantial long-term commitments are considered appropriate subjects for TAs.

Question 4. In a TA should the impact of a new technology on job structure *be* examined?

Answer 4. Yes, a new technology can impact job structure as well as environment, economic systems, social patterns, etc. Of special interest are the questions of whether the technology will generate the need for additional training and development of new skills, and whether existing workers can be effectively transferred to work with new technologies.

Question 5. How is TA information worked into reports?

Answer 5. As one of the analyses, in much the same fashion as an economic *or* market analysis.

Question 6. Based upon your TA experience, what lessons have been learned? Has TA affected the way business is done at Coca-Cola?

Answer 6. Technology assessment is an extremely difficult process. It requires people with systems skills. The assumptions upon which the assessment is structured are critical. Quite often data is difficult to develop. The second question is difficult to respond to with specificity. However, we can say that TA has widened the perspectives of decisionmakers. For instance, there now is a mechanism within the company for examination of new businesses and technology—the Corporate Business Development Department As the department gains experience, it should have valuable input.

Question 7. Is there any attempt in your TA process to involve the public?

Answer 7. No. We are, of course, concerned with the impact of TA on the public, and this aspect is carefully examined. Also, outside specialists are engaged as needed. However, no direct input from the general public is Solicited.

Question 8. Would you describe how your organization goes through the environmental impact analysis process that is involved in an MIS? Do you attempt to explain impacts and to educate the public and employees ahead of time?

Answer 8. An EIS can be requested by a city, county, State, or Federal Government. The need for such a statement is based on a project having environmental implications such as: increased traffic, noise, water and air pollution and high consumption of energy. As part of our capital project review process, projects are reviewed for engineering adequacy. This includes an analysis of the environmental impact of the project. Thus, a capital project review is not appoved unless it states how it will affect the environment, includes steps to come into compliance with all applicable standards, and provided capital funds to carry out the necessary work. Thus, the environmental impact analysis process can start at the plant level and progress through the division and corporate level It is typically a combination of all three levels working together to provide the best analysis and solution to a possible environmental impact.

This decision is made on an individual basis. For example, during the recent Bellevue plant expansion, notice was placed in the local Bellevue paper concerning the plant expansion's effect on storm and surface water. In the case of the Hightstown waste-water treatment system, agreement was reached with the local township concerning treatment to be provided. Employees involved with plant operation were informed of the treatment process and the necessity for proper operation of the treatment facility.

Question 9. What value do you see *in* having closer relationships between the public and private sectors? Do you see any value in working closer with State and local governments?

Answer 9. Too often *in* the past an adversary relationship has existed between the public and private sectors. The mutual exchange of information in a candid and cooperative atmosphere can be helpful in maximizing the constructive utilization of TA. I think that there are some issues in which a closer working relationship with State and local governments could be productive.

Question 10. How do human value systems affect technological development? What role should the analysis of value systems have in assessing the impacts of technology on society and on the environment?

Answer 10. Human value systems have a tremendous impact on technological development. The fact that a technology exists does not necessarily mean that it will be adapted successfully. The adaptation will be based *on* socio-economic factors, as well as the technology itself Value systems actually relate more to decisionmaking **than they do to TA. TA is a tool to provide information to decisionmakers who will then draw conclusions and make judgments within the context of some value system.**

Mr. BROWN. Our next witness is Dr. Dale Compton, vice resident for research for the Ford Motor Co. We are very pleased to have Dr. Compton here this morning.

Dr. W. DIALE COMPTON, VICE PRESIDENT-RESEARCH, FORD MOTOR CO.

Born January 7, 1929, Chrisman, Ill., B.A. Wabash College; M.S. University of Oklahoma; Ph. D. physics University of Illinois.

Employed at U.S. Naval Ordnance Test Station, China Lake, Calif., 1951-52; U.S. Naval Research Laboratory, Washington, D. C., 1$55-01; professor of physics, University of Illinois, 1901-05; director, Coordinated Science Laboratory, University of Illinois, 1965-70; director chemical and physical sciences, Ford Motor Co., 1970-71; executive director scientific research staff, Ford Motor Co., 1971-73; vice-president scientific research, 1973-75.

Over 40 publications in leading physics journals both American and foreign as well as in reference works.

A member of: Advisory committee for research and advisory committee on research applications policy, National Science Foundation: visiting committee, National Bureau of Standards; energy laboratory advisory board, Massachusetts Institute of Technology; energy advisory board, California Institute of Technology; Advisory Board to College of Engineering, University of California, Berkeley; board of visitors, School of Engineering, Oakland University; Arch T. Colwell merit award board, Society of Automotive Engineers; board of directors, Michigan Cancer Foundation; board member, Bloomfield Hills Junior High School, Parents Teachers Organization.

Honors include Phi Beta Kappa; a station fellowship from the U.S. Naval Ordnance *Test* Station for graduate study at the University of Illinois; and a certificate of commendation from the U.S. Naval Research Laboratory.

STATEMENT OF DALE COMPTON, VICE PRESIDENT, RESEARCH ENGINEERING AND RESEARCH STAFF?, FORD MOTOR CO.

Dr. Compton. Thank you, Mr. Congressman. Mr. Chairman and members of the Office of Technology Assessment (OTA). I am Dale Compton, vice president of research, Ford Motor Co. We are pleased to have this opportunity to review for you some of the ways that Ford uses technology assessment (TA), and to offer some comments on the limitations an strengths that we perceive for the TA process.

The National Academy of Sciences has suggested that TA is the process that "occurs when the likely consequences of a technological development are explored and evaluated." Within this definition, we regularly carry out TAs and we believe that the results provide a valuable input to our decision processes. But before discussing specific examples, I would like to offer some general comments concerning the development and utilization of TAs. There are four issues that we believe are of particular importance.

First, a clear distinction between TA and technological forecasting must be maintained.

Second, a short time frame and a stable environment are critical if the assessment is to be useful.

Third, the ability to make an accurate assessment depends upon the adequacy of the data base being used.

Fourth, an objective assessment requires that no pre-assumed bias be allowed to penetrate the assumptions of the study.

It may be helpful to expand upon these points briefly. The assessment recess tends to assume an existing technology and to explore the ramifications of implementing it. This assumes that the technology is reasonably well-developed. one cannot establish the technical facts by consensus votes. Hard data on the particular technology must be available and must be agreed upon by the experts if an assessment is to be useful. This does not mean that implications drawn from the data will be universally accepted. In fact, the conclusions may be controversial. After all, one often is dealing with sociological forces and the ability to predict social events is at best imprecise. Far too often assessing the social implications comes down to a matter of judgment, rather than to a prescribed means of making a prediction. But the technical data must exist and must be valid before any assessment should be undertaken.

Further, it is basically impossible to anticipate the unusual event. The timing of an OPEC embargo is not predictable. Assessments are usually predicated upon an extrapolation of the current status. So if the time frame is long, the chance that an unusual event will occur is great. This suggests that an assessment should be viewed as a living issue, with frequent review and updates to reflect recent unpredicted events.

Forecasting technological events is subject to even more uncertainty than assessing the impact of technology. Technological feasibility can be established with a fair degree of certainty, but the probability of implementation is often not predictable. As a recent examle, the Wankel engine was in automotive production overseas and well on its way to implementation here when fuel economy became of increased importance. An engine that had been considered to be technically feasible suddenly became technically questionable, when the basis for assessment required that different values be assigned to the various criteria. The distinction between assessment and forecasting relates closely to the time frame being considered. An attempt to assess the long-term consequences of an event generally is more akin to forecasting than to assessment because of the greater uncertainty in the conclusions and assumptions.

Finally, it is terribly tempting to use TA as a tool for advocating a particular predetermined bias. We sense that the TA process at the congressional level has been based on the assumption that Federal intervention through legislation is required. Under such conditions the assessment process should be viewed as an investigation of the impact of intervention, and not as an unbiased TA of an area of interest. These concerns do not mean that it is improper to attempt TA. What they do suggest is that it is important to maintain an awareness of the limitations of the process and to recognize the dangers inherent in making major long-term decisions based upon such assessments.

The TA process has been used by Ford Motor Co. for many years in planning its product offerings. Recently, we have incorporated as integral parts of our assessments, the impact of a variety of new external factors along with market forces. In particular, we have seen the need

to assess on a continuing basis the interdependence of energy, environment and resources as a key factor affecting the impact of the motor vehicle on our society. Consequently, our considerations of the impact of our product actions go well beyond the study of the sale of vehicles. Similarly, we carefully examine the implications of proposed actions relative to manufacturing as part of our assessment activity

I would like now to give you some examples of specific assessments we have performed. My intent is to concentrate on the reason for the assessments and their impact rather than to discuss the substantive details of the assessments themelves.

My first example concerns the development of a company position. As a large corporation, we want to speak out on public issues that may have a significant indirect bearing on our business, and we have found that the principles of TA are extremely helpful in the development of such company positions. An example concerns the 55 mph speed limit. Early in 1974, when the issue was the subject of general debate, we undertook an assessment of this issue. Various f actors were considered, including the impact on mobility and quality of life, the environment—specifically noise and air quality-safety, energy consumption, and car sales. While the assessment forecasted a near-term decrease in sales, the forecasts of reduced fuel consumption, reduced highway accidents, and improved environment were Instrumental in forming a company position solidly in support of the proposal. An interesting aspect of this assessment was that we revisited the issue a year later and published an updated report comparing the forecast with actual experience, and commenting on the probable impacts of more rigid enforcement. We found that our forecast was surprisingly close to the results for the first -year.

A second example, which concerns our manufacturing processes, is an assessment of the paint system that will be utilized by the company in the years ahead. This was precipitated by pending actions at both State and Federal levels regarding the allowable emission level of hydrocarbons from assembly plants. The proposed regulations appear to require the development of an alternative to the present paint system that uses organic solvents. A number of possibilities exist, including water-based paints, powder paints, and low-temperature curing paints of a very different chemical formulation than that presently used. The energy required to handle these low-temperature systems is substantially lower than for the others.

This assessment was required, not only to deal with the tradeoffs regarding energy costs and environmental considerations, but to consider allocations of natural gas, availability of propane, maintenance of outstanding product quality, the minimization of plant investment that would be required to introduce any of these technologies, and the timing that could be expected for requiring the achievement of particular levels of emission. This assessment was particularly instrumental in establishing the direction of future paint system development that will be needed to solve particular technical problems, and to maximize the probability that the optimal system will be available in time. Similar TAs have been performed on the opportunities and limitations of material recycling, and on the desirability of further developing specific manufacturing processes.

My third example will concern our product itself where most of our TA activities are focused. We must, as a part of our product planning strategy, assess impacts well beyond car sales in our attempts to develop contingency plans capable of dealing with changing consumer demands and a changing regulatory and legislative environment. A major constraint on these assessments is the recognition that our capital is limited, and our investments must be recovered through sale of our products. This constraint, which is an essential element to industrial TAs, requires that the theoretical net benefits of an innovation be weighed, not only against the identifiable internal and external costs but also against the risk of failure of the technology itself or of consumer acceptance of it.

Recent product-related assessments have included a wide variety of automobile power systems including turbine, Wankel, hybrid, electric, and many derivatives of our present engine. We believe that we are reasonably competent at this process, but we also recognize that we might overlook some key issues. For this reason, we recently did something unusual in the TA business. We asked a highly competent outside group to work completely independently of us to carry out an assessment essentlally parallel to our own in the evaluation of the potential of future automotive powerplants. On Ma 23, 1973, Mr. Lee Iacocca, president of Ford Motor Co., told the U.S. Senate Subcommittee on Air and Water Pollution, that our company intended to make a ant for an assessment of alternate power systems for motor vehicles cause "we feel we need to have an outside, independent check on our technical judgment as well as on our evaluation of such factors as the most approach utilization of national energy resources, the transportation needs of the future and the economic implications" After a lengthy selection process, a grant of $500,000 was awarded on October 3, 1973, to the Jet repulsion Laboratories (JPL) of the California Institute of Technology to conduct the assessment. I have submitted to the Board a copy of our description of the desired assess—ment. (See app. C, exhibit 2. It was understood at the outset that JPL would operate totally in independently of Ford. In fact we asked for no progress reports and agreed to read the final report only after it was released to the public. We did provide, *on* request, nonproprietary data for the study. Similar requests were made to many other elements of the automotive industry, and we are pleased that they responded so well to these requests.

We asked JPL to forecast the extent of the future development of the current internal-combustion Otto cycle engine, and to compare alternative future technologies with regard to economic, natural resource, environmental and societal impacts including production, and logistic and energy support requirements. We also introduced some new questions. We asked JPL to investigate various introduction dates for new technologies, and to evaluate introduction timing as a parameter. And finally, we asked them to try to sort out research and development requirements into those tasks which would logically call for either Government funding or industry funding based on considerations of risk, potential benefits, and cost, and the potential for meaningful industry-Government relationships.

We believe that the study met the objectives that were established and is proving valuable as a baseline source of information for Government and private sector policy guidance. This does not mean that all of the conclusions of this study are accepted by everyone, including us, but it has been very useful. It is also interesting that the Energy Research and Development Administration has recognized the need for a continuing evaluation of this area and has chosen to fund an update of this study on a regular basis.

Recalling my earlier remarks about an inadequate data base for assessment, we were particularly interested in the assessment that JPL gave of the potential of the turbine for vehicular propulsion. Several years ago we entered the turbine engine business, based in part on the results of an assessment. It was only after we were in business that we discovered that the stability of one of the key ceramic components severely limited the durability of the engine. The assessment led to the wrong business decision because of its failure to adequately explore technical details and its failure to account for risk. The JPL study recognized that this problem had now been solved. The availability of new materials now makes the turbine an attractive alternative.

What have we learned about TA as applied to our needs? First of all, we do not have a formal technology assessment office nor do we think one is desirable for us. We believe that it is important that the TA philosophy be understood and practiced by all of the groups in the company who are involved in decisions on technology. Our product planning staff, research staff, environmental research office, car operations office, and our various manufacturing divisions all participate in these assessments. We also frequently a preach the TA job on a task force basis with appropriate staff and line representation. A critical element is the identification and involvement of those who are best informed regarding the technologies at issue.

Second, we have tried to avoid the development of a highly structured methodology because we have not found a single methodology that is applicable to all of our needs. We have tried to be consistent in adhering to the principles of scientific methodology, that is, to make data and analyses available for critical review by others within our technical community, and to avoid the temptation to analyze complex, highly quantitative problems on the basis of opinions alone.

Third, we have found it essential to make every effort to maintain objectivity. Without proper review and extensive debate of all alternatives, it is easy for TA to degenerate into an advocacy tool. When this happens the conclusion of the assessment must be viewed as suspect.

We will continue to use TA as a means of evaluating various alternative products and manufacturing actions and their (societal) public implications. Accordingly I suggest that it could be of mutual benefit to the office of Technology Assessment (OTA) and to industrial organizations, such as Ford Motor Co., if procedures existed whereby we could more effectively provide an early input into governmental studies. It seems to me that the adequacy of the data base and the objectivity of the assumptions underlying assessment studies would be strengthened by opening the channels for greater industrial inputs into OTA studies. opportunities to contribute our own findings and analyses during OTA studies rather than the more limited system of com-

menting on finished reports, provides a healthier climate for Government-industry interaction. Recent experience along these lines in the OTA durability assessment now underway, demonstrated the value of early interaction.

Once again I wish to thank you for the opportunity of appearing and I would be happy to try to answer any questions that you may have.

Mr. BROWN. Thank you very much, Dr. Compton. I think your statement is an extremely valuable contribution to the subject matter of this hearing. I don't think we can stress too much the importance of some of the points that you have made about the necessity for adequate cooperation between the arms of the Congress that are trying to provide data for policy decisions, and the private business entities that are also involved in the results of these policy decisions.

In your opinion, does the study that you commissioned at JPL fit within the general structure of what we call technology assessment (TA) ?

Dr. Compton. We believe that it does.

Mr. Brown. Could I ask you to amplify a moment on what you felt the advantages were of having this done on an outside basis rather than internally within the company ? What were the factors which led you to feel that this was the best procedure to follow in getting the kind of results that you wanted?

Dr. Compton. Well, Mr. Brown, the principal reason that we wanted an organization outrode of our company to do this was because we wanted an assessment that was independent of our own biases. We often find that our studies are considered to be biased and self-serving and that our conclusions and suggestions, therefore, are often ignored out of hand. In this particular case, the subject matter was of such great importance to the country and to our own future business interests that we felt an objective independent study was needed that would have credibility, both with the public sector and with the private sector. Thus, we felt It was essential to go outside the company to have it done. I might say that it has served as a very valuable internal tool for our own planning and this has been very important to us.

Mr. BROWN. Well, I am stressing this because it bears directly on our own mode of operation in the Office of Technology Assessment (OTA); the question of whether we should do internal studies versus commissioning external studies. We follow both procedures at the present time, as you do in your company, and yet we need to be aware of when the circumstances might dictate going as you have done with JPL on this kind of study.

Mr. Daddario, do you have some questions?

Mr. DADDARIO. Thank you, Mr. Chairman. Dr. Compton, in your closing remarks you refer to the importance of the constant involvement of industry in various OTA TA activities, and yet that runs somewhat counter to what you have said about involvement in your own study. Why were you so sensitive to your own involvement, that this same philosophy would not have applied?

Dr. COMpton. Well, I think it can be compatible in both cases, Mr. Daddario. In the JPL study, we provided a whole range of information and we attempted to respond to any question that JPL asked us during this study. We also were allowed to critique the as-

sumptions that formed the basis of the study, but we were not involved in the assessment process itself. That was done by JPL independent of Ford.

