TECHNOLOGY ASSESSMENT—THE PROCEEDINGS OF A SEMINAR SERIES

July 1969

Program of Policy Studies in Science and Technology
The George Washington University

TECHNOLOGY ASSESSMENT

The Proceedings of a Seminar Series

at the

Program of Policy Studies in Science and Technology
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CONTENTS

INTRODUCTION

The rapid pace of technological progress has been accompanied by an increasing attempt to foresee and evaluate the consequences of new technological applications. On the one hand, we recognize that technology has yielded great benefits. But at the same time it is becoming evident that not all of the impacts of technological innovation are beneficial and that some can lead to quite serious, and often unexpected, hazards. The concept of "technology assessment" represents an attempt to understand and appraise the results of technological progress in order to allow the development of policies for the rational application of technology.

Studies of the meaning of "technology assessment" and its effective implementation have been a major part of the research effort of the Program of Policy Studies. Work in similar areas has been carried on in other academic institutions, in some government agencies, and even in the Congress where hearings held by several committees have investigated various approaches to the assessment function.

But just as the actual assessment process has been characterized by a high degree of fragmentation among various organizations and individuals, so the study of the assessment process has also been performed by individuals who are often isolated from the thoughts and ideas of others investigating the problem. This fragmentation has adversely affected the quality of work in the field; the lack of an effective base structure of definitions and concepts has caused each investigator to carry out his research as though no one had examined any aspects of the problem previously. This is, of course, one of the problems of any new area of study; the development

of a common ground from which to discuss important substantive problems is perhaps a sign of maturity.

With this in mind, the staff of the Program of Policy Studies felt that the institution of a seminar series dealing with certain aspects of the technology assessment process would provide an opportunity for some of those interested in the problem to get together and to discuss their ideas in a relatively informal atmosphere. Such an exchange of viewpoints would, it was hoped, lead to an understanding of the ways in which others approach the concept of technology assessment in order to create a kind of background for further study in the area.

Participants were invited from academic, industrial and governmental organizations in an attempt to gather as broad a spectrum of ideas and opinions as possible. Four sessions were held in the Winter and Spring of 1969. At each the author of a prepared paper moderated about two hours of discussion among the participants. The general chairman of the series was Louis H. Mayo, Vice President for Advanced Policy Studies and Director of the Program of Policy Studies in Science and Technology at The George Washington University.

Clarence Danhof, a Senior Staff Scientist of the Program of Policy Studies, presented the first paper on "Assessment Information Systems" which called attention to some of the problems involved in obtaining the information necessary for the assessment function to proceed. The role of the technical expert and role of the public were considered at some length in the paper and the ensuing discussion.

The second paper was prepared by Richard A. Carpenter, Senior Specialist in Science and Technology for the Science Policy Research

Division of the Legislative Reference Service of the Library of Congress, and dealt with "Technology Assessment and the Congress." It considered the needs of the Congress and the present role of the Legislative Reference Service in fulfilling some of those needs. The lively discussion ranged from an exchange on the partiality or impartiality of committee hearings to the position of the engineer in assessment. This breadth in the topics discussed was perhaps somewhat more extensive than might have been expected but merely serves to indicate the wide scope of the problem.

Harold P. Green, Professor of Law and Director of the Law, Science and Technology Program of The George Washington University National Law Center, followed with a discussion of the "Adversary Process in Technology Assessment." The paper provoked spirited debate on Dr. Green's proposal to establish an organization whose purpose would be to determine and publicize the detrimental aspects of technological applications.

Finally, Louis H. Mayo considered "The Management of Technology Assessment." He stressed his view of the total problem approach to technology assessment and once again the discussion covered numerous topics. Consensus was not reached in this or any of the other discussions, but then, consensus was not the goal of these sessions.

Summaries of the major points raised in the discussion sessions were prepared by Raphael Kasper. It should be noted that this seminar series was not intended as a final and completed study of the assessment function, but rather as a series of exchanges which could provide a basis for further examination of the problem.

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1: ASSESSMENT INFORMATION SYSTEMS

Clarence H. Danhof

Long before man had begun to make purposeful use of fire, he, no doubt, had accumulated a stock of transmittable information comprehending effective and ineffective, safe and hazardous materials and methods that related to his interests in accomplishing an objective--such as securing food. The knowledge of materials and methods that yielded desired results constituted the applied technology and was maintained since it was in constant use. Experiments with materials or methods that yielded results of neither positive or negative significance no doubt tended to be forgotten. But special efforts were made to retain knowledge of materials or methods that proved so harmful in the results of use as not to be repeated voluntarily. The taboo served to communicate and preserve such knowledge.

The first action credited to man in the book of Genesis is the naming of all the animals and birds--the foundation of an information system. Of greater interest is the third action there recorded which was an effort to extend the available knowledge of resources with regard to their suitability for some desired use, in this case food. The problem was the relatively simple and straightforward one of determining whether the fruit of a certain tree would, when eaten, a) provide satisfaction and b) yield undesirable consequences. The existence of a taboo against the use of the fruit of the tree suggested that earlier experience had been unfavorable. The possibility of undesired results

was therefore of particular importance, inviting consideration of whatever advice might be found. Adventuresome Eve sought the advice of the serpent who offered himself as an expert. The serpent assured Eve that "eating the fruit of the tree which is in the midst of the garden" would not produce death but instead "your eyes shall be opened and ye shall be as gods, knowing good and evil." [1]

The advice was of compelling appeal. Eve did violate the taboo and ate, and called upon Adam to confirm her satisfied reaction. Three consequences are recorded:

1) The immediate result was desirable--the fruit was good.

2) Adam and Eve became aware of their nakedness and invented clothes--an intermediate result subject to a variety of explanations.

3) Adam and Eve did encounter evil--they lost Eden. A technological system together with its related culture, disappeared to be replaced by another.

In modern parlance, Eve was engaged in the assessment of new technology, a process which man has undertaken countless times over in his history. Though Eve's assessment effort was, viewed superficially, a simple operation, it had all the elements common to the modern process. These are:

1. Initiative in identifying a solution to a felt problem or an opportunity to gain a desirable objective, both requiring exploration of an area involving some unknowns.

2. The application of expert, specialized knowledge to the problem at issue, so that possible gains and hazards can be defined as clearly as possible.

3. A new technology may yield good or bad results or, frequently, a mixture of both. The undesired consequences may affect the immediate user, a large group, or all of mankind. Such undesired consequences may appear immediately, in which case cause and effect relationships are clear. The consequences may also emerge slowly, perhaps within the memory of a generation or two. The consequences, however, may become evident over so prolonged a period of time as to be perceptible in long retrospect so that cause and effect relationships can be ascertained only by very complex analytical techniques, if at all. In Eve's case, the immediate and intermediate reactions were met by user reaction but the long range impact involved higher authority.

The Assessment Process in the Contemporary Society:

The development of a new technology is, in the modern situation, usually a far more complex process than the determination of the edibility of a fruit. The development process is part of an elaborate effort to search out new knowledge and to appraise such knowledge for possible application to desirable objectives and the avoidance of those that are undesirable. The provisions made by society for dealing with these hazards has grown substantially but there is increasing evidence that the machinery is far from what it might or should be.

The assessment of new technology is an integral part of the process of accomplishing technological change. For our purposes the development of a technology occurs in two distinct stages in each of which the assessment process differs in significant ways. In the pre-introduction stage

of development, it is the developer who, seeking to find a desirable use for a technique or material, applies tests he deems relevant to determine both the positive and negative characteristics. In the application stage, it is the user who applies such tests, employing what may be somewhat different criteria. An essential part of the assessment process, then involves the using public which provides a large part of the effort in seeking those conditions under which the benefits of the new technology can be best attained. Such efforts continue over a prolonged period of time, thereby permitting the longer term effects of the new technology to make themselves apparent.

The decision by the developer to make the innovation available to the public through the market or otherwise is presumably made with some confidence that it will perform a desired service at an acceptable cost-benefit ratio and that it will do so without undesired consequences if prescribed conditions of use are followed. In the usually long process of developing an innovation, numerous actions have occurred that yielded negative or undesired results. Both contribute to the originator's knowledge of conditions under which the innovation must be applied to secure hoped-for results.

The decision to introduce may have rested wholly on the basis of information developed and assessed within the originating organization. In many cases, however, outside assistance has been sought. The device may then have been user (market) tested. It may have been submitted to examination by experts for conformity to standards established by an industry-wide organization, by an independent testing organization or by a government agency. In the case of new drugs, and certain food or food-related items, it will have been clinically tested and then submitted to

the Food and Drug Administration for its approval. When finally offered to the public, the considerations favoring public experimentation with the innovation are substantial. No unfavorable results accompanying use have been identified or if some have been it is believed that they can be eliminated, or controlled within acceptable levels, by advice and warnings controlling the circumstances of application. The first stage of assessment has been completed.

The central characteristic of the second stage of assessment is the involvement of the general public. No testing under limited and possibly simulated conditions can completely comprehend all the possible circumstances of use. Public application is likely to present a more comprehensive range of possible applications under widely varying circumstances and hence to yield a wider variety of results, both positive and negative. Some undesirable effects will emerge under unanticipated conditions and only over a more or less prolonged period of time. Buyers can be expected to communicate their opinions of the innovation to the originator in numerous ways. The rates of purchase will indicate acceptance with more or less unqualified enthusiasm as may also the appearance of competitive suppliers. Potential users may, on the other hand, cease to purchase or may return the device if warranty arrangements had been made.

We are concerned here, however, not with performance that falls short of expectations nor with adverse effects that are merely unpleasant to individual users. Our concern is rather with adverse effects of the new technology and the relationships that follow between users and originators. Such adverse effects may result from the failure of the originator to provide proper materials and instructions or to anticipate results that could reasonably have been forecast. Undesirable results may also follow because of actions by users beyond the reasonable

anticipation of the originator or sponsor. It is true that new technologies are sometimes viewed and accepted with great caution, particularly when they constitute new complex systems that make fixed capital investments obsolescence and require substantial capital investments to apply. Other new technologies are quickly accepted and may then be applied less critically and with less discrimination than occurred in the late stages of the originator's testing. Such was the case with, among many others, penicillin and other early types of antibiotics, some medical techniques such as X-rays, ovarectomies, appendectomies, and tonsillectomies, and such pesticides as DDT. As undesirable effects of application accumulate in the professional literature, are summarized and evaluated, constraints develop. This occurred in the past with regard to some use of arsenic and lead and seems now to be occurring with regard to many uses of mercury compounds. This process of re-evaluation may proceed solely between users and the sponsor, with the expert group involved, or may also involve non-experts as in the current controversy over the use of DDT.

In this second stage, the problems of observing, recording, analyzing and communicating the results of application may be more complex than in the pre-introduction stage since more or less numerous appliers are involved and the circumstances of application may vary widely from those of the first testing stage. The probability of unanticipated adverse effects therefore increases at the same time that the observation, recording and analysis of such adverse effects--internal to the originating group in the first stage--becomes difficult because of the numerous scattered participants and the need to establish cause and effect relationships

in what are frequently exceedingly complex situations that operate over long periods of time.

One broad reaction by the society is to require the sponsors of new technology to undertake more elaborate pre-introduction tests. Such efforts are strongly constrained in many cases by consumer interest in enjoying the apparent benefits, the possibility of the existence of a "moral issue" in the withholding of a new technology,[2] as well as great reluctance to discourage the innovative process as by increasing its costs. In a society in which growth is a basic desiderata and in which it is assumed that problems can be solved by technological discovery, the withholding of a new technology even for a limited time, tends to be viewed as an offense to society.

Adverse Effects: Death.

The most earnestly avoided adverse effect of new technology is human death. Death is also one of the most carefully recorded events in our society. Since protection against controllable or avoidable death is a legal right, the cause is assigned of each death and reported to responsible authorities. Assurance that such recording is made follows from the fact that burial, in most jurisdictions, requires a permit which in turn requires that certification as to the cause of death has been made by a prescribed official--an attending physician, a public medical officer, or in their absence a coroner who may call upon experts and upon a jury to assist him. American society has a complex organization to investigate possible causal relationships between a new technology and death. Evidence will be accumulated by qualified experts for government authorities or professional groups--rapidly as in the case of Thalidomide, much more slowly as in the realtionship of emphysema and

cigarettes. In any case, observations concerning possible relationships accumulate as reports published in the professional or technical journals and occasionally reporduced in the popular press.

The approach is inherently slow since even a number of suspected deaths may yield no more than a hypothesis regarding a causal relationship.[3] The reporting system lends itself to statistical compilation and analysis in the search for a causal relationship or the confirmation of a hypothesis. The results of such statistical analysis may stimulate expert investigation on a substantial scale.

Adverse Effects: Personal Injury.

Many new technologies present few, if any, intrinsic dangers. Many others can be adapted to include built-in safety provisions or require only simple instructions and cautions that, it is assumed, will assure safe usage given a public of reasonably high levels of functional literacy. The benefits of other technologies are obtained indirectly in which the public secures the services of the technology through an expert and does not itself control its application.

A death attributable to the use of new technology represents a failure of the efforts of the originator and, possibly, of the larger society to anticipate hazards, to impress the user of the existence of a recognized danger, or to provide methods whereby the desired services can be obtained safely. It is an inherent part of the process of developing a new technology that hazards be identified and that the procedures involving hazards be eliminated or minimized. The originator will have acquired or have available a stock of information on hazards and their avoidance. In some areas, the originator--and the public--have available

testing services that provide for the application of standards developed from experience that provide constraints. These form the basis for the formulation of rules for safe application of which the user should be fully informed. It remains true, however, that in public usage, the circumstances of application will be more varied and on occasion less guarded than was the case in the originators' laboratories. If a hazard exists, sooner or later some member of the public will experience it and the critical question is that of frequency. Data on injuries by type of technology are by no means as accurate as death data, although causal relationships are in many areas more readily established. The collection of data on public experience is then an essential function, contributing to the continuing development of the technology and to the procedures governing its safe use. One of its products is the development of data on probabilities of adverse reactions, these being essential to the determination of the risks being accepted in the usage of any given technologies.

Such analysis of experience has led to a variety of public actions to assure safety. These may be categorized as follows:

1) Legal prohibition of the use of a technology, e.g., opium, LSD, lead for water piping. (Note the failure of the effort to prohibit the beverage uses of alcohol.)

2) Legal prescriptions of the conditions under which a technology may be used, e.g., prescription drugs, electrical and plumbing installations, nuclear energy, X-rays, aircraft, vessels. Generally, such regulation utilizes licensing, certification

and inspection procedures and typically is applied to situations in which benefits of the technology are provided to the public through an intermediate supplier of the service.

3) Legal requirements that the user be informed of risks and of limitations on use procedures, e.g., prestícides, cigarettes.