What I was suggesting is that it would be very helpful for industry to be involved in the discussion of the study assumptions at a very early date, and also in the discussion of what data are available and the reliability of those data. But if it is to be an independent study, the carrying through of the assessment process would have to be done independently by the OTA.

Mr. DADDARIO. I recognize that, but I think that the argument works both ways. When a company has so much knowledge of the data, being so sensitive to the objectivity part of the TA might not allow you to take advantage. You might in fact have had a better report if you had participated more. I wonder if you have any comment on that?

Dr. COMPTON. I don't think we feel that the report was inferior because we did not have direct participation. We clearly have some questions with it and we have disagreements with some of the conclusions. But the processes which JPL followed led to some new methodologies that had not been used before. Those have proved to be very valuable to us. The important thing is for the discussions to take place at an early stage of the development of the study. Hopefully, this will lead to agreement on the general approach and will help prevent a confrontation on the results of the study. While there may be strong disagreements that can never be resolved, I think it will be valuable if these can be aired before the study is complete.

I might give one example outside of the OTA studies about which we have felt very strongly, Mr. Daddario. The National Academy of Sciences (NAS) study on air pollution was done for the Congress. When that study was published, it was reviewed and generally found to have some rather serious technical limitations. There was not an opportunity to critique that or to discuss the methodology prior to the final publications. And it became then a case in which we were confronting NAS in front of the Congress. I believe that the technical issues could have been resolved much earlier, much to the benefit of the country, if a serious review of the technical issues could have been held early in that study.

Mr. DADDARIO. Well, I would agree with you on that. You state with reference to the OTA durability assessment in which there was considerable involvement of all parts of the community, that this would be a good thing to do in all assessments. We have in fact, in every instance, followed that same approach where there is involvement, even though your statement indicates to the contrary. There is involvement in the first instance, and through the entire course of the assessments. So when the final drafts are sent out to industry, they have already been participating. I think we have done that in every instance.

Dr. COMPTON. There certainly is industrial representation on your advisory board, and some of their views, of course, are represented to you via that mechanism. But I don't believe that industrial groups have been asked to offer comments and to represent official company position. We did make a formal presentation in the wear and durability study, and it was very valuable, I think, to both of us.

Mr. DADDARIO. Well, you are making a distinction then, and I think it is an important one. It is very helpful that we have this dialog. It may not be enough to have the representation of expert people on an individual basis, but perhaps there ought to be some stronger involvement so that the connection is to the company as well as to an individual who has knowledge about that particular area of activity. Do you think that this might strengthen the process?

Dr. Compton. Yes, I believe that a stronger involvement of those companies competent to comment on specific issues is important. The involvement of experts is also important, but their views should not be considered equivalent to corporate evaluations.

Mr. DADDARIO. You touched earlier on four points The second one says that a short time frame and a stable environment are critical. What do you consider to be a short period of time?

Dr. Compton. It depends a bit on the technology that one is discussing. In the automotive industry, major near-term changes are restricted because of our leadtime problems and the type of investment that we have. Thus, a long-term technology assessment refers to 10 or more years. This was the general time frame that the JPL study was oriented to.

There are many studies that could be quite appropriate for 2 to 3 years in the future. It really depends? I think, on whether the investments and the commitment revolved in the implementing of a plan, a product, or a control process are so large that the inertia of the system and the time frame to change it is very long. Then you have to look well beyond where that time frame is. So you have to examine each case independently. In the automotive industry we think that technology assessment of new vehicle powerplants should be concerned with the events of the mid-1980's to the mid-1990'&

Mr. DADDARIO. One of the reasons I asked you the question about your own involvement in the JPL study, is that in our activities we sometimes find that in the course of our carrying out an assessment, a part of what is being done becomes useful. If we had to wait until the assessment was completed we might not have been able to use it during the course of other activities. For example, in our Outer Continental Shelf assessment, which has been going on over the course of almost 2 years, three or four sections have been taken out and utilized by congressional committees that have been placed in an adversary position. This material is put back in but not necesssarily ***in*** the orignal form. In a sense, this keeps it vital--one of the points that you raised-and makes the assessment a live type of activity. The material is not only useful but is also strengthened. I wonder if that is not an important involvement.

Dr. COMPTON. It is very useful. You recognize, of course, we were doing similar studies internally, and we had the benefit of those studies as we were carrying them on ourselves. But we felt the need for a high credibility for this study, which would not be a self-serving document.

Mr. DADDARIO. I am not talking about the JPL study now, but rather from a general point of view.

Dr. COMPTON. From a general point of view, I agree with you, sir.

Mr. DADDARIO. I would like you to go into a little greater depth, if you might, Dr. Compton. You touch on the concern you have about the TA process at the congressional level, the biases that might develop and the importance of having unbiased TAs with which, I am sure, the Technology Assessment Board would completely agree. It is a very important point and I wonder if you might elaborate *on* that a little bit.

Dr. Compton. May I just give you two examples of what we see as biases toward possible Federal legislative intervention. In the product and equipment durability study that is still under way, the stated objective, as we understand it, is the identification of the legislative options for the stimulation of the control of corrosion and wear. The important point here is the word control.

In the study that is underway on the changes of the use and characteristics of automobiles, the original request by Mr. Hart? we understand, was to assess the impact of Government regulations on the automobile industry employment and its financial health. It is our view that the major effort being devoted to that study is an assessment of the ways to cause changes in the characteristics and use of automobiles and to effect changes in the industry. We believe that there are significant differences between the original and the present objectives of these studies, and we are concerned that the results of these studies will reflect a preestablished bias for the need for Government intervention.

Mr. **DADDARIO.** Well, I would agree with you. As these activities continue to go through their design phase, within which I believe there is a good cross-representation, I would expect that these matters would be taken into consideration.

The significant point is that the question of bias is important. I think this question is important to the Technology Assessment Board, because the original request that came from Senator Hart was examined and returned. Adjustments were made over the course of time, all of which took into consideration certain of the concerns that were expressed by the industy that was most affected. The Board was certainly anxious to see to it that, as this assessment continued, it would be objective and unbiased. At the present time we certainly are making every effort to see to it that there is both objectivity and that type of participation. Thank you.

Mr. BROWN. I will now call on Mr. Leathers, one of whose functions is to provide that input from the industrial community to which you referred.

Mr. Leathers.

Mr. LEATHERS. Thank you. I have a question concerning the assessment examples that you have described. I really wanted clarification or some elaboration on whether or not TA as you presently carry it out, Dr. Compton, is not an extension of what was formerly known as economic evaluation, feasibility studies, and economic assessments ? You then extended it by adding the environmental impact of energy and similar considerations.

Dr. COMPTON. Yes, sir, they are indeed extensions of the types of studies you mentioned and they use many of the same tools that we have used for years in industry.

Mr. LEATHERS. Thank you. There is another aspect to this discussion you just had with Mr. Daddario on assessments. The Advisory Council is troubled that some requests as written to the OTA or the Technology Assessment Board, in our opinion frequently contain a basis. The Advisor Council has spent a great deal of time making sure that the final document is completely fair with all the biases clearly stated. We try to point out all the options available for Congress to act on without making recommendations or drawing conclusions. This sums up what I have to contribute to this discussion.

Mr. BROWN. Thank you, Mr. Leathers Just a question or two, Dr. Compton. In one of the earlier hearings in this series the view was expressed that there was a possibility that as TA procedures become more widespread, they might contribute to reducing the governmental role. The theory behind this was that frequently the governmental role becomes necessary as a result of a failure on the part of an enterprise to adequately account for all the second- and third-order effects of a particular course of action. But as those effects are taken into account in current planning, and where they are adverse to the public welfare, suitable preventive actions or alternative courses are. adopted, a certain amount of governmental intervention will be obviated. Do you see this as a possible benefit of the TA process or are we missing something?

Dr. COMPTON. I would hate to predict that as being a consequence of TA, because it seems to me that the critical issue here is what are the incentives to accommodate these second- and third-order benefits.

Mr. BROWN. Benefits or negative effects?

Dr. COMPTON. The negative effect. Unless the incentives are clearly defined and can be applied universally across the entire industry or product, it is very hard for them to be accommodated, I think. I would hesitate to predict that this would change the level of Government involvement, but I would ho e that it would focus it, and make it such that we would realize the implications to both the public and to the private sector of a particular involvement on the part of the Government.

Mr. BROWN. There are many members of the Technology Assessment Board who would like to see TA used to analyze the effects of Government regulation on technologies, as well as on the physicial or economic-social impact of the technologies themselves. Do you see anything incompatible with the concept of TA that would preclude using it in this fashion, to delineate the problem for assessment as, what are the socioeconomic, environmental, and other impacts of a particular regulatory option that might be followed?

Dr. COMPTON. I think it is extremely important to include all of these factors. Had such an assessment been carried out very carefully at the time the clean air amendments were being discussed, I believe that it would have been recognized that there were insufficient data to make some of those prediction?, and insufficient technology to assume a certain time frame in which the specified levels of emission could be met. It would have been extremely important to have had a careful assessment of all of those factors at the time that those regulatory measures were being considered. The same is true, of course, of many of the water-pollution regulations that are now under consideration; from a physical point of view, to insist that

there be zero discharge has certain implications in terms of the technology.

Mr. BROWN. I want to change the line of questioning briefly and get into another area. We are concerned about the role of public particpation in the assessment process. Frequently, when you are attempting to evaluate certain types of potential effects the views of the public are an important element in determining the nature of the final results of the assessment.

Have you faced this problem in connection with the kinds of TAs that you make in your company? Does the assessment that you had JPL do have any component of public participation in it? This doesn't necessarily mean the general public, but It could mean concerned special publics. You have referred for example, to the technical community and their reviews. Well, that is one kind of a public. How do you encompass this in your own thinking about TA?

Dr. Compton. We tend to look at various aspects of issues; how they affect the total labor market? how the-y affect the marketing and acceptance of our products, and so forth. When we do these internal assessments we do not generally invite public participation.

From the standpoint of assessments that are being carried out in the public domain, as are OTA studies, I think it is apropriate that the public be involved but only at an appropriate time. It seems to me that the technical consequences have to be considered and examined based on technical facts. The implications from a technical point of view have to be as carefully determined as possible. Technical issues should really not be debated or decided by public opinion. Where the public interest is important is the impact of an implementation strategy. I would view that as a second step, but make very sure that the initial step was as much a factual data-base evaluation as is absolutely possible. Always recognizing, of course that there are times where we have to extrapolate from a limited data base.

Mr. Brown. Well, in the public domain, we have a particular problem in dealing with the public. For example, assuming that it was a desirable public policy say, to have offshore oil drilling or a large offshore supertanker port, some people might say that this was in the best interest of the public and of this country. Yet the people in the area might object to it. A political entity seeking to influence this public opinion is accused of manipulation. Whereas In the private domain, if you seek to influence the public on behalf of a particular technology, that is just sound marketing. There is a difference here.

This raises the question of what relationships the marketing role plays in your assessment activities! The history of the automobile indust is replete with examples. For example, when General Motors (GM) went to annual models, whereas Ford has been in the old days content with the model T. The question a TA would have raised would be; going to annual models by GM is going to take more capital, more energy , and a lot more other things, but it may sell a lot more cars; how do you reconcile the marketing role, which is best for profitability, and the TA role, which gives you a measurement of all of the energy, capital, environmental and other impacts ?

Dr. Compton. I think the important distinction is that TA establishes what the options are; that is, what the cost of those options will be. The marketing comes in determining what is a proper product.

Do you envision that it will be profitable to implement option A as opposed. to option B ? The answer to this then requires an investment of a major kind. But the options are based upon technical issues. For example, what does it take to go to 500,000 units a year of vehicle A with plant B, and so forth. Those are the technical issues that form the basis for the corporate action that then will lead to a product of one type or another.

Mr. BROWN. But stating this in an extreme form—suppose you took the worst possible technical option, because it turned out to be the best possible marketing option?

Dr. Compton. That could happen.

Mr. BROWN. What's the value of having TA then?

Dr. Compton. Because it resented the options to the corporate management that has to make the decisions on how to best use its capital and how to make the best profit on that capital.

Mr. BROWN. But is your final criterion or action always going to be best return on capital?

Dr. Compton. The final criteria involve many things, obviously. There are considerations such as corporate responsibility that are in that equation; there are issues such as customer loyalty that may be more important over a long period of time than a gain in the near term. There are many things that enter into that corporate decision. But the technical issues have to be presented as sound options. The other factors then get built in during the management assessment of these options.

Mr. BROWN. How do you evaluate the merchandising role, then? Suppose that it was conceivable that you could merchandise the best option from a technological standpoint if you put the resources into merchandising it-it would cost a little bit more than merchandising the worst option, but the social benefits might justify it. Are you or any industry, particularly one as important as the automobile industry, in a position to consider the effects of your merchandising activities; that is, the money that is put into promotion, media, and so forth?

Dr. Compton. Of course, that is part of our cost and has to be considered as part of the investment in a new product.

Mr. BROWN. How much interrelationship do you in the research end of the business have with the marketing and merchandising end of it?

Dr. COMPTON. We have very limited interaction within the Ford Motor Co. with either marketing or merchandising.

Mr. BROWN. This is a very serious part of the policy problem that Government faces, you know, because assuming that we exercise our trusteeship role properly, Government is not so much concerned with marketing and merchandising as it is with public welfare aspects. Here again, the point might be made that if an industry were to consider using its resources to implement the strategy most compatible with the public welfare, the need for the Government role would be reduced.

Dr. COMPTON. If one could be assured one's competitors would be doing the same and, if not, that there would be no net disadvantage to you, then of course—

Mr. BROWN. A pretty big "if."

Dr. COMPTON. The free market will operate properly.

Mr, BROWN. We thank you very much for your testimony, Dr. Compton. I think that this does illuminate very well some of the key

policy problems as well as some of the important technical problems in the TA process. We would like to submit some additional questions to you in writing, answers to 'which will help us complete the record.

Dr. Compton. Thank you.

Mr. BROWN. We are very grateful to you.

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

***Question 1. In* your TA activities, what limits do you place on the TA concept?**

Answer 1. Essentially the only limits that are imposed on the TA concept result from the availability of reliable data that can be used in the evaluation of the issue under consideration.

***Question 2. How* do you decide what problem should be examined with TA? What kind of decision-planning process is gone 'through in the conduct of a TA from its inception to publication and final utilization?**

Answer 2. As I stated in my testimony, we use TA in decisionmaking regarding products, processes, and public positions. The planning process varies depending on the application. In general, we examine a problem with TA when there are questions that involve technology options which cannot be answered by traditional economic or market analyses.

Question 3. Would you describe how Ford goes through the environmental impact process? Do you attempt to explain impacts and to educate the public and employees ahead of time?

Answer 3. In the case of facility construction or expansion programs for which regulations require the submission of an Environmental Impact Statement or Environmental Assessment, we would prepare such a report with our own staffs *(or* possibly with outside contractor help). Such reports, once submitted to the agency, are on public record. We consider environmental effects on a regular basis, but formal impact statements are only prepared at the instance of Government.

In the case of our products, we attempt, through public statements, to inform our customers and the public regarding the benefits and the costs of current and future environmental controls.

Question 4. In a WA should the impact of a new technology on job structure be examined?

Answer 4. The impact of new technology upon job structure is just one of many factors considered in a TA.

***Question 5.* How is TA information worked into reports?**

Answer 5. It is often included as an integral part of the total report.

***Question 6.* Based upon your overall TA experience, what lessons have been learned? Has TA affected your way of doing business?**

Answer 6. Good data are essential. Opinion is of little value. Yes, we have modified our thinking on various options as a result of a TA.

Question 7. Regarding the Jet Propulsion Laboratory-California Institute of Technology (JPL-Cal Tech) TA, would you desribe what the impact of that study was on decisionmaking and policymaking at Ford?

Answer 7. The JPI-Cal Tech TA provided an independent assessment of the advantages and disadvantages of various engines. The document provided an important input for our assessment of the desirability of continuing work on turbine and Stirling engines.

***Question* 8. Did it have an impact on the planning process?**

Answer 8. Yes, as I just mentioned, it was used as an input into our planning process.

***Question* 9. What lessons were learned as a result of that TA?**

Answer 9. Questions of manufacturability, tooling costs, process changes presented problems for the grantee. A better methodology is necessary for attacking these issues.

***Question 10.* Have any new TAs been commissioned to follow on that TA?**

Answer 10. No.

***Question 11. Do* you expect that any will?**

Answer 11. Yes.

Mr. 13 Brown. Our next witness is Dr. Henry L. Duncombe, vice president and chief economist of General Motors Corp. And you have an associate with you?

Dr. DUNCOMBE. Yes; I have, Mr. Chairman. Dr. Frederick Bowditch.

Mr. BROWN. Dr. Bowditch, we are very pleased to have you with us also.

Dr. DUNCOMBE Thank you very much. Before I proceed with my testimony, I would first like to call your attention to a report that I have submitted to the Board. This is the 1975 General Motors (GM) Report on Programs of Public Interest. I want to cite here some seven chapters in this report that deal with improvements in vehicle emissions control and fuel economy, alternative automotive powerplant research and development for improved fuel economy and reduced emissions, industrial energy management in General Motors, automotive safety engineering progrms to establish field-relevant tests, public transportation as General Motors views it, noise-control regulation for medium and heavy trucks, and an update on continuing programs to control the industrial environment. All of these chapters, I believe, deal with this matter of TA and would be of immediate relevance to the concerns of the Board in its work.