4) Legal requirements that a given technology must be used as part of a system, e.g., aircraft, certain regulations pertaining to air and water pollution, federal auto safety legislation. (Note that licensing procedures cited under #2 above may include such positive requirements.)

Adverse Effects: Collective Injury.

In the preceding discussion, attention centered upon injury to a person or relatively small number of persons occurring within a relatively short period of time as a result of some direct contact with a technology. Adverse effects can also be experienced by persons--possibly very large numbers--because the environment within which they live includes within it adverse forces that may cumulate into uncontrollable and eventually disaster proportions. Many problems of this nature have arisen in the past but have been successfully dealt with, as in the case of development of public waste disposal systems or in the substitution of processed and chlorinated water for water naturally "pure." Indeed our society rests upon past successes of this nature.

Such "fixes" will no doubt continue to be achieved but there is much evidence that they will become more difficult. The possibility also exists that both because the nature of a solution to a problem or because no technological fix is available, society may find itself forced to change

its structure and values if it is to deal with some adverse effects of new technology, the alternative being disaster.

It is the long range effect that presents particular problems, partly because of the difficulties of determining the causes of adverse effects and partly because the values by which adverse effects are judged are not a matter on which consensus is easily obtained. Many a new technology has made possible the achievement of an immediate goal only to produce over a more or less prolonged period of time new problems of great difficulty. Viewed broadly, many of the problems arise from the very success of man's efforts to expand his technology which has created problems that threaten his achievements if not the existence of society itself as now structured. Excessive population growth rates is one of the more obvious aspects of the problem.

The experience of Adam and Eve is again relevant. That they were correct in their assessment of a new technology--up to a point--is obvious. Man has subsequently greatly elaborated upon their procedures. The disaster that befell Adam and Eve we may wish to consign to myth or fable--or to the wrath of God. If it were a unique experience we might be justified in the view that it holds no significance for us. It was, however, not unique but rather, as Arnold Toynbee recounts in some detail,[4] a frequent experience over human history. We know little about such societal catastrophes. Numerous forces were no doubt at play. That technological failure was a component of many if not most seems a reasonable hypothesis.

If man's increasing mastery of his environment has expanded--enormously in the Western world of the 20th century--man's relationship to that

environment has at the same time become increasingly brittle and fragile. Man's facile assumption that he can manipulate his environment to his to his own exploitative objectives without changing that environment in some basic and perhaps critical characteristics is an assumption that is increasingly dubious and perhaps perilous. Man's ecology clearly has changed--and we are increasingly recognizing that not all the changes are improvements. If then, man increasingly cannot assume his "natural" environment as a given--because he has changed it--enormously important questions arise. It is the nature of the man-made environment that requires analysis and careful monitoring.

In this category of assessment problems, the originator of the technology has passed from the scene as a central figure since technology is now thoroughly accepted and highly valued for its benefits. The users and beneficiaries of the technology now constitute a vested interest. The technology is no longer new but is thoroughly embedded as a component of the society.

The problems presented by the technology are dealt with by procedures that differ sufficiently from systems previously discussed to warrant designation as a third type or stage of assessment. It is in these areas that the role of the expert and particularly his interaction with the public is least developed and most uncertain.

Information Systems and the Role of the Expert:

The preceding effort to define the range of assessment problems gives emphasis to what is undoubtedly obvious. Since the days of Eve, man has relied upon expert observation and analysis as the foundation of its efforts to deal with technological change. As a result of the growth of knowledge being probed for its application potentials, the expert has

become both quantitatively and qualitatively more important than in Eve's day. The expert ferrets out potentially useful technology, is a principal source of advice and persuasion, and assesses results, by serving as gatherers, synthesizers, and interpreters of observational data and analysts of causal relationships.

Society is dependent upon its stock of qualified experts:

1) To ask relevant questions and record their observations.

2) To communicate with each other to confirm their observations and to establish magnitudes. (It is here that the growth of knowledge has produced numerous problems of information organization and retrieval. These problems affect the expert function but only as such do they relate to the assessment process.[5])

3) To summarize their finds, preferably as a consensus but in the absence of a consensus, then as to areas of agreement and disagreement.

4) To indicate the significance of these findings to an audience capable of determining that action is or is not warranted.

On its part, society must provide such an audience, providing in so doing a source of guidance as to areas of concern, an opportunity to determine areas of agreement and disagreement and in the process reappraise the nature of the values being considered.[6]

In the case of Eve, the expert did not hesitate to communicate enthusiastically his concept of the advantages his advice offered his client. In this respect his performance differed little from that to be found in much contemporary popular scientific literature.[7] The experts

did include some predictions as to the long range consequences that might follow and of their effect on man's society. As experts do, the serpent left to his client the decision as to the long range values she wished to pursue, and the evaluation of the gains that might be made as compared with the risks she was prepared to assume. Then as now, expertise does not carry with it any special qualifications as to values one wishes to pursue.[8]

As the expert becomes more important, societies develop methods of dealing with him. A first step is to establish and protect confidence requiring some procedure to distinguish between the qualified and the charlatan. In both the routine exercise of expertise and in the production of new knowledge, a variety of checks exist though all of them tend to rely on the peer system whereby experts certify to the competence and the quality of work of others in their field. A major problem not easily dealt with is that of the confidence merited by an expert group, a question that from time to time requires non-expert examination of the assumptions and methods upon which the expert's claimed knowledge is based.[9]

Far more difficult is the question of the use that the nonexpert public should make of the expert. It is a well established principle that the "expert be on tap but not on top," at least in policy-making.[10] In form that principle is well observed; in practice there are difficulties. The public cannot expect to obtain from the expert what it feels it needs unless it is able to ask questions that will elicit appropriate answers. Recall that Eve's source of expert opinion is referred to, after the fact,

as a serpent. Considering the consequences to her of the expert's advice, Eve's opinion was no doubt justified.[11] It is at least possible that the relationship might have been more satisfactory had Eve asked her expert some questions that pushed the analysis into a more critical consideration of long range consequences. In the area of assessment, as in others, effective relationships between the experts and the public rest upon interactions in which each urges upon the other consideration of its concepts of problems and values. Flexibility in this respect would seem to require an avoidance of "officially" sanctioned expertise and other forms of rigidity that hinder the free flow of observations and analyses and that may lead too quickly to consensuses in which values and underlying assumptions remain unquestioned.[12]

The nature of the problems differ with social experience with the involved. Where legal responsibilities have been assigned, reporting procedures develop into well-structured systems, as in the case of human fatalities. This is not to say that the operation of that system might not be improved but the weaknesses that appear to exist lie with the discretion exercised by the expert observers. We can reasonably doubt that the cause of all deaths is determined with any high degree of accuracy. However, from the point of view of assessing the technological source of fatalities, it seems likely that over time significant experience will be identified and reported with reasonable promptness. In any case, very considerable progress has been made.

The reporting of technology-related injuries is less satisfactory with the exception of those areas for which specific responsibilities has been legally assigned. In the case of aircraft fatalities, pharmacological, and industrial accidents, legal requirements and compensation

provisions seem to assure substantially accurate reporting, and to stimulate efforts to reduce hazards. In other areas, the reporting procedures are less satisfactory, data collection is frequently haphazard, legal and financial liabilities are uncertain with the role of human negligency a source of confusion. Corrective measures are usually of the advisory and educational type.

In areas involving collective safety, significant steps towards assignment of legal responsibility recently have been taken relative to air and water pollution. In both cases the evidence has been sufficiently persuasive to support such action but much data collecting remains to be done before the precise nature of the problems is known or corrective procedures fully developed. Meanwhile, data collecting is enhanced through the enforcement machinery provided. Establishment of standards provides a guide for observation and measurement as well as a focus for debate over the values involved.

Other areas may follow the pattern by which human waste pollutions are controlled as for air pollution, solid waste, noise, thermal problems, and scenery. Environmental control is a concept of some appeal but the wide variety of problems and values comprehended suggest that the approach will be component by component. These and related areas--such as the population problem--are in the stage in which information is developed and exchanged principally within the research community and with those members of the public already convinced of the seriousness of the problems. Some members of these groups are carrying out the functions of synthesizers and publicists and some are organized for the purpose of influencing legislation.

In a mature communication structure, the process of observing, collecting, and disseminating information will reflect the interests and values of the responsible organization. Even when a formal organization exists with responsibility to act upon technology-generated problems, informal observations and reporting continue as an important input to the assessment process. Indeed, while the formal organization may conduct considerable research on experience in public usage, private groups remain an important source of information and assessment. This role of private groups is particularly important when there are differences in the values held by the responsible agency and those held by private groups. In the case of DDT, for example, the responsible agency has contented itself with controlling adverse effects of usage by requiring cautionary labels. Some private groups believe that sufficient evidence has been accumulated to demonstrate clearly that the continuing use of the material is too dangerous to non-human life, and eventually to human life, to countenance. A principal problem of such groups is to find an audience that can react to its findings in such manner as to contribute to the formulation of public policy. In this instance, the private groups are by-passing the cognizant agencies of the federal government. They are presenting their case instead to state regulatory agencies and may eventually appeal to that fundamental constitution--the court.

If, as in the case of DDT, the experts disagree as to the scientifically determined facts and the economic values involved the public finds itself in the position of determining the basis for the disagreement. Frequently the disagreement rests upon inadequate knowledge and the solution is a continuation of research on the problem. The public then must recognize that the best available scientific knowledge at any given point of time is subject to change--and sometimes very drastic change. Permissible

levels of exposure--as to radiation or pesticides--are, for example frequently judgements by experts rather than well documented determinations. We must expect these to change over time though the direction of change is difficult to predict. In such common situations, expert disagreements stem from interpretations made regarding the significance of available knowledge and the crux of an assessment is one of the values applied, frequently implicitly rather than explicitly. In the DDT case, as in many others, there exists a conflict of values. The knowledge expert can be granted no special competence as an expert in the values held or in the choice of values that a public group or society as a whole may take. The public cannot and should not passively accept the values of the expert as its own.

Conclusion:

One can argue that the apparent evolution of assessment procedures is proceeding along lines that will provide adequate control machinery when the need is clearly demonstrated. This may mean a continuation of our traditional approach of responding to a crisis or near crisis. The nation has done better than that in some areas, but only time will tell if we have been properly alert in others.

If the earlier comment regarding the fragility of man's control over his environment is sound, then our society faces problems of an urgency not easily measured but assuredly reflecting the very rapid rate of scientific and technological change. We may, in fact, fact the prospect of irreparable crisis. Even the possibility of such a crisis suggests that reliance upon the slow evolution of public acceptance of responsibility is unsafe.

In this situation, recognition should be given to the greatest difficulty facing expert observers in those areas that lack a formal information structure, particularly those that are viewed in a long time perspective. The problem is not that there is a total lack of expert warnings of possible undesirable developments. Our society--as most others--has a fair number of prognosticators who serve as Jeremiahs. The difficulty is the absence of a platform and an audience before whom their assessments can be given adequate and authroitative consideration in the light of long-range public policy. The President's Scientific Advisory Commission, the National Academy of Sciences and the National Academy of Engineering and similar organizations have acquired important though limited functions in providing authoritative reviews of expert thought.

In the last analysis, the problem is one of identifying the social significance in an assessment situation. At this stage the assessment is no longer solely a function of the expert but involves the values and objectives of the society and frequently the conflicting values and objectives of groups within the society. The problem is then one to be resolved through the political structure of society. In that process the role of the expert as advocate is no doubt necessary since he is most knowledgeable and most involved. As advocate, however, he presents special problems of credibility to the interested public, particularly since he frequently if not normally takes positions well beyond what can be documented by information generally accepted as true. Securing public acceptance of an action affecting its values and objectives is not difficult if there is a clear threat to life. In situations where the threat is a low statistical probability remote in time, securing

public action is far more difficult. It is with regard to such problems that the nation's information system is precariously ineffective. One approach might be a periodic, authoritative, public review of the nation's progress toward its scientific and technical goals including in those goals the protection of its hard-won achievements.

Footnotes

[1] Genesis, Chapter 3, v. 4-5, King James Version.

[2] As occurred in the case of the Salk vaccine, See House Committee on Science and Astronautics, 91st Congress, 1st session. Technical Information for Congress, A report by the Science Policy Research Division of the Legislative Service, 1969, p. 321.

[3] It is not suggested that the system is beyond criticism. For extensive criticism with reference to the evaluation of new drugs see U.S. Senate, 89th Congress, 2nd session, Committee on Government Operations, Interagency Drug Coordination, 1966, particularly 102-262.

[4] Arnold J. Toynbee, A Study of History, 6 vol. Oxford University Press, 1934. Unfortunately Toynbee's analysis pays scant attention to technological factors.

[5] These problems are surveyed and assessed in National Academy of Sciences, National Academy of Engineering, Scientific and Technical Communication, 1969.

[6] Philip Ritterbush writes: "The problems in environmental improvement at the federal government level should not be characterized as deriving from too little scientific knowledge, but from the failure to devise a suitable forum within which conflicting expert views could be reconciled and comprehensive program planning could be carried on...." op. cit. p. 112 in "Environment and Historical Paradox," General Systems, Yearbook of the Society for General Systems Research, XIII (1968) p. 112.

[7] At the present time, the reporting of the possible results of new and hoped for knowledge in genetics is markedly characterized by prophecy. See, e.g., Albert Rosenfeld, The Second Genesis, Prentice-Hall, 1969.

[8] A still useful analysis is Harold J. Laski, "The Limitations of the Expert," Harpers, 160, December 1950, pp. 101-110.

[9] Joseph Jastrow (ed.) The Story of Human Error, New York, 1936, makes for disquieting reading in this respect.

[10] The aphorism is attributed to Harold Laski by Paul H. Appleby, "Making Sense Out of Things in General," Public Administration Review, XXII, December 1962, p. 175.

[11] Note too that the serpent was severly punished by higher authority. Genesis, Chapter 3, v. 14-15.

[12] For one of many such, see Ashley Schiff, Fire and Water: Scientific Heresy in the Forest Service, Harvard University Press, 1962.

Discussion of ASSESSMENT INFORMATION SYSTEMS

The discussion centered on three general topics (the role of experts, the adequacy and destination of information, and the role of the public) and touched briefly on several others. As might have been expected, there was little consensus but a broad range of opinions was presented by the twenty-six discussants.

Role of the Expert:

The seminar participants differed on the extent to which reliance should be placed upon "experts" in obtaining the information necessary to perform assesments. The views ranged from those of a Congressional staff member who believed that only "specialists and experts" could solve the problems of technology assessment to those of others who indicated some reservations concerning the great dependence upon experts which seems to characterize assessments. A university professor was concerned with the fact that experts can, and often do, differ on matters of substance. "I'm sure," he stated, "that we've all seen a number of cases in which both sides have witnesses with expert credentials and yet come up with completely opposed views." A government official raised the problem of

> finding unbiased experts. It seems to me that the experts who are most capable of making technological assessments are liable to be in the employ of bureaus or companies that are interested in furthering technology.