Mr. BROWN, Without objection, that study will be made a part of the record of the hearing, Dr. Duncombe, you may proceed with your statement.

[For information about obtaining this report see appendix C, exhibit 3.]

[The biographical sketch of Dr. Henry L. Duncombe, Jr., is as follows :]

DR. HENRY L. DUNCOMBE, VICE PRESIDENT AND CHIEF ECONOMIST, GENERAL MOTORS CORP.

Born January 11,1914, Grand Forks, N. Dak.

B.A. University of Chicago, 1934; M.A. Northwestern University, 1938; Ph. D. economics, Northwestern University, 1948.

Instructor, Northwestern University; assistant dean and professor, Amos Tuck School of Business Administration, Dartmouth College; economist, Machinery and Allied Products Institute, Washington, D. C.; statistician, special studies, the treasurer's office, General Motors, 1957; director of economic studies, the GM Financial Staff, 1968; chief economist, 1972.

Consulting for industry and government relating to domestic and international economic problems in marketing research, labor arbitration, and economic and statistical analysis.

Advisory activities include: Chairman of the Economic Research Committee of the Motor Vehicle Manufacturers Association, the Technical Consultants to the Business Council, and the Economic Research Committee of the Business Roundtable; economic adviser to the International Chamber of Commerce; and member of the Council on Trends and Perspectives of the Chamber of Commerce of the United States.

Honorary and professional memberships include: honorary member of Beta Gamma Sigma, the national honorary business fraternity; and member of the American Economic Association, the American Statistical Association, and the National Association of Business Economists.

STATEMENT OF HENRY L. DUNCOMBE, JR,, VICE PRESIDENT AND CHIEF ECONOMIST, GENERAL MOTORS CORPORATION; ACCOMPANIED BY FREDERICK W, BOWDITCH, EXECUTIVE ASSISTANT TO THE VICE PRESIDENT, ENVIRONMENTAL ACTIVITIES STAFF

Dr. DUNCOMBE. Thank you very much, Mr. Chairman and members of the Technology Assessment Board. I am Henry Duncombe, vice president and chief economist of General Motors (GM). With me

today is Dr. Frederick W. Bowditch, executive assistant to the vice president, environmental activities staff.

As we understand the congressional intent in establishing the Office of Technology Assessment (OTA), it was to give Congress an independent capability to understand the technological issues involved in legislation. OTA was created, according to the preamble of the Technology Assessment Act of 1972, to provide Congress with unbiased information concerning the physical, biological, economic, social, and political effects of the actions Congress may take on programs involving science or technology.

This is an awe-inspiring mandate as we would view it from the perspective of a single industry. It is truly breathtaking when we consider the diversity and dynamism of the American economy. I would like to discuss TA as we view it in General Motors (GM), with primary emphasis on the economic, marketing, and commercial considerations that of necessity are important to any private enterprise. We hope that with our statement and in answer to your questions we will be able to assist you in your search for a sharper definition of the potentials of TA.

General Motors has long been concerned with at least some of the elements included within this all-encompassing term. Engine and drive-train efficiency and performance, the structural integrity of our vehicles, feasibility for volume production, cost and marketability would all be relevant considerations in the normal course of the conduct of our business. And while all manufacturers have had to assess their products in terms of their appeal to the customer, the industry has long been concerned to improve highway safety, to understand the evolving role of the motor vehicle in the Nation's transportation system and its impact on land use and demographic change. We, even more than OTA, are concerned about the characteristics and the uses of the automobile.

During the past decade, the passage of legislation that superimposes nonmarket vehicle standards on those required by the customer has, of course, involved manufacturers in a much broader range of considerations. The recognition of photochemical smog and its relation to vehicle exhaust emissions, prompted research that produced the catalytic converter. Recognition of the Nation's dependence on overseas and insecure petroleum sources resulted in the voluntary economy commitments made by each company to President Ford, and we have of necessity, made assessments of the mandatory fuel economy standards included in the Energy Policy and Conservation Act. In the area of mandatory safety standards, we have on repeated occasions, expressed our views concerning feasibility. cost, and benefit.

In short, motor vehicle manufacturers have lived with the necessity for TA. broadly defined, for most of the past half century. What is new is the explosive growth of regulation affecting almost all facets of the design and performance of cars. In this process we have been forced to assign an increasingly higher priority to meeting Federal standards. relative to our traditional concern with the suitability of a vehicle to the customers to move **people** and goods

If we understand the term correctly, TA must involve a forecast, or more precisely, a complex of related forecasts. These would include the probability that a perceived technological alternative could be

developed, as well as an evaluation of its costs and benefits relative to existing and other perceived technologies, an assessment of its acceptability to the customer in performing its function, and its related advantages and disadvantages. I can speak to the problems of forecasting with a substantial amount of personal conviction. During the past 20 years, the responsibilities of my staff have included the development of macroforecasts and, based on these, estimates of the probable levels of motor vehicle demand and the mix of car sales.

In the past, such forecasts have been made in a climate of reasonable stability in terms of the outlook for economic growth, our understanding of the regulatory recess, and, at least prior to this decade, without significant concerns about energy availabi lity. In spite of this, our and other forecasting records have sometimes been wide of the mark, even when limited to a relatively short time horizon.

The stable climate of the past no longer exists. From the manufacturer's point of view, the regulatory outlook is pure chaos. Great uncertainties surround national energy policy and the courses of action that will be taken to reduce the Nation's vulnerability to insecure external energy sources. Finally, there is widespread debate about the content, nature, and magnitude of Government efforts to assure sustained economic growth in the future. To try to build, in this sea of confusion, an island of coherent policy applicable to motor vehicles alone for a period from 5 to 15 years in the future is, under the best of circumstances, a very difficult undertaking.

Business enterprises must do advance planning. This is paticularly ue in the automobile industry where long lead-time considerations make it imperative that we look ahead for several years, and try to anticipate changes in economic and social conditions, Government regulations, and life styles that affect demand for our products. The product decisions we make on the basis of that advance planning are not always correct. For example, current large inventories of unsold compact and subcompact cars reflect our inability to predict precisely market demand earl enough to tailor our production plans to conform ideally to that demand. And I would point out that these production plans were established less than 6 months before they were proved to be wrong.

When a business enterprise makes *a* decision based on a faulty assessment that business suffers the consequences of its failure to anticipate market demand. In that case, it loses out in relation to its competitors whose forecasts are more accurate. However, when the Government is in error in the assessments it makes as a basis for regulating the industry, the entire economy, not just one business, will be the loser. If for example, the fuel economy standards mandated by the Energy Policy and Conservation Act for the year 1985 were in effect today, it is highly probable manufacturers would be able to offer no more than a few of the intermediate and full-size models whose current brisk sales are contributing to the Nation's economic recovery.

The Government forecasters who believe they can define the "right automobile" for the eighties on the basis of studies today, and then impose their determinations through legislation and regulation on the automotive production and marketing system, are attempting to overhaul an extremely delicate and complex mechanism with a bludgeon. If they fail, no one will bear the responsibility in the vast anonymity

of Government; but millions will pay the price of unemployment and the entire economy will be the victim.

Misdirections in regulations affecting vehicle technology are not always merely a consequence of failure to correctly assess the distant future. There are instances of failure to take the known facts into consideration in decisions affecting the short term. Insofar as our company is concerned, we think that there is indeed a high potential for OTA to play a constructive role in informing Congress and, in turn, other branches of Government, of the technological issues involved in automotive regulation, and thus improve the quality of overall decisionmaking in this area.

For example, Congress is now en din another round of amendments to the Clean Air Act that include consideration of amendments to the auto emission standards. We are hopeful that Congress will amend the stringent standards now schedule for the 1978 model year to a level that is more consistent with the existing state-of-the-art and a reasonable assessment of air quality needs. However, until such amendments become law, the industry must continue to try to develop technology to meet the statutory 0.4 grams per mile standard for nitrogen oxides. This is true in spite of the fact that it has long been recognized by the Environmental Protection Agency (EPA) and a large segment of the scientific community that the standard was not only established in error but is also substantially more stringent than necessary to meet air quality needs. Moreover, we still do not know the full cost. For examle, the existence of that standard has served to discourage the further development and introduction of alternative technology such as the passenger car diesel engine, which would make a contribution to national energy conservation objectives.

As an economist would view it, there was no evacuation of costs and benefits before the standard was set, and even after the direct cost-benefit relationship was shown to be negative, the. industry must continue to be concerned with its implementation.

In the area of vehicle safety regulation, many additional examples exist of standards already implemented with no clear demonstration of a positive cost-benefit relationship or demonstration of cost effectiveness. On past occasions we have reported that the cost to the customer in meeting current safety standards is estimated at $385 per car. If GM costs can be considered typical, this would be a total cost approaching $4 billion in a lo-million-car year. Has this expenditure resulted in a commensurate benefit? Equally important, if we are to impose this added total dollar cost on the consumer, is this the most effective way to spend it? Hopefully, these vehicle safety costs will be reduced in the future, but this does not reduce the need to subject both existing standards and proposed standards to the discipline of these questions. Surely we need better data, as GM and others have been urging for some time. This is in the interest of the Congress, the industry, and the national economy.

In our view, the time for Congress to pause and take a prudent dispassionate look is now, before new regulations are imposed on the industry. It is in this area that we also see a constructive potential for OTA. As great as our concern is that mandated vehicle standards clearly meet the related economic tests of benefit commensurate with cost and demonstrated cost effectiveness, we believe that OTA has an

even more compelling mandate to assist the Congress in its understanding of those areas in which regulation maybe required, and those where market forces are superior. In our private competitive economy, it seems to us that the burden of proof must be on those who propose to limit the free expression of consumer choice by regulation.

The vehicle fuel-economy standards in the Energy Policy and Conservation Act passed last year are a clear case in point. The fuel economy of U.S.-produced cars is improving very rapidly in response to market demand for more fuel-efficient cars, and as a consequence of the fourfold increase in world petroleum prices. There is every reason to believe that the consumer's preference for small cars would have been accelerated had the price of domestic petroleum not been artificially held down. Even with this unwarranted intrusion in the domestic petroleum market, low group cars, compacts and subcompacts, are currently accounting for 45 percent of all new car sales, and vehicle manufacturers have responded to this market. The fuel economy of cars already has improved. The fuel economy of GM cars already has improved by 38 percent since 1974, according to EPA data, and we have estimated that the improvement would exceed 50 percent by 1980 in response to market demand, and without any action by Congress on fuel economy standards.

Mandatory fuel-economy standards, together with petroleum pricing, represent another entirely unsupported intrusion of the regula--tory process into the competitive market. Even up to the time the Energy Policy and Conservation Act was passed, there was no technological or other assessment demonstrating that it was desirable, let -alone necessary, to override the free choice of the consumer in this area; nor was there a convincing assessment of the implications of these standards.

As GM's president, E. M. Estes, testified before the Senate Finance Committee, the 1985 fuel-economy standard can be met-based on all we know about the automobile-only by limiting GM's production almost entirely to cars the weight of the current Vega or smaller. Hopefully, with time we would, as a normal consequence of market forces, make further progress in fuel economy. But who took the time to assess the consequences of this act before it was signed into law ? Our own preliminary assessment, which admittedly can be refined, is that the adverse consequences of the law for the industry and the economy will be very large and the contribution to the goal of energy conservation highly conjectural. But the point is, there was no real determination of what normal market forces in both the petroleum market and the vehicle market would have accomplished before we plunged ahead with new layers of Government regulation.

Another bill now waiting Senate action, the Automotive Research and Development Act, calls for the Department of Transportation to develop one or more "production prototypes" of "advanced automobiles" that are cleaner, safer, less expensive, more damage resistant, and more energy efficient. The approval of such legislation by a Senate committee also betrays, in our view, a disturbing lack of understanding of the compelling economic incentives that motivate the private sector to attempt to accomplish those objectives. Now, Dr. Bowditch can speak from a lifelong experience about these pressures.

As one who is concerned with the economics of these issues, I am appalled by the apparent lack of congressional understanding of the competitive pressures to which motor vehicle manufacturers must submit. If any manufacturer had been able to identify the ultimate technology and design the vehicle described in the bill I am discussing, it would have been done long ago.

It is frequently charged that auto companies are reluctant to adopt new and superior engines or other automotive components because of the magnitude of their investment in tools to make the current products This is a myth that is perpetuated only by misunderstanding of investment analysis. In GM's case, we have been and are planning to spend billions of dollars to improve fuel economy that will affect virtually every component of our products. GM expenditures to replace existing tools and equipment have been estimates to exceed $2.5 billion annually between now and 1980. Some of the changes that involve these large" expenditures of money are expected to result in fuel-economy improvements of small fractions of a mile per gallon. This effort however, is being made because we expect our customers to continue to demand improved fuel economy.

If there were an alternative engine or powerplant available that would deliver improved fuel economy and meet all other engine requirements at reasonable cost, let me assure you we would spare no effort to develop it and market. it. A minimal understanding of the return-on-investment criteria and analysis is all that is needed to see that "sunk costs" are not a limitin, factor t. investments that offer advantages to consumers. A distinguished British economist over a century ago put this matter cogently when he said, 'bygones are forever bygones." There is nothing more useless than an obsolete investment.

Mr. Chairman, we are prepared to discuss this subject as fully as you wish. GM's interest in vehicle prototypes and power research is well known. And we know the costs and the risks; we have made the assessments. For example, it, is well known that GM mounted a major effort in research and development on the rotary engine and advanced to within **a** few months of actual production before deciding that fuel economy and emissions problems were substantial enough to justify assigning lower priority to the development of that engine.

GM- also had conducted a major research effort on the Stirling engine over a 12--year period. However, this project was curtailed in 1970, because in our judgment. the remaining technical **problems are too** great for us to consider the Stirling a viable candidate for the near or intermediate future. There are. some in the corporation who assert that GM continued its development program on the Stirling engine long after the limitations of this engine had been fully established.

Our experience with the automotive gas turbine also is relevant. We are continuing a major effort toward production of heavy-duty gas turbines, and we have made substantial progress. Our development work on the passenger car turbine also is continuing. A GM passenger car gas turbine has demonstrated the capability for low emissions, but fuel economy continues to be a problem. Although work on the gas turbine is by our assessment, somewhat encouraging, a reliable

and durable system that meets all Federal emission standards has not been demonstrated.

GM research laboratories and engineering staff have done, and continue to do. a great deal of research on electric propulsion systems. But this research and engineering effort, would have little direction without an understanding of the role of the electric vehicle in the Nation's total energy policy. A research laboratory's assessment of the energy utilization of electric vehicles concluded that a small, lead-acid battery-powered 2-passenger shopper vehicle would use from 25 percent less to about the same amount of energy as a gasoline engine with similar performance, if coal were the prime energy source. With petroleum as the prime source of energy however, the same battery-powered vehicle would consume from **40-** to 90-percent more energy than its gasoline-powered counterpart.

Let me summarize this part of my statement. We urgently need a better congressional understanding of where the free play of the market should end and regulation begin. Before we move farther down the road toward **a** regulated economy, we need full, clear, and concise assessments of whether the market is an inferior ***or*** superior institution for achieving our national goals in each particular instance. The OTA could make an enduring contribution to maintaining our free society if it would move forward with this task.

The second area where the OTA could make an invaluable contribution is by insisting that in those areas where additional regulation is required, an adequate data base be established as a precondition for new or more stringent requirements. One EPA scientist was quoted in the news media recently as saying the Government is making billion-dollar decisions on the basis of a 25-cent data base.

The validity of that statement was well illustrated last year by the turmoil that occurred over the issue of sulfates in automotive exhaust. An EPA report early in 1975, based on a mathematical model of atmospheric dispersion of sulfates, warned of the potential future danger to health of roadside accumulations of sulfates from automotive catalytic converters. In order to assess the extent to which sulfates could accumulate along the roadside, GM, with the cooperation of EPA and other auto companies, conducted a massive experiment at our proving ground in October 1975. This experiment, designed to create the environment of a busy "1985 freeway," required 6 months of planning, a fleet of 352 test vehicles equipped with catalytic converters and air pumps, the latest and most sophisticated air sampling and data gathering equipment for 20 different sampling stations? and participation of more than 450 GM employees. Nearly a million vehicle miles were driven in the course of this assessment.

While the results of this massive experiment ***have*** not yet been fully evaluated by GM and EPA, preliminary findings indicate that EPA's original estimates of the potential sulfate buildup at ground levels along busy freeways may be up to 20 times too high. Thus the calls by some for sulfate regulations now appear to have been unwarranted: and these calls were never supported by the carefully documented evidence of need that we support. This is only one indication of the need for improved data to provide an adequate foundation for reasoned analysis.

To proceed with costly regulations in the absence of a clear showing of need is, in my view, to invite disaster. If additional data are required, we should proceed with the development of the necessary information, not rush into the establishment of possibly unwarranted and expensive standards. When costly requirements that cannot be justified, either in terms of cost-benefit or of cost effectiveness, are imposed on the public, the result is higher consumer price-inflation by Government fiat. The inevitable consequence of unjustified regulation is lost sales, a lower level of production, reduced employment, and reduced standard of living. The whole economy suffers from excess regulation.

General Motors has responded and will continue to respond constructive to any standard for which a need can be clearly identified and justfied. However. we share with the President and many Members of the Congress the conviction that our national dedication to individual freedom and competitive enterprise has already been dangerously eroded by the proliferation of ill-conceived regulation. If events of the past 15 years teach us any lesson, it is that regulation begets more regulation and there seems to be no end. The current advocacy by some in Congress of national economic planning is, in our view, one more manifestation of this debilitating process.

I am hopeful that this process can be reversed. I would like to think that in the OTA there is a possibility for unwinding the regulatory maze in which the American economy now finds itself. 1 can assure you that GM stands ready to help in identifying areas where standards are in the national interest, or where our technology and expertise can contribute to the establishment of socially desirable standards, and in the elimination of regulations where the free play of the market can clearly do a superior job. But we would also submit that there is much more potential in this market economy for realizing our national goals than there is in the further proliferation of regulation.

Thank you very much, Mr. Chairman.

Mr. BROWN. Dr. Duncombe, first may I recognize the presence of our distinguished colleague, Marvin Esch from Michigan. Mr. Esch is a Member who has had a great concern with these problems of technology assessment for a considerable period of time, and I think he also has a legitimate concern with the health of the automobile industry. We are happy to see him here.

I hope you don't think I am trying to be offensive when I say that there is a considerable element of political ideology in your statement. I might say that to some degree at least, I have been converted, as many elected political officials have in today's climate, to the truth of what you say about the possibility that we have proceeded too far down the road toward regulation. What we are looking for are constructive alternatives to this. I say that in all sincerity.

Dr. DUNCombe. Yes, and I think in all sincerity—and the politics of this question aside—1 did not intend that. I think that some of the points I am making are bipartisan. But I think that the constructive alternative is a reassessment of the great virtues of the market economy. I think that in the past 10 or 15 years the tendency has been, possibly for some very good and sufficient reasons, to conclude that the market cannot accomplish our goals and that the only alternative

we have is more Government regulation. And that, I think—I hope, I very much hope-that we are beginning to see that the market can perform many of the socially desirable functions that all of us seek.

Mr. BROWN. I have been converted-it was a very painful conversion, I might say—to the position that we would serve the public better by not seeking to set artificially low controls over the price of energy. You dwelled on that point as obviating the need for the regulation of automobile fuel efficiency-if we had merely let energy assume its expected price level in the economy today. The difficult problem facing anyone seeking public office, is that a large part of the public, independent of party, seems to think that there is some value *in* paying as small an amount as possible for energy . If you try to convince them that they would be better off paying a higher price, you lose an awful lot of votes.

Dr. DUNCOMBE. I realize that.

Mr. BROWN. I am willing to lose a few votes. But I have to carefully measure how many I will lose in pursuing this political course. I must say, in all honesty, that I don't think the automobile industry has helped to ease that problem by their insistence on continuing to market the less fuel-efficient automobiles, and conveying through the media the impression to the American people that this represents the epitome of the American lifestyle. I maybe doing you an injustice, but that nevertheless is the reaction that I have under these circumstances.

What I am trying to say is that none of us is without sin in this rather difficult situation. It is our hope and desire, in seeking to improve the processes of TA, that we can use this as a vehicle for helping to educate not onIy the Congress but also the public to the realities, the physical realities, as well as the institutional realities, the regulatory realities, that exist in our society today. It is the purpose of these hearings to explore ways in which we can improve on tEe job that we are doing. Well, with that pontification, I will call on Mr. Esch, and ask him if he has any questions or if he would like to wait for a few moments.

Mr. ESCH. Thank you very much, Mr. Chairman. I read your comments with interest. I guess I sensed some bias. It has been interesting that a major difficulty we have had in OTA is somehow to separate technology from ideology. I think our chairman, and our executive group, and the staff have tried to draw that line. I am not certain that we always can.

I sense that your comments obviously reflect the frustrations of a regulated industry, but I also sense that the suggestion is that perhaps out of the anti-Washington sentiment that emanates, both from a former Governor of California and a former Governor of Georgia, that we may be looking at new ways to interface between industry and Government.

You have suggested that General Motors stands ready to move away from the adversary relationship that regulation could cause, into perhaps a more constructive relationship in which your expertise could be more fully used. This Office and the Congress stand ready to welcome suggestions about what kind of structure could be employed to do that We don't see anything as yet to replace regulation. Would you comment on that broad area?

Dr. Duncombe. Yes, I would like to make two or three comments, if I may. First of all, on this matter to which the chairman referred, on the merchandising of cars. This year General Motors introduced a whole new line of cars that involved an investment of man-y millions of dollars. I was very closely involved in trying to estimate the probable sales level for this car just about a year ago now. Such estimates were necessary, because they would help us define the investment in tools, equipment, and plant that we should be making to produce this car. At that time our analysis and our investment were based on our sensing that we could sell 250,000 Chevettes in this model year. Our current sales of that car are going at about 103,000 units, less than half of what we had estimated. We had contemplated at the time that we introduced the car that we would bring on a second production facility in California to expand the production of that car, giving us the potential of 400,000 units a year.

That car is a highly fuel-efficient car; it is as fuel efficient as almost any car offered in the world today. From a manufacturer's point of view we can offer that car priced competitively, and I think it is priced highly competitively. But there is no way that we can take the customer by the hand and tell him this is what he has got to buy.

I think t is bears on the regulatory process, too. Unless we as a nation are willing to limit peeple's freedom, in the national interest, to severely limit their choices, there is no way that we can the. average American to go in and buy what we tell him he has to buy. I think, as we have said on many occasions in the past, we are convinced that were we to do this-and,, as you know, the **1985** fuel-efficiency standard would virtually limit us to that type of car—we think that this would be counterproductive. We believe it would be counterproductive because we think—and this is an assessment-that a great many of our customers will elect to drive their older cars longer rather than trade them in on new cars. So that rather than getting a contribution to fuel efficiency, we may be **getting** a **negative contribution** to **fuel** efficiency.

These are assessments. And I am not going to debate the question of assessment now, beyond making the point that there was really no systematic analysis. Having decided to regulate petroleum prices, we —the Nation-then decided to regulate fuel-efficiency standards. As I said, one regulation begets another. It does seem to me that in this process one of the many virtues of a competitive economy is that you can minimize the politics of economics that you have alluded to, which causes all of you equally all of us, so much soul searching.

I think that minimizing the politics of economics ought to be our objective. If you don't mind my continuing this, our country really grew and we have achieved more in this society of ours, in terms of relieving hardship and of achieving a thoroughly decent standard of living for our people, by relying on free expression and incentives for individuals. I think we can continue to do that.

One of the difficulties that we got into is that we seem to have been swept over into regulation. Carrying the politics of economics one step further, it is my view that a professional organization such as OTA can provide the Congress, and all of you who must be concerned with politics, with objective standards for judging where regulation is essential to the public interest. I am thinking here about areas such as emission controls, water controls, and so forth—at what level they

ought to be? The OTA can give you the unbiased professional guidance that is required, and also help you to sort out those areas that are more properly left to the private economy. That is where looking down the road, I see the great strength of OTA helping us in this way.

Mr. ESCH. Thank you for your comments. I want to associate myself with many of them. Senator Muskie said recently, in a Detroit Economic Club speech, that he thought we should force technology in this country. I think that has been tried in other economic systems in other countries but we don't see it here. To put it in another way, perhaps that is why we are selling our trucks to the Soviet Union rather than vice versa. I think it is fine that you suggest a function that we in OTA can serve. But I am still concerned about the degree to which we can utilize the expertise in the private sector and maximize that use. We still really don't see a mechanism through which we can give you some broad parameters in which to function while still utilizing your expertise, especially related to emissions, to safety, and to similar problems. The situation that we find ourselves in, particularly with respect to the Department of Transportation and EPA, is that your personnel are spending a great portion of their time reacting to a regulation or a requirement rather than being productive, and innovative, and creative themselves.

How do we realize, how do we develop a system such that we could begin to maximize the expertise in the private sector, while still recognizing that we have a public responsibility concerning our environment and energy needs? How would you change it? We haven't heard anything constructive from the corporation as to how you would change what we have now restructuring it to have less emphasis on regulation. What would you do so that we might more fully utilize the expertise of the industry?

Dr. DUNCOMBE. Dr. Bowditch I think, can comment on that more fully than I can.

Dr. BOWDITCH. Well, as far as the corporation's expertise, we obviously work very, very diligently in any of the areas in which there is potential regulation or where regulation has already been initiated, if for no other reason than in self-defense, to maintain body and soul, if you like.

Mr. ESCH. That's the point, you are always reacting. What I want to know is, what you are going to do to contribute constructively before, rather than being in a reacting posture with respect to Government regulation?

Dr. BOWDITCH. Well, there are probably two different answers, or two different kinds of answers in this regard. First of all, we are working in the areas that we see in our future as being applicable to our product. We do that through many of the functions of our corporation. Second, I think that as a result in part of the rapidity with which we have seen some of these regulations come along, that the regulations have indeed caught up to technology. We are operating, as are you, on the policymaking end of the ruling business. We are both right up at the same level of technology. You are concerned with what we see, even with all of our capabilities, as being possible in the next few years, because the regulatory process has overtaken the technology end of the business. We spend a great deal of time,

men, and money looking at the future. But I think you are right up there dealing in the same future we are.

Mr. ESCH. Should we give you more time? Should we give you 3 or 4 years in some of these areas and say go to it? Do you think you could really reduce more that way? You know, that is the real question facing Congress in terms of safety , in terms of emissions, or of energy, when we go to the floor and discuss whether or not we should give you more lead time. What are you going to produce with more lead time? Should we tell you to determine the standards for the next 3 years and go at it? Do you think you could do more that way ?

Dr. BOWDITCH. This gets back to what Dr. Duncombe has already indicated, how important is it that the solution be tomorrow, or a year from tomorrow, or 10 years from tomorrow? What are the appropriate times spans? We have a agreed that this is one of the functions that OTA should be doing, helping to make decisions about how rapidly these developments should come along. There were some instances, as I believe the scientific community has shown, that some of the present regulations kind of got off on the wrong kind of a calendar. I am sure there are others who say that we are right on the kind of a calendar we should be. But this is the kind of TA that I think is one of the a appropriate areas for OTA to be involved in.

Dr. DUNCOMBE. I do think that the virtue of OTA can be its potential for bringin_ _ ater objectivity to some of this decisionmaking. Possibly it could both provide a balance between the reluctance of the private sector to take the steps that are necessary on occasion, and the political pressures on the other hand that go faster than is desirable. If it can play this professional role, it seems to me that there is some real hope both for getting a better approach to the whole regulatory process, and also a better definition of where the regulatory process is appropriate and where it is not appropriate.

As I have tried to indicate and as we have said many times last year, we did not fed that in the case of the fuel efficiency of automobiles, that the regulation was appropriate. Given a functioning market, that was a task that could be performed by the market. On the other hand, we are fully in agreement that in areas involving externalities, such as emissions, particularly-safety is a more ambivalent area-but certainly in the area of emissions, these regulations are required, and the goal ought to be to make sure that the regulatory processes are established which will meet the needs at a minimum cost and with maximum effectiveness. Certainly in the whole area of defined externalities, of which the automobile is clearly a part, there is a proper role for regulation. What we are concerned about is that the proper role of regulation is moving over into an area where it is not required.

Mr. ESCH. Thank you very much for your comments. I think thw last statement was significant, because I see that as we enter a new generation in the next Congress that it will surely be an antiregulatory Congress. That will place added burdens. I think, on someone, such as OTA, who wants to function to supply the expertise. I see OTA as a major channel through which we might affirmatively utilize the private sector, the academic sector, and those in the departments and agencies responsible, in order to bring these together in a nonadversary relationship that can perhaps produce the evidence needed to make more

adequate determinations in the regulatory agencies. Thank you very much.

Mr. BROWN. Thank you, Mr. Esch. Mr. Daddario?

Mr. DADDARIO. I have a comment rather than a question, Mr. Chairman. The discussion between Mr. Esch and you recalls to my mind the same type of discussions that took place at the time that Congress was trying to come to a decision as to whether or not it would support a concept such as OTA. During the early discussions, the question of regulations came up in somewhat the same way as it has here this morning, and the same amount of importance was attached to it. One of the concerns at that time was that we were then beginning to regulate--and some of us were questioning the regulations-automobile emissions during the time periods 1975, 1976, and 1980. There was some question then as to whether or not we actually had enough technological knowledge about those facts to so legislate.

At any rate, we passed legislation and the law came into existence. But as we examined this legislation, we were concerned about how this should be implemented. The discussion came to the tentative conclusion, that we should first come to an understanding of what our technological capabilities were, then regulate in keeping with the current level of technology. At the same time, we would encourage research and development in these technologies and increase the level of environmental regulation, whatever the impacts, as new tichnology was developed. Thus the one would keep ace with the other. The main idea was that we would not be overregulating, but we would be regulating with accurate facts and greater knowledge.

I think Mr. Compton's remarks this morning were aimed in this direction. How do you do it ? How do you get the data together! How do you do it in an unbiased and objective way so that there could be a better understanding. If there is a better understanding, it follows that there will be a better dialog between the Government and the private sectors. Such a discussion, I think, is very healthy and raises the level of our dialog. Indeed, since the issue that is being raised today, concerns the Congress when it first considered the TA concept, we may very well be close to arriving at an understanding on these matters.

Dr. DUNCOmbe. I think it is worth working for. It is essential that we work toward it.

Mr. BROWN. Mr. Leathers?

Mr. LEATHERS. I have a comment rather than a question. One of the aspects advocated in these regulatory matters pertaining to technical developments, is that where t e technology does not presently exist to correct an actual or perceived problem needing correction, that you start where the industries or companies are in the technology and work towards the regulations. So it is a rate of improvement, where the company sets its goals for improvement from year to year. If this is accepted by the regulatory body, then the industries are measured against their improvements. I am specifically speaking about areas where the technology is not readily available. My experience with this has been mostly in industrial plant air and water emissions.

Mr. BROWN. Gentlemen, there are a number of other questions or further aspects of this discussion that we could pursue, but in the interests of time I think it would be desirable if we proceed to our next witness.

I want to thank you very much for being here. I hope that we can continue a dialog with you. Possibly if we needed to complete the record, we might want to submit some written questions to you for your response to them.

Dr. Duncombe. Thank you very much.

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

Question 1. **What formal structure exists for doing technology assessment (TA) at General Motors (GM) ? Has TA been institutionalized throughout your organization?**

Answer 1. General Motors does not have a staff or an office that is labeled TA. Nor do we label any specific reports as TAs, Rather, changes in technology affect our business decisions at almost every point. We believe that to be most useful a TA must be made by those individuals most familiar with the concerns of consumers and the possible technological solution. As a result, both technological possibilities and requirements are assessed at essentially every level and almost every part of the Corporation via cooperative efforts of various staff groups.

To be specific, as I indicated in my testimony technology at all levels involves basic engineering considerations such as engine and drive train efficiency and performance, the structural integrity of our vehicles, and the feasibility for volume production. At another level, considerations of cost and consumer acceptability must be evaluated. At still another level, we have long been concerned with the relation of our vehicles to highway safety, air pollution, and the evolving development of urban and national transportation systems. There are, as I am sure you are aware, interactions among these many levels of our concern that must be evaluated *on* a continuing basis The comprehensive nature of these processes is well-described in the "1975 General Motors Report on Programs of Public Interest" that was submitted for the record with my statement.

***Question* 2. How is TA defined at GM? What limits do you see for this concept in this definition and application? How it is bounded? Does it relate to your planning, decision- and policy-making processes?**

Answer 2. Technology assessment is as broad as the corporation. It begins with individual research projects and extends through our engineering and design efforts into assessments of cost, marketability, and ultimately the place of vehicles-both cars and trucks—in the Nation's economy. To define TA any less broadly is, in my opinion, to increase the always-present risk that some vital link will be overlooked. These concerns enter into GM operations and decision- and policy-making processes. However, as indicated in my Answer to the first question, the TA process is not formalized or institutionalized so that the type of assessment made and the way it is utilized will vary from case to case.

***Question 3.* How is TA information worked into your reports?**

Answer 3. Where apparently warranted, the equivalent of a TA is an integral part of a report or study. In some instances, these have a narrow focus such as a report on the development of a new engine or transmission and the implications for drivability. However, others are much wider in focus. For example, reports on the catalytic converter hare dealt with fundamental societal concerns such as the effectiveness of the converter in controlling emissions, the potential for the converter when widely applied to making a contribution to air quality, evaluations of the potential life of the converter, and its dollars and energy costs to the vehicle purchaser and to society.

Question 4. Based upon your use of T4 what lessons have been learned? Has TA affected the way you do business? How do you decide what problems should be examined with TA?

Answer 4. We have long recognized that TA is, at best, **a very uncertain art. I recall, for example, reading in Alfred Sloan's, "My Years with General Motors" the discussion of the so-called "copper cooled" engine and the inherent difficulties involved in making assessments of complex automotive systems. Prior to the passage of federally mandated safety, emission, and fuel—economy standards, all manufacturers were concerned about producing cars to meet a variety of State** vehicle **regulations. Inherent in this was the need to assess such factors as the structural characteristics of the vehicle, the adequacy of lighting, and**

the performance of brakes—all of which reflect both customer and societal concerns. This process has been extended in order to conform our vehicles to Federal regulations and, of necessity, this regulatory process requires evaluation. For example, we have strongly urged a stretch-out of 1976 auto emission standards and encouraged a reasoned evaluation of whether the tighter standards still mandated for the future would be desirable even if accomplishable.

Unfortunately. the particular problems analyzed are to an undesirable degree a result of governmental regulations or proposals. I say "to an undesirable degree" because time and effort spent in such areas necessarily utilize scarce analytical resources that could otherwise contribute to cars meeting consumer demands and the transportution needs of society better.