This developmental bias of experts often makes it difficult to find technically competent opponents of a particular technological application.

In the words of another university professor:

> I suspect, today, that there are at least several areas of technology which are controversial, at least to the layman, with respect to which it is almost impossible to find an expert who will take the anti-technological point of view so that the negative view never gets articulated, whether it's sound or not.

One suggestion for overcoming the "biased expert" problem was provided by an agency representative who held that greater use of university scientists in an assessment role might overcome the predominant influence of development-minded industrial scientists. The problem of locating impartial experts was, in his words,

> one of the best arguments that I know of for us having a broad scale federal support of research in the universities and gathering up a lot of these functions (of obtaining information for assessment processes) within the free play of the intellectual market place in the academic sphere. There you do have the whole tradition of public disclosure and public discussion--in fact, the whole system works on the public nature of the exchange.

The universities are, in part, shielded from those market pressures which make it difficult, if not impossible, for industries or agencies to undertake candid and impartial assessments.

Some of the participants, including a university scientist, noted a serious communications problem that exists between technologists and non-technologists. There is a need, in the view of an agency official, to "vulgarize" technology ("and that meant in the best sense") in order to make it understandable, "if not to the man in the street, at least to the average Congressman." The use of the mass media was suggested as a means of increasing communications between the scientific and lay communities, though it was pointed out that journalists possess a vested interest in their quest for higher circulation which often leads to inaccuracy in the pursuit of sensation.

Part of the concern with the reliance on experts was based on the contention, presented by a government agency representative, that the experimental skills of scientists and engineers do not necessarily coincide with those skills necessary for identifying and analyzing the consequences of new or existing technologies. A university scientist disagreed and contended that, in fact, the experimental research outlook may give the best possible information for assessment purposes. Although one of those present attempted to minimize the problem of just who the experts are by holding that experts only make suggestions and recommendations and do not perform the actual assessment, another took issue with this point:

> I think that to the extent that we have technology assesment today, the assessment is made by experts. To the best of my knowledge there is no agency of the U.S. government today which assesses technology which does not have, on its staff a significant proportion of technologists or scientists.

While suggesting that experts "may have some competence to evaluate the risks" of a technology, the speaker, a university professor, doubted that technological experts have the competence "to determine, let alone qualify, the benefits." Perhaps, he added, a wider membership in the assessing group including social scientists and lawyers as well as scientists and engineers might lead to a more effective mechanism of assessment. "The process we are talking about," he concluded, "needs larger doses of common sense and smaller doses of expertise."

Adequacy and Destination of Information

Several participants questioned the adequacy of existing information about the consequences of technologies. One, a university researcher, believed that the prepared paper had been "overly optimistic" in its

implication that required information is either in hand or relatively easy to acquire. For both existing and on-going technologies, current sources of information are, in his opinion, not sufficient and

> there are serious conceptual problems in many cases as to how you would actually develop the information. I think in a lot of cases you would have to undertake extensive research programs to develop the kind of information you needed.

He expressed some concern with the fact that in most instances, we lack the institutions with the resources, responsibility, or incentive to generate the necessary information. An agency representative saw a need for greater specification and accuracy in the reporting of consequences of technological applications; a lack of such detailed reporting has hindered assessment processes greatly. It was noted that virtually all police reports of automobile accidents, for example, cite as the cause "excessive speed and drinking" because attributing an accident to such a cause is easier than performing detailed and complex studies to determine the actual cause. This kind of reporting for purposes of expediency rather than accuracy is prevalent and leads to the conclusion that statistics are not always a very meaningful source of information about the effects of technology.

But if information systems with reference to existing technologies are not satisfactory, what then then can be said of the performance of such systems in identifying the effects of new or developing technologies? This question was raised by a government official, but aside from noting the complexity of any effort to foresee future consequences, the participants declined to elaborate further and limited the remainder of the discussion to the "post-introduction" phase of technologies.

Several speakers raised the problem of determining what occurs within private industrial firms. This is quite an important matter since,

as was noted earlier, qualified experts in any given technological field are almost always employed by industrial concerns which are involved in the development of the technology. A Congressional aide noted the "tremendous difficulty of obtaining the highly essential information that is in the files of the large corporations" while emphasizing that "we've got to get very honest reporting from the private sector in order to know exactly what's going on in terms of possible dangers." Some new Senate bills, he indicated, may have the effect of opening up for public consideration some results of individual research.

The destination of any gathered information may play a large role in determining the type of information which is to be obtained. To one university professor, this is the "crucial question." After all, he claimed, when no mechanism or organization requires information, when can information be termed inadequate; "as long as nobody wants the information in any detail except for statisticians, any information is sufficient" regardless of how sparse it may be. It is only when an organization exists to examine the information that one can begin to be concerned with the adequacy of the information. The need for an opportunity to present information, to have a hearing, was repeated by several participants in the course of the session. "Whether or not the issues were accurate was not the point," stated one speaker in describing his personal difficulty in obtaining a hearing. "The point really was whether there really was an opportunity to discuss them?" Often, those who seek to obtain a hearing, he claimed, are resented and refused any opportunity to testify.

A mild dissent concerning the emphasis on information systems was presented by a government official. He made it quite clear that he believed that information, or even information systems, could not be considered in isolation; "When I consider the quest for information

systems to be used in this context, I have to ask myself: Information systems to what ultimate end?" He went on to decry what he termed a cult spawned by improved data collecting capability which seems to hold that better information handling alone is a solution to the technology assessment problem. This is a false view, he claimed.

> You could go on accumulating mountains of information about technological problems that go on and won't quit. The issue to me is--what are you going to do with it? Who, in the end, is going to organize the political power to translate the information into corrective action. I'm more interested in that end of the problem than I am, frankly, in accepting the presumption behind the argument for information systems because I think we can exhause a great deal of energy and resources with the best of intentions and yield very little [if we concentrate on information systems alone].

The point, he said, is that expert opinion, and even common sense, haven't produced effective action. (It may be noted that the remaining three seminars of the series are concerned with the use of information and its translation into action.)

Public Participation

The discussion turned to the question of public participation in the assessment process. In commenting on the prepared paper, an agency representative noted that it

> says very little at all about the extent of public participation in the technology assessment process. In our democratic society, the way we generate political pressure is to have the public involved and to have some real broad scale public interest. What we don't really seem to have is a way to match the expertise of our expert to the intellectual resources of the public. If we concentrate on something like a technology assessment agency that does not allow for public advocacy we really won't have gotten anywhere at all.

It was his view that technology assessment is performed almost secretly and outside the usual framework of the comocratic process. The situation can be corrected.

> I think that many of the things that we find to be very serious public problems that do not get adequately ventilated would be adequately ventilated if the recommendations of the scientific advisory apparatus were public and its documents freely available to the public.

The importance of television as an educator of the public was strongly emphasized by a Congressional aide.

To the suggestion that assessment proceedings be made public one participant expressed concern that "if the assessment process is too public, if all of the preliminary recommendations and suggestions and some of the wild ideas are publicized at the earliest stages, then you will deter the kind of candor and imagination you want to encourage" on the part of the assessors who might be leery of pursuing certain potentially fruitful lines of inquiry in the face of public disclosure of their efforts. He felt that it was necessary to strike a "fairly complicated balance... between making the final recommendations open and available for public scrutiny which is not always done and making every preliminary step in the assessment process available to the public."