Question 5. Would you describe how your organization goes through the environmental impact statement (EIS) process ? Do you attempt to explain impacts and to educate the public and employees ahead of time? What relationships do you see between the environmental impact and TA processes?

Answer 5. The requirement to file EISs is imposed on Federal Government agencies in connection with major actions or regulations that are likely to impact the environment. Insofar as the Federal Government is concerned, GM does not have the responsibility for tiling EISs. However, GM does evaluate environmental considerations in connection with major facilities projects, and State governments have varying requirements concerning environmental studies and assessments.

The procedure GM follows in considering environmental impacts often varies to fit the needs of the particular problem involved. In this connection we have expressed our views on the cost-benefit relationship of specific automotive standards in the hope of contributing to the establishment of standards that show promise of yielding a margin of benefit in relation to cost. In addition. as a consequence of the explosive growlh of Federal regulations, their often contradictory objectives and negative impacts on the product viewed through the eyes of the consumer, we have felt an obligfition to try to inform the public as to what is involved. I call attention, for example, to the cooperative GM-EPA program to check allegations concerning dispersion of sulfate emissions from catalyst-equipped cars as a case in point. A brief summary of this sulfate dispersion experiment is attached for your information (see appendix C, exhibit 4).

Question 6. In a TA should the impact of a new technology on job structure be examined?

Answer 6. The term "job structure"' is vague. New technologies very often involve new skills or the expansion of old skills and thus job requirements. However, changes due to such causes are apt to be relatively s1ow and nondisruptive if they are accomplished through the marketplace.

Unwise regulations that require forcing unwanted car types on consumers could result in unemployment of major proportions. General Motors has strongly advocated that such costs should be carefully factored into evaluations of new regulations. Unfortunately, this was not done in the case of the fuel-economy standards now scheduled for implementation.

Question 7. In your TA process, how do you involve the public?

Answer 7. In contrast to most TAs done outside the auto industry. we have every incentive to consider the views of the public. Technological developments that have market attributes-such as fuel economy of new engines—must be evaluated via product clinics, market surveys, and ultimately consumer purchase decisions.

Externalities, such as emission controls, are not market attributes and must he treated in a different manner. Emission and safety regulations all involve costs that in one way or another the public must bear. Insofar as our research contributes to a better public understanding of costs and benefits, we try to make this available for public information and debate.

The most difficult aspect of any public policy decision involving externalities is the ultimate reaction of consumers. Consequently, we have tried from time to time to test public reactions on a voluntary basis. For example, some years ago we offered a low-cost vehicle emission control retrofit in Phoenix as a test market. It reduced emissions on older cars by about 50 percent. Even though there was a major advertising campaign, we found that the car owning public was not interested. Similarly, we have *offered a* passive restraint system (the air bag) at a cost to the customer substantially below GM's cost and we have found what can only be described as a negligible response to this program.

Question 8. You mentioned that GM mounted a major research and development program on the rotary engine that advanced to within a few months of production, Did you conduct a TA on the engine prior to stopping all work on it?

Answer 8. A continuing assessment was conducted at all stages of the research and development program on the rotary engine. The final decision to postpone introduction of the rotary engine was announced on Tuesday, September 24, 1974. While the level of R, & D. effort on the rotary engine was reduced when the decision on the postponement was reached, GM has not stopped all work on the rotary engine, R & D on the engine is continuing.

Question 9. Regarding the California Institute of Technology-Jet Propulsion Laboratory (CalTech) TA that dealt with the question "Should we have a new engine ?" How did that study impact the decision- and policy-making processes at GM? Did it have any impact on the planning process?

Answer 9. GM cooperated closely with JPLCalTech during the two-year period of their study of the question "Should we have a new engine?" Much of the information contained in the report was supplied by GM and most of the information was familiar to us prior to publication. Soon after the report was issued however, we did analyze it very carefully. For the reasons stated in the following summary of the GM critique of the report, it has had minimal impact on the decisionmaking. planning, and policymaking process of GM.

GENERAL MOTORS' ANALYSIS OF JET PROPULSION LABORATORY REPORT "SHOULD WE HAVE A NEW ENGINE? AN AUTOMOTIVE POWER SYSTEMS EVALUATION"

SUMMARY

The Jet Propulsion Laboratory (JPL) report entitled, "Should We Have a New Engine? An Automotive Power Systems Evaluation", dated August, 1975, has been reviewed by several interested research and engineering groups within General Motors. Generally, they concluded that the Report is a good technological review of the stat-of-the-art in alternative power plan development, identifying the pertinent characteristics of the various engines studied as well as many of the obstacles which must be overcome. Certainly, this type of report is useful at any time.

One of the major GM concerns with the Report centers on its assessment of all of the various technical interactions and, from these, the probable resulting characteristics of the various alternate power plants. This process depends heavily on the reliability of the predictions made for overcoming the technical obstacles, and the associated impact on the total design development and production capabilities of the industry. To illustrate this concern, a review of the conclusions reached in a number of similar alternate power plant studies made Iv "contemporaries" of JPL shows that they reached widely different conclusions even though they used essentially the same set of facts. There is certainly no consensus in the conclusions reached by these studies.

The JPL Report, as with most other studies of the alternative power plant situation, contains an array of assumptions concerning how and when various obstacles will be overcome. Included is the tacit assumption that all of these problems will be solved "on schedule" with adequate funding. Thus, the assumption is made that it is possible to "schedule" technological breakthroughs. Past **experience does not support this, and GM engineers and scientists are not able to find support for this *critical* assumption in any of the past history of alternative power plant development.**

A second major GM concern is that the Report fails to recognize that the ultimate success of any alternative power plant must be determined in the marketplace. The economic and market risks cannot be "assumed away," as is the case in almost all technological-fix studies. Before any precisely stated conclusions such as those included in the JPL Report can be formulated, the total area of technological and economic risks, manufacturability and materials must be effectively evaluated. This should occur both *in* terms of the organizations which are required to take the risk, and acceptance of the results in the marketplace. Without this type of sensitivity study, no realistic actions may be taken regarding the conclusions.

In summary, while the study is interesting, there does not appear to be any significant new information contained in it, and the conclusions appear to be highly speculative.

Mr. BROWN. Our next witness is Dr. Dean Gillette, executive director of systems research of the Bell Laboratories. Dr. Gillette, would you object if I called Mr. Day from Bell Canada to come up?

Dr Gillette. I would be pleased to join with Mr. Day.

Mr. BROWN. All right. Mr. Day, would you come forward also. We will ask each of you to present your testimony. Then we will question both of you together in the hope that we may be able to complete this by a reasonable time.

We are very happy to have you here, Dr. Gillette, representing the Bell Telephone Labs, which I visited about 10 years ago. I know what an outstanding restitution it is. Possibly you can help shed some light on how we can distinguish between systems research and technology assessment (TA).

Dr. GILLEtte. Thank you for your kind words, Mr. Chairman. I am pleased to have this opportunity to describe some of the methods we in the Bell System use to assess the technology we develop, manufacture, and operate to provide telecommunications for the Nation.

I have prepared a written statement for the record of these hearings, and with your forbearance I will submit it, and here only select some portions and give illustrative examples.

Mr. BROWN. Without objection, the full text of the written statement will be included in the record.

[The biographical sketch of Dr. Dean Gillette is as follows:]

DR. DEAN GILLETTE, EXECUTIVE DIRECTOR, SYSTEMS RESEARCH DIVISION, BELL TELEPHONE LABORATORIES, HOLMDEL, N.J.

Born Chicago, Illinois.

B.S. chemistry, Oregon State College, 1948; M.A. mathematics, 1950, Ph. D. mathematics, 1953, University of California at Berkeley.

Joined Bell Laboratories, 1953, worked on a variety of government systems. Appointed executive director, the Transmission Systems Engineering Division, 1966. Assumed present position, 1971.

Member of American Mathematical Society; **the Society for Industrial and Applied Mathematics; the Institute of Electrical and Electronics Engineers; the Research Society of America; the American Association for the Advancement of Science.**

Numerous articles published in: IEEE publications, Annals of Mathematics, Trnasactions of the Communications Society, Research and Management, Bell Magazine, and Bell Laboratories Record. Also articles published in the proceedings of communications conferences both in the United States and abroad.

[Tile prepared statement of Dr. Gillette is as follows:]

STATEMENT OF DEAN GILLETTE, EXECUTIVE DIRECTOR, SYSTEMS RESEARCH DIVISION, BELL TELEPHONE LABORATORIES, INC., HOLMDEL, N.J.

Mr. Chairman and distinguished members of the Technology Assessment Board, I am pleased to have this opportunity to describe some of the methods we in the Bell System use to assess the technology we develop, manufacture and operate to provide telecommunications for the Nation.

As a regulated common carrier, the Bell System is responsible for providing services that are in the public interest. We also feel it is our responsibility to take care that the apparatus and equipment needed to provide service is made and used beneficially. Further, because the Bell System's structure embraces all aspects of technology from research through recycling, we have some unique opportunities to shape the direction of technical progress and to control some of its less beneficial side effects.

We at Bell Laboratories have a special role in telecommunications. Our broad mission is to provide the knowledge and technology needed by the Bell System in meeting its service obligations in both the near term and in the more distant future. This mission includes assessment of the impact of new technology on the Bell System's services, on its work force and on the environment within which it operates. While our terminology may differ somewhat from that currently used in formal TAs, I feel that much of what we do in evaluating systems options is consonant with its basic concepts. Some of our methods have been in use for decades as a part of our systems engineering and human factors work. Other efforts, particularly in environmental protection, are newer, but all reflect our continuing interest in developing and applying technology for the Nation's benefit.

SYSTEMS ENGINEERING

"Systems Engineering"—a term created at Bell Laboratories-involves analytical and experimental investigations of the potential value of new systems to be integrated into the Bell System plant. One purpose of systems engineering is to provide information to help in deciding whether to allocate funds and manpower for design and development of a new product or service. A second purpose is to establish broad requirements for the product or service, given that it is to be developed. A third purpose is to evaluate the impact of introducing a new product or service into Bell System operations. This includes interaction with other parts of the plant and demands on the new system for new skills to be acquired by craft and operational personnel. If we think of impacts on type, quality, or cost of service as the "first order consequences" of a new product, we may take as "second order consequences" the impact of a new development on the other work at Bell Laboratories, on the capital and expense needs of the Telephone Companies, on the physical environment of the plant, and on the nature and quality of work of the plant forces. Systems engineering does take these factors, as well as many others, into account and so includes many aspects of TA within an even broader context.

Perhaps I can illustrate some of our methodology of systems engineering by describing some of its facets. To begin with, we take it as a necessary condition that any new system will be introduced into the plant without disrupting service. We do not attempt to assess the consequences of a service interruption ; we know they are serious, so we try to minimize their occurrence. To meet this sort of objective means that we must know the characteristics of all of the plant. A single example suggests the need. On its first day of operation, the newly developed No. 4 ESS toll-switching machine was connected to 219 other switching machines of many different types and vintage. It was designed to- and did—interact with each of these flawlessly, immediately on being put into service. Intimate knowledge of plant details was, of course, critical to the rapid restoration of service after the New York Telephone Company fire in 1975.

The methods used in plant characterization range from simple counting of facilities to intricate measurements of the electrical behavior of built-up connections. Bell Laboratories engineers plan the plant characterization programs and work closely with AT&T and the telephone companies in carrying them out. In many instances, the telephone companies conduct the surveys and report their

findings for BTL analysis. In cases where experimental or novel performance measurements are needed, Bell Labs people will carry out the characterization. Modern data-processing methods and field use of minicomputers make the process more effective and the results more relevant. The most recently completed such project characterized the performance of the network in controlling echo on long distance circuits. l-he result of this study, like past ones, are published in open literature to be of benefit to all manufacturers of telecommunications products.

An existing design is obviously the most viable alternative to a new system development. Initial questions in a systems engineering study are directed at just this issu--will a new system offer an advantage over the one it is intended to replace? The continued emphasis on cost reduction can make an existing design a formidable competitor. Systems based on the new technology will be used only when they are less expensive than the newest models based on the older technology. Nor example, we are now exploring guided lightwave technology as an alternative for interoffice trunks. The existing system concept, pulse code modulation (PCM) on wire pairs, was introduced commercially in 1962 by the Bell System. In 14 years, first costs of PCM have decreased in spite of inflation. Western Electric's original PCM system repeaters were sold at $143 each; their current version costs the Telephone Companies $73 each. We think that lightwave communication systems will be even more economical.

Analyses of relative costs were originally of the simplest sort: will the price of the new product be lower than that of the old? More recently, with better understanding of in-service costs and with use of modern computing technology, we have been asking more sophisticated questions and gaining deeper in sight. First, price remains important, and for many years we have recognized the time value of money in such terms as present worth of future costs. Many of our analyses now follow discounted cash flows in annual operation—including development and start-up costs, as well as maintenance and administration. These analyses investigate alternative strategies of meeting anticipated growth in demand-including options for use of any of several products. And we study these parametrically in discount rates, relative costs and inflation factors. Application of such mathematical models to system analysis is *not* unique to the Bell System or even to telecommunications. However, because of the technical integration of the Bell System, analyses of economic impacts must consider all aspects of technological innovation from design through introduction and administration. And, since all aspects are coordinated within the enterprise, the Bell System can maximize the economic benefits to the subscriber by balancing development, manufacture, installation, and operation.

In our studies of needs for communications, we try to anticipate long-term demands as well as to establish requirements for current designs. We expect the Bell System to be providing service well into the future. In our assessment of economic values of a given technology, we look to long-range impact, and as we compare technical alternatives, we do so in the context of our perception of the most promising directions of technological evolution. For example, it seems that in the long run it may be technically and economically advantageous to *use* digital techniques for transmitting and switching almost all kinds of telecommunications. Thus, in the future nearly every part of a connection may be over a pulse-code modulated, multichannel facility. This long-term view influences our research and advanced development programs, but does not divert us from short-term realities. Right now for example, it is less expensive to connect most subscribers to the central office with single-channel wire pairs carrying analog signals.

Of course, performance of the telecommunications network can always be improved at the cost of more expensive equipment; the interesting questions center around trade-offs. Another task of systems engineering is to establish quantitative relationships between increased cost and improved performance process that must take into account differences in the nature of the service. The operational quality of data transmission service can be measured by such objective criteria as mean error rate or error free minutes, and can be readily monitored and recorded, When the service is voice or image transmission-either video or

facsimile-important criteria are in terms of human responses. To discover whether modified electrical behavior will lead to a perceived service improvement, we must carry out subjective preference-testing under carefully controlled conditions. For example, our studies of satisfaction with echo control methods were fundamental to the measurements in the previously-mentioned assay of the echo characteristics of the plant We have been doing that sort of work in the Bell System for well over half a century. And such efforts must continue as social needs for communications change and as individual preferences are influenced by experience with the increasingly complex technical environment.

Major advances in telecommunications depend on discoveries in the physical sciences and developments in technology, and Bell Laboratories has a worldwide reputation for contributions in these areas. The examples of systems engineering studies suggest the importance of other sciences-including mathematics, economics, acoustics, and behavior. Research in these too, is carried out at Bell Laboratories, again with results appreciated outside the Bell System and applied within, both to enhance the value of communications to our subscribers and to improve the effectiveness of our work force.

HUMAN FACTORS

The Bell System as a whole employs almost one million people, of whom 800,000 are in AT&T and the Telephone Companies. These are the people responsible for assuring that the Bell System network functions to meet our subscribers' daily demands for telephone service. We are convinced that the best service is delivered by a well-motivated, highly trained work force. New telecommunications technology introduced with the purpose of improving service or increasing productivity will be effective only if its impacts on the plant work force are beneficial.

The humanistic approach to work motivation resulted in great part from a 1925 study of work conditions in an apparatus assembly line in Western Electric's Hawthorne plant. The purpose of the study was to find the shop environment—light-level and wall-color, for instance-that would give greatest productivity. In one sense, the experiment was a failure because it was found that many of the changes tried increased productivity, and none could be isolated as critical. But in the greatest sense, the experiment was a turning point in scientific management because it showed that productivity went up when the work force recognized that it was their interests that were being considered and that they were being valued as individuals.

The insight into motivation gained at Hawthorne has been followed up. One example is AT&T's broad effort to reduce tedium and routine and to make jobs more personally satisfying. The improvement program was fittingly called "The Work ItseIf." And too, the physical work environment is protected, certainly by adherence to the standards set by the Occupational Safety and Health Administration (OSHA), as well as by results of older interests. One such is noise level& By heritage and by the nature of our business, we know a great deal about human perception of sound-of light and images too, for that matter. We are concerned about sound levels in the work environment as well as on telephone circuits. This interest led us, for example, to assist a motor generator manufacturer in controlling the noise level in a 2.5 megawatt reserve power system before it was installed in a Bell System building. We also consider low-level sounds. Studies have been made in telephone equipment rooms and in other work locations to determine if certain noises, such as the clicks in an operator's headset, could be annoying or disrupting.

Application of research to practice is important in other areas of behavioral science. Improvements in training methods are particularly valuable since nearly 500 million dollars are spent annually in the Bell System to teach new employees the skills they will need on their jobs, and to train experienced people in new technology being introduced into the plant. AT&T also supports Bell Laboratories research in learning processes and in applying skills in plant operations. One learning study showed that fact retention is enhanced by testing immediately after a lecture. Analyses of maintenance documents and their use in the field have led to new ways to prepare materials for use by the craft forces in maintaining the network.

Assessment of work environment and its impact on the work force are not nearly as susceptible to mathematical modeling as is, say, comparison of products on an annual expense basis. Despite the lack of formalism though, we feel

that attention to the working environment has helped the work force help the business. For example, Telephone Company output *per* man hour increased at the rate of 6.5 percent per year from 1960 through 1976--compared to 2.4 percent for the private domestic economy for the same period. Perhaps clues to success are in the depth of knowledge of specialists at AT&T and Bell Labs, in AT&T's continuing support of research in the field, in competent management in the telephone companies or a combination of these. Combining research and application in long-term programs enhances the opportunities for early implementation of new practices and for research based on observations of effectiveness.

ENVIRONMENTAL FACTORS

The telephone industry is relatively nonpolluting and has not had to make major changes in products or processes to conform with new environmental protection standards. Localized trouble spots have gotten needed attention. For instance, stack gasses from the reserve engines I mentioned earlier can exceed standards if not controlled. Bell Labs has developed new instrumentation to accurately measure pollutants from these so that effective mitigative measures can be taken.

Certainly Western Electric's (WECo) manufacturing plants are more likely to contribute pollution than are telephone central offices. Control of manufacturing by-products is an area in which WECo has long been active, well before it became the prominent public issue it is now. The company's concern for the environment is the logical extension of its traditional concern for safety among employees. All of WECo'S plants had the most modern waste-treatment facilities designed into *them* at the outset, and older locations are modernized to meet new standards. At the new Phoenix plant, "used" water from cable-making operations is released cleaner than when it came into the @ant. Heating and power plants have converted to low-sulfur fuels to reduce sulfur dioxide.

Bell Laboratories and Western Electric have worked together on new manufacturing processes that will reduce or eliminate pollution hazards. One example is a new closed loop printed circuit etching cycle that allows the recovery of the etched copper and restoration of the etching strength of the bath, thus avoiding the disposal problems for the spent baths.

Another way to limit waste products is to salvage--recycle--junked equipment. The Bell System has been in the recycling business in a big way since 1931 when Western purchased Nassau Smelting and Refining-now Nassau Recycle Corporation. All kinds of scrap materials are sent through Nassau, which reprocesses and reclaims a large variety of critical material and redirects it back into the Bell System. For example, the following percentages of Bell System usage were obtained from Nassau:

[Amount in percent]

	1974	1975
Copper	31	51
Lead	100	100
Gold	52	47
Palladium	23	28
Platinum	48	100
Rhodium	58	64

Recycling of junked telephones is a project that well illustrates the importance of close association of materials research, manufacturing, and scrap recovery logistics.

The process of recycling the plastic in the telephone must cope with the nonplastic items that are part of the working telephone-the cotton balls in the handset and the brass and steel inserts and screws in the housings. Materials scientists and telephone design engineers at Bell Labs know exactly what these are and developed a separation process tailored to the composition of the scrap. Further, the recycled plastic has properties different from original raw materials, but design groups are now busily engaged in setting specifications for different compounds in which the reclaimed materials can be substituted for raw resins in many molded parts.

The Bell System program of recycling plastics is still at the beginning stage. The pioneering work continues at Western Electric, and the rate of production is expected to reach half a million pounds per year. Nassau Recycle is setting up a similar reclamation plant. The amount that potentially can be reclaimed may total as much as 6 million pounds a year from scrap phones alone, and reclamation of other components is anticipated.

SOCIAL IMPACTS OF THE TELEPHONE

So far I have spoken mostly to our assessment of technology and control of second order consequences as they might affect the Bell System itself: cost savings, work force impacts, and environmental controls and recycling. These actions are also beneficial to our subscribers. As a regulated industry, we pass on cost savings to telecommunications users, whether the savings are achieved by introducing more efficient technology or by increasing the productivity of the work force. Certainly any environmental protection benefits all.

We are aware that we have created in our network *a* national resource. We are also constantly working to improve the network, to find new ways to use it, and to add to its capabilities, To help us choose directions of augmentation that have the greatest potential benefit, we carry out research into the various factors that influence the ways that people communicate with each other, and into individuals' judgments about their communications. These factors include communications modality-for example, telephone, face-to-face, closed-circuit television—the situational context or task, and the relationship between communicators. One purpose of such research is to help understand customer needs and how to tailor new services to meet them. We find for example, that there is little difference in gross visual behavior between face-to-face-in person—and closed-circuit TV discussion. However, there does appear to be a difference in speech activity between the modalities; there is more simultaneous talking in person than over TV. Even so, we install a "mute" button in video conference systems, just as we do *on* a speakerphone installation. We do find video conferencing to be effective-for example, as a means of conducting the business of a regularly scheduled committee. Audio conferencing, by itself, is not nearly so powerful. However, when supplemented by a real-time graphical capability, a facsimile adjunct, or even premeeting distribution of documents, audio conferencing can be extremely useful.

The Bell System also supports studies of broader social impacts of the telephone, mostly carried out by scholars outside of the Bell System. One example is a program of seminars and invited papers at MIT that culminated in the March 10, 1976, symposium celebrating the centennial of the telephone.

Another type of societal-technological interaction has received recent attention-the exchangeability of telecommunications and travel. We are familiar with the studies of the Office of Telecommunications, Bell Canada, the British Post Office, and others. We have also carried out internal studies of the values of telecommunications in managing affairs in our physically separated operations. Our methods are conventional; we use surveys, questionnaries, and experiments with various systems and we make additions and changes to our telecommunications facilities as they seem economically beneficial. (Let me hasten to point out that I am talking now about how we at Bell Laboratories use telecommunitions-- and we pay full rates for all services.)

Our studies of our own enterprise have shown that the costs of added communications are hard to recover by savings from reduced travel. It may be. though, that this result differs from that of others because of the amount of communications we now use. We have facsimile equipment at all locations, speakerphone and conference telephone sets available to those who need them, and experimental video services between major locations. Others have a different base and different findings Recent studies by the British Post Office, for example, suggest that the "loud speaking telephone" will be of great rise, and they are planning an experimental installation. We agree they are valuable; the Be11 System has offered the service for forty years, and we use them extensively at Bell Labs. We expect that video services will help us manage our decentralized business more efficiently, and will add to the facilities we now have as costs come clown.

I have now come full circle in my discussion of TA. As users of communications. we find that the limits of applicability to, and impact on, our business

are in the costs of service. It is exactly these costs that are under the most intensive attack in our programs of research development, and systems engineering. As we at Bell Labs find opportunities for technical advances, we expect that our commonality of objectives with Western Electric, AT&T, and the telephone companies will enable us to improve telecommunications services and lower costs. I have tried to illustrate how these various elements of the Bell System work together to achieve these objectives without producing side effects that are harmful to our work force, our environment, our natural resources and the society we serve. The most important single method in our efforts to control side effects of technological innovation is integration of research, development, manufacturing, and operation in a single enterprise.

STATEMENT OF DEAN GILLETTE, EXECUTIVE DIRECTOR, SYSTEMS RESEARCH DIVISION, BELL TELEPHONE LABORATORIES, INC.

Dr. **Gillette. Thank you. As a bit of background, we realize that as a regulated common carrier the Bell System is responsible for providing services in the pubic interest. We also feel it is our responsibility to take care that the apparatus and equipment needed to provide service is made and used beneficially. Further, because the Bell System's structure embraces all aspects of technology from research through recycling , we have some unique opportunities to shape the direction of technological progress, and to control some of the less beneficial side effects.**

We at Bell Laboratories have a special role. Our broad mission is to provide the knowledge and the technology needed by the Bell System in meeting its service obligations in both the near term and in the more distant future. This mission includes assessment of the impact of new technology on the Bell System's services, on its work force, and on the environment within which it operates.

Many facets of the assessment of the director first order impact of technology are also part of a through engineering study we carry out before the development of a new product or service. Different words may be used to describe, these engineering studies and TAs, but the intent is much the same. They overlap in great part, but not completely. For example, the Technology Assessment Act requires the Office of Technology Assessment (OTA) to identify existing or probable impacts of technology or technological pograms. In our case, for a new transmission system, we would evaluate the savings to the Bell System if the new system rather than the old one were used to meet growth demands. We would also evaluate the costs of development at Bell Laboratories.

Similarly, the act calls for identification of alternate technologies and alternate programs to reach the same ends. An engineering study would compare the benefits of one new system with another, and with developing nothing new at all, but rather continuing to use what we have. Such studies area part of what we call systems engineering, something we have been doing for decades at Bell Labs. TA also includes identification and analysis of indirect effects of technology, second-order consequences. Among these are human and social impacts, environmental effects, and natural-resource demands. We too, take such factors into account. I will discuss those. But first, I would like to expand a bit on systems engineering because of the desire on your part to have indications of the kinds of methods that we use that are in areas similar to TA.

One purpose of s stems engineering is to provide information to help in a decision of whether to allocate funds and manpower for the development and design of a new product or service. A second purpose is to establish broad requirements for the product or service, given that it is to be developed. Here is an example where systems engineering really has no parallel in TA. A third purpose of systems engineering is to evaluate the impact of the new development on other work at Bell Laboratories, on the capital and expense needs of the telephone companies, on the physical environment of the plant, and the nature and quality of the work on the plant forces. All of these must be done before development of a new product is started. It is part of the decision process.

Perhaps I can illustrate our methodology by describing some of its facets. To begin with, we take it as a necessary condition that any new system will be introduced into the plant without disrupting service. We do not attempt to assess the consequences of a service interruption—we know they are serious. So we try to minimize their occurrence.

To meet this sort of objective means that we have to have a thorough understanding of the characteristics of the existing 'plant. Let me give you a single example. The No. 4-ESS is a name that we have given to an electronic machine for switching long-distance telephone calls. This new machine has a capacity of handling half a million calls an hour; it can be hooked up to 100,000 trunks. It was just put into service, after 6 years of development, in January of this year. And when it was cut into service, it was connected to 219 other switching machines of many different types and vintages. It was designed to, and it did, interact with each of these flawlessly immediately upon being put into service.

The methods used in plant characterization range from simple counting of facilities to intricate measurements of electrical behavior of dialed-up connections. Simply keeping track of 10,000 switching machines, 6 million trunks, and nearly 70 million subscriber lines is a big job in itself.

We also make new measurements of the existing plant. For example, much of the existing plant was installed first for voice service. When the need to transmit data-digital signals—arose, we found ways to use the old plant for the new purposes. To get the most benefit, we wanted to send high-speed data. signals, so we measured the capability of the switched network. Here is an example of an assessment that led to a need for more data collection. It is also an example of a use of existing technology for a new service rather than -developing a new technology to meet the need. Bell Laboratories engineers planned the plant characterization program and worked closely with A.T. & T. and the telephone companies in carrying them out. In many instances, the telephone companies conduct the surveys and report their findings for Bell Laboratories analysis. The results of this study, like many others, are published in the open literature so as to be of benefit to all manufacturers of telecommunications equipment.

Analyses of relative costs are another aspect of systems engineering. Originally these were the simplest sort-will the price of the new product be lower than that of the old? More recently, with better understanding of in-service costs and with the use of modern computing technology, we have been asking more sophisticated questions.

We are certainly concerned with first costs, but man of our analyses now follow lifetime costs in annual operations, including development and startup costs as well as maintenance and administration.

We also investigate alternate strategies in meeting anticipated growth in demand, including options for the use of many products. We study these parametrically, in discount rates for the time value of money, relative costs among the various products, and inflation factors. Certainly, the use of mathematical models in systems analysis is not unique to the Bell System. However, because of the technical integration and because of our scope of interest, we have to worry not only about Bell Laboratories but also about the manufacturers including Western Electric, the associated companies and, as I will get to in a bit, recycling.

I have cited these examples of systems engineering to suggest methods that we use to assess the direct impact of technology, measurements of the existing plant, mathematical modeling, economic studies and so on. We are also concerned with other effects, particularly the impact of new technology on the plant forces.

The Bell System as a whole employs almost a million people, of whom 800,000 are in A.T. & T. and the telephone companies, and these are the ones that are responsible for assuring that the Bell S stem network system functions to meet our subscribers' daily demands for telephone" service.

We are also concerned about the physical work environment, certainly ***as*** a result of adherence to the standards set by the Occupational Safety and Health Administration (OSHA) as well as other interests. We have been working on these things for a long time, too. One example is our enduring studies of noise levels. Of course, by heritage and by the nature of our business, we know a great deal about human perception of sound—we know a lot about light and images too, for that matter.

We are concerned about sound levels in the work environment as well as on telephone circuits. This interest led us, for example, to assist a motor generator manufacturer in controlling the noise level in a 2.5-megawatt reserve-power standby power system before it was installed in a Bell System building. We are also concerned about sound levels that seem relatively small. Studies have been made in telephone equipment rooms and in other work locations to determine if certain sounds, such as the clicks in an operator's headset, can be annoying or disrupting.

Improvements in training methods are particularly valuable, since nearly $500" million are spent annually in the Bell System to teach new employees the skills they will need in their job, and to train experienced people in new technology being introduced to the plant.

Another impact or facet of TA that we carry out is environmental impact evaluation. The telephone industry, fortunately, is a relatively nonpolluting one, and has not had to make major changes in products or processes to conform to the new environment protection standards. When localized trouble spots occur, they get needed attention. For example, the stack gases from the reserve engine I mentioned can exceed standards if not controlled. We at Bell Laboratories applied some of our knowledge of X-ray spectroscopy, laser techniques, and mathematical modeling, to **develop new instrumentation**

and analytic methods to measure and understand the effect of pollutants and how to control them so that we might take effective mitigative measures.

Bell Laboratories and Western Electric have also worked together on new manufacturing processes that will reduce or eliminate pollution hazards. one example is a closed-loop, printed-circuit etching cycle that allows the recovery of the etched copper and restoration of the etching strength of the bath, thus avoiding disposal problems of the spent bath.

Recycling of junk telephones is a project that well illustrates the importance of the close association of materials research, manufacturing, and scrap recovery logistics. The process of recycling the plastic in the telephone must also cope with the nonplastic items that are part of the working telephone--cotton balls in the handset and the brass and steel inserts and screws in the housing. We know exactly what these nonplastic parts are because we designed the telephone, and we know what the scrap is because we in the Bell System collect it. Materials scientists at Bell Laboratories have developed a separation process tailored to the composition of the scrap. Further, the recycled plastic has properties different from the original raw material. The design groups are now busily engaged in setting specifications for different compounds in which the reclaimed material can be substituted for the raw resin in the molded parts.

So far I have spoken mostly about our assessment of technology and control of second-order consequences as they might affect the Bell System itself. We are also constantly working to improve the network, to find new ways to use it and to add to its capabilities, to help us choose directions of augmentation that have the greatest potential benefit. We carry out research in the various factors that can influence the ways in which people communicate with each other, and into the individual judgment about communication. We do that at Bell Laboratories.

We also get help from the public. The public helps us by commenting on our service, sometimes critically. We ask their advice; for example, we send out surveys for service attitude measurements. We also get advice and assistance in the kinds of service and the grade of service from the regulatory agencies. All of these provide inputs to our studies of communications.

Another type of societal-technological interaction has received a great deal of recent attention—the exchangeability of telecommunications and travel. We are quite familiar with the studies of the Office of Telecommunications, the work of Bell Canada, the British Post Office, and others.

We have also carried out internal studies of the values of telecommunications ourselves, part of our processes within Bell Laboratories in managing the business. I will give you an example of this, but let me hasten to point out that I am talking about running our own business at Bell Laboratories. I should also remind you that we pay full rates for all services—we do not get telephones free within Bell Laboratories.

Our own studies of our enterprise have shown that the costs of added communications are hard to recover by savings from reduced

travel. We are a widely dispersed, distributed, laboratory collection, and we find we have to use a lot of telephones, and we also have to travel a great deal. This may be because of the kind of communications we have and the kind of business we are in. We have facsimile equipment at all locations. We have speakerphones, and conference telephone sets available to those who need them. We have experimental video services between major locations. We would use more video services to help us manage our decentralized business if they were less expensive, and we will add to the facilities as the costs come down.

Of course, I have now come back full circle. I am talking about the economics and the costs of communications that we at Bell Laboratories not only pay for but study. As users ourselves, we find that the limits of applicability to and impact on our business are in the cost of service. It is exactly these costs that are under the most intensive attack in our programs of research, development, and systems engineering. As we at Bell Laboratories find opportunities for technical advances, we expect that our commonalty of objectives with Western, A.T. & T. and the telephone companies will enable us to improve telecommunication services of lower cost.

I have tried to illustrate how some of these various elements of the Bell System work together to achieve the objectives without producing side effects that are harmful to our work force, our environment, our natural resources, and the society we serve. This increased interest in the side effects is a direct result of changes in the national interest, and in emergence of TA as a recognized activity. Actually, as far as implementation goes, I think our single most important method in controlling the side effects of technological innovation is our integration of research, development, manufacturing, and operation into a single enterprise.

I would like to thank the Board for the opportunity to present these views, and I will be happy to attempt to answer any questions.

Mr. BROWN. Well, Dr. Gillette, you certainly covered a broad range of activities of the phone company here, and one which does raise a number of questions with regard to the role of the company in some of the startling new technological developments that I am sure are going to be before us in the near future.

I would like to proceed however, to Mr. Day and receive his testimony at this time.

Mr. DAY. Thank you for the invitation, Mr. Chairman. I would like to formally submit my written testimony and just make a few brief remarks summarizing some of the material in it.

Mr. BROWN. Without objection, the full text will be included in the record.