Some of those present had reservations about the role of the public in assessment. An educator noted the characteristic tolerance of the American people toward technological change. "The man on the street," he stated, "will tolerate anything... in behalf of the advancement of technology." Unless some change in this prevalent attitude can be induced, the public will remain ineffective in producing meaningful action regardless of how well educated it is about the nature of the problem. But even if the public inertia could be overcome, the public

role might not become an effective one, at least in the view of one speaker. He believed that public involvement is important only in extreme cases. Smaller issues cannot excite the public interest and the majority of assessment problems fall in this category rather than in crisis class.

Other Considerations

The remainder of the discussion touched briefly on some miscellaneous points of interest to the participants. A Congressional aide and a professor expressed some concern with the fact that technology assessment seems to concentrate on the detrimental aspects of technologies. They asked for more perspective in noting the positive aspects of technological development. Another Congressional aide held that Congress does in fact, assess both benefits and risks and noted that "Senator Muskie and Congressman Daddario always use the word 'benefit' first and then they talk about hazards." Others felt that the problem of identifying benefits is not crucial to the assessment process. In the words of a university professor,

> In the very nature of things one can always assume that the benefits of technology will be more than adequately articulated because there are very powerful vested interests which want to articulate those benefits. The read problem is how you articulate the costs and the risks.

An agency official agreed and suggested that all new technological developments be subjected to energetic opposition for the purpose of exposing risks which are either unnoticed or neglected by proponents of the technology. (This argument is pursued further in the third

session of the seminar series in which the central concern is the adversary process in technology assessment.) Perhaps the position of many of those present was summed up by a Congressional aide who said of the consideration of risks and benefits that "the two go together - they always go together and they have to go together." Any assessment, to be complete, must consider both.

Two interesting and practical examples of the current state of information systems and assessment were discussed and deserve some note here. One of these concerned the setting, by the National Committee of Radiation Protection, of radiation exposure standards for workers in the atomic energy field. These workers are permitted to receive radiation doses ten times as large as those to which the general public may be exposed. The decision to set higher limits on allowable doses for industry personnel was arrived at without any consultation with the workers and it was predicted by one seminar participant that this desregard for ordinary collective bargaining procedures might lead to strikes in the nuclear industry.

The other example was the establishment and operation of the National Transportation Safety Board which is required by law to make its findings and recommendations available to industries and the public. The Board operates solely in the interest of the public and, in the view of one discussant, has been effective in inducing changes in the transportation industry through a combination of letters to offending industries and news releases which have notified and educated the public. There was some skepticism among other present over how the effectiveness of such an organization can be evaluated. However, it was suggested that despite the fact that the Board has no way to apply legal sanctions

to any safety offender, the letters and publicity had produced some changes in conditions in the interests of increased safety.

2: TECHNOLOGY ASSESSMENT AND THE CONGRESS

Richard A. Carpenter

This paper is designed to take advantage of the Seminar Series to elicit opinions from the participants on a particular question: the Legislative branch of government as the major focus for technology assessment. My thesis is that the Congress is the most important user of such information and that a bridge to assessment capabilities must be built. The details of its organization, activities and relationships to other agencies and the private sector are not yet developed. The thoughts expressed herein must, of course, be considered as personal opinions and not charged to the Legislative Reference Service or to any Member of Congress.

Having been involved in the development of technology assessment for some years, I am not hesitant about offering a definition, even though such an act entails risks of diversions into semantic nit picking.

Technology assessment is the process of identifying and studying consequences of the applications of science. The objective is to optimize the use of knowledge for the benefit of society -- to enable us to manage the affairs of a complex, technology based civilization. Consequences which are unintended, unanticipated, and unwanted are to be minimized. Assessment includes forecasting and prediction, retroactive evaluation, and current monitoring and analysis. Measurements involve non-economic, subjective values as well as direct, tangible quantifications.

In the United States, the combination system of free enterprise democracy is the vehicle for technological change, economic growth, and social progress. The market place continually weighs and balances costs

and benefits. The political process performs a similar function for governmental programs. Risk taking is accepted in America as necessary for private profits and public welfare gains.

In the past decade, a dramatic challenge to this method of operation has been recognized. A much more sophisticated view of technological change is required. The close interdependence of mankind and the natural environment is increased by the swelling world population. The social environment is sensitized to untoward effects by the concentration of people into cities. Hidden economic factors often outweigh obvious market values. New forces are available from the application of science which have the power for world-wide and long-term changes--often irreversible.

Thus, the development of a technology assessment capability is an urgent task, recently imposed on our economic and political systems by the exponential terms of the growth of population and science.

The harbingers of technology assessment include nuclear weapon testing, persistent pesticides, nonbiodegradable detergents, smog, thalidomide, automation, the computer revolution and so on. A hundred less spectacular events could be listed from many industrial and environmental situations. The rubric is broadening to include the often trivial concerns of consumer protection, the intricacies of a sea level Panama canal, the worldwide effects of fossil fuel combustion and the cosmic concerns of planetary contamination. All these questions boil down to a need to know more.

I would add a special aspect to technology assessment--that is, the positive value of knowing more about our actions. The alarms and restrictions can too easily become the dominant theme. In fact, assessment can have great value to commerce and to government in revealing

unknown benefits and providing confidence for decisions which otherwise would not have existed. Falsely based inhibitions can be just as bad for society as encountering undesirable consequences.

In summary, I see technology assessment as the final step in a long sequence which could be termed the socialization of science. In this sequence science has been apart from the mainstream of society for most of recorded history. Up until the end of the 19th century science had its own momentum and direction--asking virtually no support from its host culture and directly contributing little in return. Then, with the industrial revolution, agricultural engineering, and applied research in the early 1900's, and the military awakening to science in the two world wars, the relationship to society grew rapidly, Science promised and delivered. Society sponsored and glorified research without question.

This arrangement continued until the late 1950's when the governmental and corporate support of science reached such financial proportions that a return-on-investment analysis was inevitable. Most manufacturing organizations had erected research laboratories--for window dressing if nothing else. The Federal budget included $4 billion for military and atomic energy R&D in 1958. Adding the space program (with its strong basis in the goal of international prestige) the R&D budget rose to $14 billion in 1966 for the three agencies of DOD, AEC, and NASA. In fact 90% of the total government R&D support in the last decade was for these purposes. In this period--roughly 1956-1966--the concept of efficiency in the application of science emerged.

The R&D practitioner was asked to carefully plan and execute his science in return for generous support from society. The systems approach to projects was perfected. Invention was put on schedule. Spin-off

and fall-out benefits were extolled by NASA. The Department of Defense procured R&D performance on incentive fee contracts. As additional agencies perceived the ways in which science could help accomplish their missions, the public needs of pollution, transportation, crime, education, housing, etc. began to be served. The demand that science be relevant was accepted. The ability of any scientist--particularly the applied technologist--to work outside this requirement diminished.

Now we are entering a final phase. It is no longer enough that applied science be relevant. And so pervasive is science in this civilization that it is difficult to think of any irrelevant experimentation. But, through technology assessment, society is insisting on eating its cake and having it too. Only when the course of innovation has been studied out and the benefits are shown to outweigh the costs, is technological welcome. Each unwanted consequence must have its "technological fix," in Alvin Weinberg's term. Consumer protection replaces caveat emptor because it is beyond the ability of the buyer to beware. Technology assessment is an added responsibility of science, to be incorporated into the research-development-innovation-diffusion sequence at every stage. Assessment is not measured solely in technical parameters but the measurement is a duty of the managers of science.