[The prepared statement of Mr. Lawrence H. Day is found in appendix C, exhibit 4.]

[The biographical sketch of Mr. Lawrence H. Day is as follows:]

MR. LAWRENCE H. DAY, ASSISTANT DIRECTOR—BUSINESS PLANNING, BELL CANADA HEADQUARTERS BUSINESS DEVELOPMENT DEPARTMENT, MONTREAL, CANADA

Born July 20, 1942, Halifax, Nova Scotia; married, two children.

B. Comm. Dalhousie University, Halifax, N. S., 1964; M. B.A., McMaster University, Hamilton, Ont., 1967.

Positions in sales and marketing, Bell Canada, Toronto, Ont., 1964; market research consultant and research assistantship, McMaster University, 1966; supervisor—Business Development (Computer-Communications Services), Bell Canada, 1967; supervisor—residence services, Bell Canada, 1969; supervisor—business planning, Bell Canada, 1969; staff supervisor-business planning/assistant director-business planning, 1970-75; Dec. 1975 promoted to present. position in which responsible for building and managing team of planners whose mission is to conduct long-term technological forecasting and assessment studies for corporate executives.

Educational activities include guest lecturer on futures research, planning, and telecommunications at a number of universities in both Canada and the United States. Also, co-chairman and organizer of "Technology and Growth," a major conference on technology assessment and the "Limits to Growth" held in Ottawa during February 1975. This conference was sponsored by the International Society for Technology Assessment and the Ministry of State for Science and Technology; one of four co-chairmen of a group of advisory committees developed for a technology assessment study sponsored by the U.S. Department of Transportation and NASA during 1974-75; member of the Steering Committee for a technology assessment conference directed towards government officials in the Northeast U.S. states funded by the U.S. National Science Foundation; and organizer of the Telecommunications Policy set of conference sessions to be held at Intelcom 77 in Atlanta during Oct. 1977.

Publications include over 40 papers published in a wide variety of international journals, conferences, and symposia. Mr. Day is general editor of a forthcoming new journal, Telecommunications Policy, that will be published by IPC Science and Technology Press of the United Kingdom. This international journal will deal with all issues associated with the development of telecommunications policy and the impacts that arise through the uses of computer and communications technologies. He is also a contributing editor to the newsletter on communication published by the World Futures Society.

Memberships in professional societies include: The International Society for Technology Assessment, the Institute for Management Science, the Association for Computing Machinery, the American Marketing Association, the Canadian Association for Futures Studies, the World Futures Society, and the World Future Studies Federation.

STATEMENT OF LAWRENCE H. DAY, ASSISTANT DIRECTOR—BUSINESS PLANNING, BELL CANADA

Mr. **DAY. Thank** you. I would like to note in an introductory remark that Bell Canada is the A.T. & T. of Canada? and that we are not a subsidiary of A.T. & T. We always like to point that out. We have a very similar structure to the U.S. Bell System; research labs, manufacturing, operations, operating companies, and so forth.

And just one final comment on the Canadian telecommunications industry, it is a mixed system. We are somewhere between the United States and Britain. Some telecommunications companies in Canada are owned by governments, others are joint ventures between government and private industry, and some are private like Bell Canada, which is a shareholder owned organization.

My group, the Business Planning Group, is in shorthand terms, the technological forecasting and assessment organization for Bell Canada. Our mission statement is to identify future business opportunities and-or threats-and that can cover considerable territory. I don't think for the sake of time that I will describe the range of our research interests. These are outlined in my submitted written statement (see appendix C, exhibit 4). I will move right into the TA area.

Our definition of TA is, I think, one that would be acceptable to anybody on your Board. We use the standard definitions from the

textbooks. These identify secondary impacts resulting from the uses of technology. I have quoted one from Vary Coates in the written testimony. This is normally the philosophy that directs our work.

We have been involved with four major TAs; three that we have conducted internally with our own resources and our own staff (we have people on staff who can conduct TAs, and one that is being funded at an outside organization, a Canadian university. And getting back to some of the discussion earlier this morning about whether TAs should be conducted in-house or out, we arc also on the third art of the triangle. My group has also a subcontract from the Stanford Research Institute in one of their communications-related TAs funded by NSF. We are buying and selling and somewhere in the middle in this whole field. For tills reason I would be happy to answer any questions based on our experience as it relates to the issue of credibility (where corporate assessments should be conducted).

We conducted one study of computer-aided instruction, an internal study using the Mitre methodology—an a preach to TA that might, if anything could, be considered classic. We have sponsored an outside funded study, the impact of new satillite-based communications services on native populations in the Canadian north. We have spent a considerable period of time researching the area of substitutibility or transferability, the int~rrelatlonshlp—pick your label--of travel and communications. This is a very complex subject, so forgive me if I use the term Substitutability, which really disguises a lot of interactions. Lastly, we have just completed a 3-year study that is a TA of the impact of so-called wire-city services. This is an interactive cable televisionlike service—the real futurist part of the telecommunications business.

We don't try to draw regulatory lines between the computer and telecommunications. That takes up a lot of effort, and many more knowledgeable people I know are busy at that. We do not try even for our TA purposes to draw that line, although it is obviously an important issue.

We make the assumption that the technologies that provide the basis for services are going to be available. Basically, we have a competitive choice of technologies in the telecommunications and information fields. It is not so much a matter of any specific technology being the basis for a service, it is more a matter of which blend of technology you are going to use. Dr. Dean Gillette of Bell Labs has pointed out the important integration issue in the communications business. It is an evolutionary use of technologies. This is not to downgrade the importance 'of telecommunications technologies. This is probably the most explosive area in technology right now, the whole field of information, computers, and communications technologies. We also assume that the market will evolve for something—we are not conducting market studies. In other words, we don't have to worry about the negative impacts of something that is not bought and used. If people don't use the services we don't have to worry about the negative impacts.

So assuming away all of the technology problems-that statement always bothers all of our engineers and people at our labs-and assuming away all of the cost-benefit marketing problems, we look at this from the point of view of services. We look at the types of services

that may be available and try to assess what the impacts may be. So we are service-oriented; the technology is not the key.

To move briefly into the substitution field, I think that it is la good example of this approach. If you think about the topic for a second, the substitution field is an impact area that is the study of impact. We are not particularly concerned about which technology will be used to create the substitution potential, and when I say substitution I am talking about two almost totally different things. The first is the substitution of intercity travel by the use of a whole array of teleconferencing, telecommunications, and information systems. We have conducted considerable research in that area in the last few years.

The second is a totally different type of substitution which, if it occurs, is going to have a very fundamental impact on society. That is the whole question of the redistribution? over a very long timeframe, of people from central cities through the use of remote working centers, remote electronic education systems, the so-called ultimate " wired-city. The key question is whether we need to come to major cities every day to work A very, very complex area. The Stanford research study is looking at this. Right now they are looking at 50 different impact areas. Each of these has varied subdivisions. It is a very complex field.

One of our major activities in the substitution field, intercity substitution, was a very large survey of business travellers in Canada before the energy crisis, to find out what their attitudes toward substitution were. Summarizing again 3 years of research in one sentence, 20 percent of the travelers said they would like to substitute the existing type of trip they were on--these are business travellers—for some form of telecommunications alternative. There seems to be interest here. That is an issue, of course, that is important. You may have a cost-benefit tradeoff, but people still may not want to substitute.

Another area of research that we have been involved with is the energy implications of substitution. The transportation sector is one of the most energy-intensive sectors in society-approximately 25 percent of the energy consumption in both Canada and the United States. We have conducted considerable research, along with the British, looking at the energy implications of this substitution field. Again, I will not attempt to summarize the results here—some of them are in the submitted testimony.

There are a host of other types of implications that we have to consider here-privacy, what happens when people start to interact this way, will it affect their approach to life, is it going to cause unemployment problems in certain industries, who is going to have the right to assess this, who should be regulating what, who should be subsidizing what. It is a rather interesting field.

Moving on toward the conclusion, our views on TA itself, we have been actively involved for about four years in this field. The impact has been dual. First, at the executive level, I think we have definitely gone through an educational process. I mean that we have a set of senior managers who know what you are talking about when you refer to TA. So I think the educational process has been a very useful function; we have a commitment right from the top of the corporation to be involved in social impact analysis. I don't think that it is accidental that since we are a regulated utility we are interested in

tile social impacts of what we do. I think it is a part of the regulatory process.

Second, at the professional level—with the people we hire to conduct TAs-we have had our fingers burned, and learned the fine details of how to and how not to conduct TAs. We could sit and debate the methodological issues for days on end. If there is a viable TA technique around, we have used it. One thing I can say is that there is no tecnique today that has received any sort of universal acceptance; they all have wide holes in them, and the professionals have a lot of fun finding out why various studies have gaps in them.

What does this mean in a decisionmaking environment ? In our type of decisionmaking environment—I would call it an incremental decisionmaking environment—relatively rarely do you approach what I call the big-bang decision. In other words you do something and you are stuck with the results for the next 20 years. It is very much of a step-by-step procees, and I think it is because of the integration issue that Dean Gillette mentioned earlier. This also means that you can have an ongoing incremental type of TA. I am very skeptical of the value of very expensive single-shot TA studies that fill many bookshelves but do not appear to be used in many cases for any decision support. Also by the time they are published they are out of date. They are published or prepared by people who then go on to study a totally different subject area. Just about the time they get up on the learning curve they have to stop. They are controlled by the availability of money. When they run out of funding from the sponsor, the study stops.

I think as far as the credibility issue goes, there is very much to be said for having the in-house capability with people who can conduct ongoing TAs and monitor what is happening as technologies are tried out. There is a very significant role for trials of new systems. We can conduct ‘(paper studies” until we are blue in the face. Let’s try out some of these services in a measured environment and see if we can determine some of the real impacts. I think this is very important.

If I can be permitted to generalize, a lot of studies have not really got at gut issues, i$_n$ funding agencies, in government, or in business *even* though today we heard some exceptions to the rule. We study matters that really aren’t near-in; some of our own studies are in that category. I will close with one of our studies that is current and that I think is going to be very important. It is a service called incasting. Briefly put, it is the opposite of broadcasting. It’s an inadequate name. but we are using it right now has an internal label. It is a form of electronic polling. We have all heard about electronic polling services, but this one is different. With this method you can use the regular telephone network. You can even be polled while the telephone is being used for a normal call. Technologically, we have now developed a way to take local or nationwide polls and deliver the responses in 10 seconds or less after asking the question, to a TV network or other user. Let me underline that I am talking only about polling and not about voting.

I know that this field-the electronic polling field has been talked about for a long time, but it has always been comfortable because we have talked about putting it on interactive cable TV systems that we knew were going to grow slowly. Now we can do it on the existing

telephone system. We have been working on the technological aspects for a number of years, and patents are now available.. We will be hap y to lease them to the Bell System, Dean. This is a very interesting business opportunity, the broadcasters think that it is fantastic, you can think of an unbelievable range of applications through interactive broadcasting, nationwide polling, interactive advertising, and so forth.

But the implications are rather interesting, too. This has mainly been discussed internally to date. It has also been discussed in a highly technological environment. What is curious is that when you get a bunch of engineers together and they start talking about "incasting," the discussion rapidly goes to the social issues. Once you explain how you can do it-and it is very simple—it comes down to the social, political, or TA issues. There have been some very strong debates at the highest levels in our corporation on whether we should or should not even introduce this service based around these social issues. I don't know which way the final decision is going to go.

Right now we are bringing selected groups of outsiders in to the evaluation process and we are assessing the possibility of a trial that we can monitor and evaluate. We have had a consulting political scientist tell us what he thinks the impacts are going to be and we are going to have a private meeting with a group of rather distinguished people associated with universities throughout the United States who have looked at the basic field for a long time.[1] We are using the TA philosophy and approach on something that I believe is going to be basic to our busines. Thank you.

Mr. **BROWN.** Thank you very much, Mr. Day. I think it is safe to say that your testimony is probably the most comprehensive, detailed, and stimulating of any that has been presented to us. You seem to be deeply involved in a wide range of fascinating potential technologies that could drastically shape the nature of our society. Mr. Leathers, do -you have any questions?

Mr. **LEATHERS.** Just one, to Mr. Day. I agree that a TA as carried out by the OTA is not provided with a mechanism for updating a TA after it has been completed. My concern is that if there were to be a mechanism for following up all the TAs, this arm of Congress would wind up with more people doing these things than the administrative branch. So I wonder if you have a suggestion for how to carry on the updating of a TA without involving a large number of people.

Mr. DAY. T was not referring to the OTA when I talked about studies going on shelves or about an ongoing monitoring operation. However, I think that both in corporations and in Government mission agencies, there are people who have the skills along with access to the necessary information, where TA should be a part of their regular decision-making process.

The OTA, I think, is a totallay different type of environment because Congress makes decisions that tend to stick for a long time and are what I would call big-bang decisions. I am talking more about the business environment and to a certain extent, the mission agency environment in the Government, where these people are involved in

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1 Mr. **Day subsequently informed the** OTA **that a successful meeting was held in early July.**

more day-to-day incremental decisiomnaking. I would not try to impose that structure on the OTA.

Mr. LEATHRRS. Thank you.

Mr. BROWN. I think we will have to face up to the problem in the OTA of the proliferation of bureaucracy, as it seems necessary to keep up with the continually increasing mass of work. The office is now relatively small; it is structured into subject matter areas, with the intent of developing an in-house expertise in certain broad technological areas—energy, for example. But as they develop more and more assessments and attempt to keep these up to date, there will be some real problems involved in how to do this.

I hardly know how to get into the questions that have been raised here. Both of you have dealt with certain developments that will have major impacts on our society. This business of video and audio conferencing—the substitutability of communications for transportation. The question that comes to my mind is that in view of the potentially massive impacts that developments of this sort could have, how much effort are we justified making in the way of TA, and at what stage in the decisionmaking process as well as in the analysis itself, do we involve a broader audience?

For example, in both countries the telephone companies are regulated utilities. You have to make decisions, I suspect, that have the approval of the regulatory bodies. How do you interface with these regulatory bodies as you proceed in exploring these potential new developments ? How fully o you have to justify your assessments? Is there a need to sound out the public in connection with these kinds of things? How do you handle that?

Dr. Gillette. If I ma-y respond first, Mr. Chairman. The interactions with the regulatory bodies in the United States, both at the Federal and the State level are as you can very well imagine, continuous. As far as the technology itself is concerned, there has been relatively little effort to regulate the means with which we provide services. Certainly the regulatory bodies are interested in our efforts to keep costs down. But the Federal Communications Commission for example, although it must approve each of the transition proposals, has not said that one technology is ours for the Bell System for common-carrier use, and another is for broadcaster use. Consider coaxial cable. for example. We use it in the telephone business to carry 100,000 telephone calls across the country in one system. Exactly the same kind of coaxial tube may be used by the local cable TV operator to carry up to 40 channels of TV in a local distribution system. Fortunately, the regulatory agencies have not attempted to describe one technology as being for one corporation, entity. or service, or another. There are counter examples, but they are few in number, and I deplore even those.

The question of getting public interest and involvement is, in part, a normal marketing activity, but the question of the social impact is not part of a normal marketing exercise. Here, we in the Bell System have had to get *some* help. We do not have a cadre of knowledgeable sociologists, so we have supported studies of the social impact of the telephone m academic institutions. A most recent example is a series of seminars that we sponsored, carried out at MIT (Massachusetts Institute of Technology) under Professor Ithiel de Sola Poole, on the

social impact of the telephone. There was a final symposium on that particular phase on March 10, the centenary of the telephone.

Much was learned, much more needs to be learned about the social impact of telecommunications. We do have advice and requests for services from the public, from the regulatory agencies, suggestions from academic institutions, even from our sister nation to the north, of new services. We certainly pay a great deal of attention to all of these.

Mr. BROWN. Mr. Day, you brought up what you call "incasting" or internal polling. This could have potentially massive effects on the political structure.

Mr. DAY. It could. I am aware of one study in the United states, a survey of congressional attitudes toward the emerging telecommunications services that came down rather negatively on these types of capabilities. They were not exactly favored. and I can understand why. Obviously these things will start small. That is why I was talking about trials. These would be done in a local area. You would pick a city where the capabilitiy would be provided. Again, problems of time. We have two different types of "incasting" on the books. One is statistical—that can take the standard polling-type of subject matter-Gallup or Nielsen or a similar type of poll. You can say this gives a snapshot of opinion. Already that has the implications of locking out people.

So we have a second type of availability that is not statistically sound. YOU say you have to give anybody one of these things who wants one. You cannot take a selected group of 1,200 or 500 or whatever number of people and say you are the guys that are going to give the polling, or you are going to provide the information. Immediately you have the problems of access, then you have the problems of how It is used. I think that since both in Canada and the United States the same regulatory body looks after both telecommunications and broadcasting communications, it will be used intelligently. These are, of course, the issues that have to be assessed. The ultimate negative scenario is electronic mob rule. obviously this would not happen. There are too many factors in the political system to stop that from happening.

I think it will start with some localized types of activities, such as municipal politics and interactive advertising. Eventually you would have nationwide capability, but it will go a step at a time. I feel Confident in saying that if in a trial some very negative things start to happen, my corporation is not going to introduce the service. We are a regulated utility. It would only represent a fraction of our existing business, so it would just be a dumb business move in the larger sense. That doesn't mean, however, that somebody else using an alternative technology such as interactive cable TV could not also do this. It's just going to take them longer? but they may want to do it as well.

What is essential to realize is that the emerging frontiers in the communications field are all going to be competitive because various institutions are going to use various technologies to provide services. You have the cable people, the computer people, and the telephone companies. No one in the communications field can make a single decision alone and make it stick If we decide not to introduce this,

somebody else might anyhow, which brings the people in the political and regulatory process into the picture at some point.

As far as your question goes, how do you get the people involved? We follow a very aggressive program of making our work public to anybody who wants it. That's the reason why I attached the list of publications, just to give you a feeling for the scope of our work. The least we can do is make the work available, put it up for critical analysis and debate, for two reasons: First, people in the public policy arena have to have access to this type of material and, second, the credibility issue again. If your people are professionals who have a professional involvement with external researchers, then if they put work out that is regarded as a piece of intellectual nonsense, they are going to get negative feedback from other professionals. The members of my staff are very conscious of their professional image.

On the other hand, if we produce just internal working papers that nobody ever sees, how do you involve the-general public? We have tried out some new methodologies that revolved members of the general public in our study process. In one study we had housewives help us try to assess the impact of some of these services. We were " told it couldn't be done; however, these ladies had some fantastic insights about what the implications for the home might be of some of these future services. We expanded this approach and involved welfare workers; students, educators, and Government officials. There are ways you can involve the public. It's very time consuming.

Mr. BROWN. Well, I imagine your business planning group, Mr. Day, must be a fascinating place in which to work.

Mr. Day. Yes. sir, it is interesting.

Mr. BROWN. I would very much like to pursue this further, but I am afraid the time is running along, and I am going to be called over for some votes on the floor shortly. I would like to ask if we could submit some questions in writing after the staff has reviewed your testimony in a little more detail than we have had a chance to do here. If you would cooperate with us on that, we would appreciate it very much.

Dr. Gillette. We would be very pleased to, Mr. Chairman.

Mr. BROWN. I do want to express my very deep gratitude to yell for your cooperation in this exercise; it has been extremely helpful to us, and I am certain that this record will be persued in great detail by the members of the Board. Thank you very much. The hearing will be adjourned.

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

Question 1. **You mentioned that part of the mission of Bell Laboratories is to make assessments of the impact of new technology. How do you define this process in terms of the impact on society and the environment? Are the results worked into reports?**

Answer 1. Probably the greatest social impact of telephone technology has been to nearly achieve the goal of universal service.

The purpose of new technology developed at Bell Laboratories is to reduce the cost and improve the quality of conventional, widely-available communication services, and to foster economic introduction of new services. The evaluation processes include systems engineering studies, as discussed in some detail in my written and oral statements. Another part of the evaluation includes consideration of the environmental consequences of proposed technology, procedures, and environment-related research efforts. Flammability of products, and X-ray and

microwave radiation effects are examples of items reviewed in such environmental studies. An Environmental Quality Committee at Bell Laboratories is responsible for advice on environmental control.

Results of various Bell Laboratories assessments of the impact of new technology are documented in internal reports supporting decisions for product and service development, and outlining broad requirements of new developments. The Bell System has an open publication policy. Results of scientific and technical work are published widely in professional journals including the Bell System Technical Journal (BSTJ) and in AT&T technical references, for the benefit of users of telecommunications services, and suppliers of telecommunications products. For example, the results of plant characterization work mentioned in my written statement in connection with echo control and in my oral statement in connection with data transmission were published in the ***BSTJ.*** Reports **of study approaches and product developments may also appear in the Bell Laboratories Record, as noted in connection with the response to Question 2.**

Question 2?. **Can you give us a specific case study of a** TA **that was done at Bell Labs and point out how it impacted the decisionmaking processes?** Has TA affected **the way you do business?**

Answer 2. Bell Laboratories does not conduct studies that are labelled "Technology assessment." Rather, we carry out systems engineering and other studies, including those of environmental effects, of the kind appropriate for the particular **technology and service. Some of these analyses—and of the follow-on product and operational developments-are illustrated in the June, 1976 issue of the *Bell Laboratories Record!.* The issue is devoted to what we refer to as "special services' '-communications applications ranging from intercity toll-free lines to data links from central computers to remote locations.**

That social values of these special services are recognized in our studies is indicated on page 142: "Clearly, special services are meeting a variety of special needs, particularly in the business community. Often, these services are not merely a convenience in a business but actually are essential. We all know what happens to a business operation when its central computer quits. The outcome is essentially the same when the branch offices suddenly find that telephone lines to the main computer aren't working. So when special services circuits fail, they must be fixed-quickly."

Such studies as those of special services, have led to decisions for development of supporting systems illustrated in other articles of the June 1976 Record issue. Development of systems to support operations such as these is an interest new to Bell Laboratories in the last several years, and is an example in which systems analyses affect the type and the way we at Bell Laboratories do our business.

That environmental factors have long been important to the Bell System *is* **noted in another item in the same June 1976 issue of the *Record.*** Under "50 and 25 Years Ago in the Record," we find an article on Conservation and Substitution Materials. Other examples of Bell System consideration of environmental effects and conservation of resources are given in my statement.

Question 3. When using Systems Engineering as a way to analyze a particular problem, how is it decided what shall be studied when attempting to determine the social impacts of a technology? With regard to future considerations, how do you evaluate the impact of your telephone service on the handicapped, on housebound, and so on? To what extent do these considerations enter into your planning? Is this Systems Engineering analysis institutionalized In the Bell System as a part of the planning and decisionmaking processes? Do you have a team that does this kind of analysis? Is Systems Engineering a kind of policy analysls? How do you involve the public?

Answer 3. Individuals and groups involved in systems engineering make the choices as to what shall be studied in connection with a given problem or application of technology. Those responsible for providing the background information for decisionmaking are expected to anticipate questions that might arise and to make appropriate analyses. Bell Laboratories systems engineers work closely with their counterparts at AT&T in carrying out these studies.

When considering the impact of telecommunications services to the handicapped and the housebound, we attempt to understand both the opportunities and limitations of conventional telecommunications. Within the Bell System we have specifi c programs for providing such specialized equipment as transmission amplification for the weak-voiced. visual signals, loud ringers and receiving amplification for the hard-of-hearing, and dialing aids for the physically handicapped. We have developed systems to connect housebound students with their classrooms

via telephone. Operating Telephone Companies make special arrangements to meet particular *needs.*

Systems engineering, as I discussed it in both my written and oral statements, is primarily an activity at Bell Laboratories. However, engineering analysis and quantitative investigation is a fundamental part of the Bell System's operations simply because the industry is technology based. Within Bell Laboratories systems engineering is carried out by groups (teams) involved in planning for evolution of the network as a whole and in product development areas.

In the sense of providing information for decisions regarding product develop ment, systems engineering is a kind of policy analysis. Since systems engineering studies must anticipate the demand for products as a portion of cost-of-manufacture analysis, it must take into account public acceptance and public demand. In addition to attitude survey and market studies, we frequently conduct trials of new products and services, and take public reaction into account in arriving at **standard designs.**

Question 4. **Regarding the introduction of new technology,** how do you discuss ahead of time with the public possible impacts and try to educate the public ahead of time? How do you get the public involved?

Answer 4. AT&T's General Departments take a leadership role in involving the public in telecommunications. In addition to guiding the service and product trials mentioned in the response to Question 3, AT&T surveys subscriber responses to service, and studies of public preference for new products and services. Subscriber views as reported by the Operating Telephone Companies are reflected in AT&T's determination of the needs for new services and products.

The public frequently does not recognize the introduction oil much of the new technology used by the Bell System except as it results in improvement of service or reduction of costs. For example, unless a subscriber chooses to use the special features available via electronic switching, he will find very little difference between the central office service provided by electromechanical switching technology and electronic stitching technology.

New services provided by new technology will, of course, be of value only if subscribers know of their availability. The marketing organizations in the Bell System are responsible for anticipating the Nation's needs for new services, and tile operating elements of the Bell System, particularly the Associated Companies, are responsible for informing the subscribers on the availability of new services and how they can be obtained and used.

Question 5. What value do you see with regard to TA in having a closer working relationship between the Public and private sectors? Do you think closer ties with state and local government would be beneficial?

" Answer 5. A close working relationship between industrial, governmental, and public sectors is important. As a regulated public utility we in the Belt System have very close working relationships with the Federal, State, and local governments, and we find these greatly beneficial.

Question 6. **What new considerations over the last five years have entered into your engineering system planning?**

Answer 6. As telecommunications technology grows more complex, it has become even more important to plan effective exploitation of the opportunities available. In the last several years, Bell Laboratories has taken advantage of the growth it has stimulated in one area to develop means of managing applications of new technology in others. A major consequence of the invention of the transistor and development of subsequent integrated solid-state circuitry is evolution of minicomputers and microprocessors that allow efficient and economic centralization of operations of a variety of systems and functions. The Bell System has developed new approaches to operations that will lead to productivity increases, service improvements, and cost reductions, as illustrated in several of the articles in connection with "special services" in the June, 1976 issue of the Bell Laboratories Record, cited in the response to Question 2.

The national emphasis increasingly placed, in the last several years, on environmental protection and natural resource conservation has influenced the *types* **of** analyses and direction of engineering studies in Bell Laboratories, as exemplified in my statement.

Quesion 7. **You mention that fiberglass technology and laser technology may become a more important factor in the future. To what extent do your systems analyses take into account effects of such new technologies on materials, effects on imports, freeing of materials for other uses, etc. ?**

Answer 7. In our systems analyses of materials, effects on imports, and freeing materials for other uses, our principal focus is on costs. We must concern ourselves not only with the initial cost and availability of materials, but also their future availability and opportunities for recovery through the recycling operations that I mentioned in my statement. This interest is not new, as noted in the response to Question 2.

Question 8. Do you examine the secondary impacts of your own developments in communication on the internal operations of Bell? That is, do you measure telecommunications improvements in terms of increases-decreases in demand,* for certain skills and similar changes in capital outlay s,* or transportations costs?* Can or should Bell attempt to measure the social sideeffects of advances in communication—for example, does the health of the elderly (and other infirm) respond to access to improved telecommunications?

Answer 8. We do examine the impacts of our own developments in communications on the internal operations of the Bell System. In my statement I gave several examples of the way we view interactions between new technology and the work force. The June, 1976 issue of the Bell Laborataories Record, cited in Question 2, illustrates the increased attention we are giving to the development of technology to improve operations within the Bell System itself.

We do analyze the interaction between introduction of new technology and costs of labor. For example, productivity increases can be and are, measured by labor efficiency. Another factor in evaluation of new technology is the change in requirements for operational personnel skills and consequent change in training programs. Because the Bell System incorporates both technological development and service application, it is possible to plan introduction of new technology and force requirements together—a process that leads to efficient and effective human resource management. Capital outlays are, Of course, central to an economic evaluation of the introduction of new technology and are essential to any systems engineering evaluation.

In addition to the considerations of the handicapped and housebound mentioned in response to Question 3, we are concerned with general social uses of telecommunications. We in the Bell System depend more upon academic studies than on internal resources for study of such social side effects as advances in communications on the health of the elderly. From all of the studies we have at hand, it seems clear that the telephone is extremely important for social intercourse among the elderly, particularly the infirm. This is one reason we attempt to keep the cost of basic telephone service as low as possible and look to other services to make major contributions to common costs.

Question 9. Does Bell limit its concerns to anticipated needs for electronic engineers as it continues to rely upon more sophisticated systems, or do you accept that such systems also call for more expertise within Bell in the social and behavioral sciences?

Answer 9. Bell Laboratories has not limited its technical staff to individuals trained in electronics engineering (and the physical sciences). Nor do we expect that such imitations would be appropriate in the future. Bell Laboratories' responsibilities require research into the social and behavioral sciences, and we have individuals and groups making fundamental contributions in these areas. Long-term interest in human elements in the operational forces and in the foundations of human communications are illustrated in my statement. More recently the Bell System has expanded its interest in broad-based economic studies, and Bell Laboratories has buiit a solid research effort in the field. We expect all of these to be long-term interests.

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

Question 1. **Would you describe how your use of TA has affected the way Bell Canada does business?**

Answer 1. To date, TA **has not altered our fundamental way of doing business. This is mainly as a result of topics studied to date, and the findings of those studies, which have not resulted in any serious negative impacts being identified. More specific comments on the impact on Bell Canada of its TA activities are documented in the written and spoken testimony and in replies to the questions below.**

• **within Bell.**

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

Answer 2. Definitely yes. In our evaluation of the impacts of the so called "(Office of the Future", we are directing a great deal of effort towards the questions of computers, communications, and job structures.

Question 3. What value do you see in having a closer relationship between the public and private sectors?

Answer 3. I assume here that we are talking about the narrower issue of public-private cooperation in the TA field rather than the broader field of business-government relations, I have no particular expertise to address the latter issue.

Closer relationships for TA purposes have the following benefits:

The sharing of information that is vital to a well conducted TA; hence, a reduction of TA costs that appear to be heavily impacted by information gathering activities.

Reduction of the credibility gaps between the sectors on the uses and quality of TA activities on both sides.

Creation of the possibility for structures that will foster continuing or incremental TAs.

Reduction of the learning curve required to address new types of impacts resulting from the use of evolutionary developments in technology.

Question 4. When you identify negative or positive societal or environmental impacts, do you try to inform and educate the public ahead of time?

Answer 4. To date, this is somewhat hypothetical for us, since our TAs have not identified serious negative impacts resulting from the use of new telecommunications services. Specified impacts on special interest groups of the public (e.g. teachers, students, government officials, etc.) have been transmitted to members of these groups with the distribution of our reports and papers. Of course, the positive impacts of any new or existing service are always communicated from a public relations and marketing perspective.

My view is that we would attempt to communicate potential problem areas to the public if they were identified in a TA of new or existing services. This is a tricky area for a telecommunications common carrier since most of the impacts are associated with the specific applications that subscribers develop as they use the telecommunications capabilities provided by the carrier. Carriers normally avoid involvement with the subscribers' uses of their services unless the application is clearly illegal or unsafe. Thus our TA activities are oriented towards new types of services Bell Canada may provide rather than the myriad of uses that customers develop.

Queation 5. **What is the basis for deciding to do a TA as opposed to some other kind of analysis? In the past how have your TAs impacted the decisionmaking and policy processes at Bell Canada? Has management requested further study, more TAs, etc. ? What lessons have been learned as a result of doing TA at Bell Canada?**

Answer 5. TAS are usually decided upon using normal managerial judgment. The decision is not so much that of conducting a TA versus some other form of analysis but more that of conducting a TA in addition to other analysis. The results of our TA studies have been used as an input to the regular decisionmaking process in the company. As noted in the testimony, some of the impact has been of an educational level. *Hence,* **it is difficult to identify specific decisions being made or modified as a result of a specific TA study. The current interest in identifying the social impacts of "incasting" is a direct result of senior management concern with the social-potential impacts of that potential service and specific decisions will be impacted as a result of the TA activities.**

The lessons learned with Bell Canada TA experience:

TAs should be directed towards specific services or products rather than towards broad service or technology trends;

.4 wide mix of methodologies should be used;

Methodologies that gather impacts from a variety of factors and interest groups should be chosen;

TA should be viewed as part of the decisionmaking process rather than a stand-alone activity;

TA activities directed towards future services rather than here-and-now ones are always more academic and educational in nature than ones directed towards services currently in existence or to be introduced shortly;

An extension of the above point is that observers seem to discover a much wider range of negative impacts that should be examined when they are told that a service is possible today rather than at some more distance point in the future; and

TA activities should be incremental and on-going if they are going to match the decisionmaking process.

Question 6. Based upon your experience, what are the factors that limit the application and utilization of TA in the public and Private sectors? How may we define the bounds of the concept?

Answer 6. Limiting factors for TA:

The subject definition must be precise; studies that attempt to examine broad issues tend to end up consisting of a series of generalizations;

impacts should be ranked in some order of importance using an acceptable methodology; too many studies end up as "catalogues-of-impacts," which reduces their usefulness;

TA results tend to be distributed only to those interested in TA itself; summary reports written for a wider public should be made more available.

We are not overly concerned with defining the bounds of the concept. It should be flexible enough to evolve, based on direct expedence with TA **studies and their impacts. Hence, my concern with "incremental" TA versus "classical" TA.**

Question ?'. How **do human value systems affect technological development? What role should the analysis of value systems have in the assessment of the impacts of technology on the environment and society?**

Answer 7. Human values impact upon everything that we do. There is no such thing as truly value-free or objective research. **All individuals and organizations have their stated and unstated value profiles. The best we can do is try and make them as explicit as possible in a TA environment. Value analysis should play an important role in TA, but most studies tend to bog down in an attempt to classify the types of values and methodologies to study values (some of the best summary work here has been that of Arnold Mitchell at SRI). Thus, value analysis should be part of the TA process as long as it does not become an end in itself for the TA.**

Value systems affect technological development at the most fundamental point—financing. Clearly, the value systems of decisionmakers in business, government, foundation universities, and non-profit research organizations help determine what technological research is funded. Some organizations state their value profiles quite clearly in the form of check sheets, scoring systems, relevance exercises, etc. Others rely more upon managerial judgment, or "gut feel", which is of course, wrapped up in the value systems of the individual or group decisionmaking entities. Value systems also impact upon what issues are emphasized in a TA, who conducts the study (in-house or a specific choice of an outside organization), which methodologies are chosen (note here the hair-splitting debates on TA methodologies that are often meaningless, considering the lack of precision in information inputs to those methodologies), how the results are presented or packaged, and of course, whether TAs are even conducted by an organization.

[The Board adjourned at 1 :10 p.m.]