Thus in 1963, in his memorable address to the National Academy of Science, President Kennedy said, "Everytime you scientists make a major invention, we politicians have to invent a new institution to cope with it." He mentioned specifically, "... our responsibility to control the effects of our own scientific experimentation. For as science investigates the natural environment, it also modifies it--and the modification may have incalculable consequences, for evil as well as good.... The Government has to clear responsibility to weigh the importance of large scale

experiments to the advance of knowledge to national security against the possibility of adverse and destructive effects.... As we begin to master the destructive potentialities of modern science, we move toward a new era in which science can fulfill its creative promise and help bring into existence the happiest society the world has ever known."

The responsibility to assess technology is recognized but assessment so far has been a haphazard affair, initiated by the Rachel Carsons and Ralph Naders or by episodic events such as oil slicks on beaches. These stimuli for assessment have been embarrassing to both the technical and political communities because the lack of control over applied science is dramatically demonstrated.

In this climate, the U.S. Congress found that its conventional sources of information were inadequate to the task of adding scientific and technical ingredients to the legislative decision-making process. Essentially, the function of the Congress is to integrate all the elements of national life, with their varying and often conflicting desires and the complex of social, legal, economic, political, and institutional values. The result is the formulation of national policy, and the setting of priorities and timetables via the three major activities of authorization, appropriation and overview. The success of the integration and compromise is judged directly by the people at the polls.

The Congress is not bound to programs during their execution and thus is in a position to critically evaluate the results as contrasted with the legislative intent. The fact that all of the House and about one third of the Senate Members stand for election every two years presents an opportunity for relatively rapid response to public opinion

compared to an administrative program which may go on for four or eight years and become entrenched in bureaucracy.

Information about science and technology is not present in the Congress in the most usual input form--i.e., the personal experience and training of Representatives and Senators. Few scientists and engineers have been elected from an active professional career and there is no sign the number will increase. Thus an information transfer process is more important in technical matters than in other areas of knowledge.

The Congress certainly does not lack for information. The openness of the legislative process provides a great variety and number of channels for facts and opinion. The public hearing is common to almost all legislative considerations.

The Federal agencies advocate and defend their programs in hearings, briefings, and continual liaison with the members and committees directly concerned. The Office of Science and Technology in the Executive Office of the President was established by reorganization plan specifically to coordinate executive branch R&D and to report to the Congress on science policy matters.

Special commissions are sometimes created by the Congress to examine a policy problem in depth. For example the National Water Commission, the National Commission on Technology, Automation and Economic Progress, and the Commission on Marine Science, Engineering and Resources are Congressionally constituted to report both to the President and to the Congress.

Industries and trade organizations often present testimony at hearings and carry on extensive information and lobbying activities when legislation

or government programs particularly affect their interests. Constituents and local businesses make specific inquiries to their representatives and carry opinions on R&D matters which have obvious political impact.

Universities and nonprofit institutions provide data and interpretive studies in the normal course of their activities.

Professional technical societies can be a most valuable source of advice and information for the Congress. In contrast to the other sources, the broad membership allows professional, rather than employment related views, to come to the surface. Their tax exempt status need not be jeopardized, nor are they required to register as lobbyists.[1] The simple conditions are that the Congressional liaison not be a major portion of their activities and that the Congress has invited their testimony.

The technical societies need not be expected to present a consensus view on issues--which might engender internal strife. Rather, they may provide a forum for discussion of science policy issues just as they have historically for the presentation of research results. This new opportunity for professional societies is well worth adding to the traditional functions of publication, national meetings, and education.

As the need for science information has become recognized, the legislators have erected a variety of transfer mechanisms and channels. Some members have personal science advisory committees. The political parties have organized scientists and engineers to assist them.

In the past few years, professional staffs of committees have been reinforced with persons of mature technical experience. Hearings and briefings are often purposefully arranged as adversary proceedings to present a variety of viewpoints. Ad hoc advisory panels are assembled

to deal with a particular subject or to provide general advice.

In 1963 and 1964, a number of studies and proposals were made relating to science advice for the Congress ranging from Nobel laureates in residence to a "think tank" organization. The Subcommittee on Science Research and Development (chaired by Mr. Daddario) of the House Committee on Science and Astronautics held hearings and issued a report, "Scientific-Technical Advice for Congress: Needs and Resources." [2] Bills to create a Congressional Office of Science and Technology were introduced in both Houses in the 88th Congress (S. 2036 and H.R. 8066). Another bill (H.R. 6866, 88th Congress, 1st session) sought to establish a small science advisory staff in each house.[3] The House Select Committee on Government Research conducted extensive studies on the methods by which Congress could improve its handling of federal science affairs.[4] Senator Clinton P. Anderson reviewed the difficulties of setting up a body of highly trained technicians solely responsible to Congress in an article in Science magazine.[5]

The conclusion of these deliberations was that a bridge between the Congress and the scientific community was preferable to an "in house" cadre of practicing scientists and engineers. The breadth of legislative problems and the rapid change of specific interests militated against retaining subject matter specialists as advisers. Instead, the need was correctly deduced for a new function to excise the scientific questions from legislative issues, to search the literature and minds of the scientific community for relevant answers, and to interpret and distill the pertinent information for easy use by the legislators.

The means of establishing the function was found close at hand. The Legislative Reference Service is a 53 year old organization with the Library of Congress. It is divided into 10 divisions which provide research and information on all fields of knowledge related to legislation. The staff numbers over 300 persons ranging from senior scholars to clerks who retrieve factual data. The specialists are thoroughly qualified and recognized in their academic fields, and, more importantly, they are skilled at interpreting and communicating technical information to the Congress.

LRS works only for the members and their committees and staffs. Projects are performed on a confidential basis and usually the resulting contributions in printed form do not indicate their origin in the Library. Partisan political influences are carefully avoided under the direction of the Joint Committee on the Library.

Into this existing organizational framework, the Congress introduced 8 new positions by appropriation action for fiscal year 1965, "to meet the increasing requests for service in the scientific and technological specialties." These positions were augmented with existing funds and organized as the Science Policy Research Division in October of 1964.

At present, SPRD comprises 10 senior professionals, 10 junior researchers and assistants, and 5 clerk-typists. The senior researchers have backgrounds in science and engineering which gives them a legitimate standing in the scientific community. Obviously not all disciplines can be covered by so small a staff, but choices are made to correspond to the principal issues at hand--i.e., space, transportation, environmental pollution, oceanography, etc.

In a typical year assignments will be handled for 50 different committees and subcommittees although the majority come from the House and Senate space committees and a few other technically oriented legislative panels. About 400 (of the 535) members will be served as individuals.

To be effective as a complete service organization, a reference function is also performed--several thousand inquiries are answered every year. This factual data retrieval has another purpose, however, in that it acquaints members with the division and often leads to policy studies. A research project may be initiated by the SPRD in anticipation of an issue likely to come before the Congress.

The objective of the Science Policy Research Division is an increased understanding by the members of Congress of the workings of science and engineering. Scholarship, or completeness of research, and objectivity, or the absence of advocacy, are the criteria of performance.

SPRD is a bridge to a diversity and plurality of information and opinion. It is not a primary source of knowledge. Nevertheless, the way in which the gathered facts are presented to the legislator often does impart a summary judgment, a responsibility which is carefully recognized and accepted.

Our experience to date is that Congress does not need advice and that judgments on technical matters must continue to be rendered within the conventional legislative process. It is not necessary or desirable for the Members to become technical experts. What many of them have become is sensitive to the capabilities and limitations of science and technology. As the NAS report "Applied Science and Technological

Progress" states:

> Congress should not attempt to second guess the experts on technical appraisals, but it does have the responsibility to convince itself that the experts have asked themselves the right questions.... In appraising the situation, it is important for Congress to listen to the skeptics as well as the enthusiasts, and to ask the enthusiasts to answer the arguments of the skeptics. Laymen can learn a great deal from the confrontation of experts even when they do not understand the details. Especially in applied science and technology, priorities and goals can be established only through a multidimensional interaction between scientists, technologists, public servants, and the general public. [6]

Thus, the critical need of the Congress is to acquire the capability for assuring that competent assessments are done in a timely manner, and for transferring assessment results into a form applicable to legislative decisions. Our technological problems are part of political problems with social, personal, and economic costs and benefits. The Congress is the political assessment body in our society and must have the output of technology assessments in order to do its job.

In operation, the Congressional technology assessment capability will initiate assessments, search out ongoing studies, structure hearings to bring about adversary views, monitor assessment functions in the executive agencies and the private sector, and assess the assessors. A relatively small group of professionals (generalists from a number of disciplines) plus a modest appropriation for contract studies will suffice. This capability may also include carrying out assessments when appropriate but a bridge to major efforts elsewhere is the primary intent. Since it is expected that technology assessment will become an integral part of scientific and engineering activity, the Congressional function will be a logical extension of the present work of the Science Policy Research Division.

The fact that applied science so permeates the entire fabric of society argues against a single assessment institution; and for the development of assessment mechanisms in a wide variety of government agencies, university and nonprofit organizations, and commercial firms.

The location of governmental technology assessment solely in the Executive branch would appear to generate impossible conflicts with the necessary promotion and championing of programs and the aggressive administration of the law. The Executive branch determines for its own purposes whether something is worth doing but the Congress determines whether this is good for the whole country. The establishment of a fourth (evaluative) branch of government as suggested by Golovin[7] may present an interesting alternative when fully developed. One objection, however, is that such a centralization would interfere with the necessity (in my mind) that assessment be a part of the innovative process wherever it goes on.

The case for a Congressional assessment capability is supported by the proceedings of a seminar held in September 1967.[8] Some of the conclusions from that discussion are:

1. Questions of concern to the Congress must be assessed to meet the legislative schedule, i.e., before decisions are made.

2. The Congress must be in a position to continuously challenge the Executive branch as to the consequences of its programs.

3. It is important that assessment proceed in an open forum stimulating wide public discussion. The Congress can provide such an environment.

4. The widest possible base of information and opinion must be accessible to assessment projects and the Congress could command this knowledge.

5. The Congress would be more attentive to assessment results if they were presented via a Congressionally chartered organization.

6. The Congress must be convinced that the experts have asked one another the right questions.

7. The political decisions affecting the future of technology rest with the Congress.

8. The Congress is sensitive and rapidly responsive to the people and is immediately accountable to the electorate.

9. The feeling that applied science is under control (through Congressionally monitored assessments) will restore public confidence necessary to a risk-taking progressive society.

10. The needs of the Congress for assessments results would assure that the necessary funds for these activities would be provided.

Footnotes

[1] "Scientific-Technical Advice for Congress - Needs and Sources," Committee on Science and Astronautics, U.S. House of Representatives, Aug. 10, 1964, p. 63.

[2] Ibid. Also "Government and Science." Hearings before the Subcommittee on Science and Research and Development of the Committee on Science and Astronautics, 88th Congress, 1st session. Oct. 15-Nov. 20, 1963.

[3] Hearings before the Subcommittee on Accounts of the Committee on House Administration, on HR 6866 and HR 8066, 88th Congress, 1st session. Dec. 4, 1963.

[4] Study Number X - Part II, Staff Resume of the Activities of the Select Committee on Government Research, U.S. House of Representatives, Feb. 18, 1965.

[5] "Science Advice for Congress," Science, April 3, 1964, pp. 29-32.

[6] Applied Science and Technological Progress, A Report to the Committee on Science and Astronautics, U.S. House of Representatives by the National Academy of Sciences, 1967, p. 11.

[7] The "Evaluative Function" in Government, Nicholas E. Golovin, Oct. 25, 1968.

[8] Technology Assessment Seminar, Proceedings before the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, Nineteenth Congress, 1st session, Setp. 21 and 22, 1967.

Discussion of TECHNOLOGY ASSESSMENT AND THE CONGRESS

Mr. Carpenter provided an extremely accurate introduction to the discussion when he noted that "this is a pretty provocative subject." In asking those present to indicate their opinions concerning the type of information Congress needs, he extended upon the remark in his paper that Congress does not need advice by commenting,

> What I should have added is that Congress obviously does not need or will not take advice on how to vote, even on fairly specific technical matters such as the accelerator at Weston or Mohole. Congress won't abdicate the final judgment in these matters and shouldn't. No one of these decisions is purely technical you can't separate the social, political, and economic aspects from the technological problem.

What is needed is reliable, complete and objective information. Perhaps the study of the Congressional role in technology assessment will lead to a search for new institutions that will enable us to "preserve a democratic pattern of decision-making and yet take full and optimum advantage of what is indeed a very technological world." Mr. Carpenter viewed the problem as that of providing a "bridge to Congress" which will make the greatest possible use of technological knowledge and on-going assessments in other sectors of the society.

Legislative Reference Service

The discussion of the Science Policy Research Division of the Legislative Reference Service of the Library of Congress which was included in the prepared paper was expanded by some of the participants. A Congressional aide wanted to make clear the fact that the LRS does not take an advocacy position but rather, in an impartial manner, lists the

questions of interest in any particular matter. Its study then provides the foundations for Congressional committee hearings. In view of comments made at the first seminar in this series concerning the role of experts in the assessment process, a university researcher wanted to know how the Science Policy Research Division of the LRS, which is made up of scientific specialists, avoids the "specialized expert" problem. It was pointed out that the LRS includes specialists in a wide range of fields and that the Science Policy Research Division has "many opportunities to use public administration people, political scientists, social scientists, and economists within LRS." A Congressional aide mentioned that the LRS has the authority to hire outside experts for specific purposes. The exercise of this authority leads, in his view, to a flexibility in the operation of the LRS which makes its studies particularly valuable. Further, it was re-emphasized that it was not the purpose of the LRS to make judgments; the hallmarks of the LRS, according to one of its staff, are "scholarship and objectivity." He explained:

> We try to get all the relevant opinion pulled out of the literature and pulled out of the minds of persons around the country.... We try to present it [the information obtained], interpret it, analyze it, and reduce it to a useful form in as objective a manner as possible and we use internal review and some external review to assure that our own prejudices and advocacies haven't slipped into the final product. Obviously, we do this successfully sometimes; not so, other times.

Congressional Committees and Hearings

The discussion turned to a consideration of Congressional hearings and almost immediately became highly animated. One participant, using the Joint Committee on Atomic Energy as an example, charged that some

Congressional committees deliberately prevent certain views from being heard. The difficulty, he contended, arises when the committee "predetermines the conclusion of the hearing; then it sets up the structure of witnesses that will justify the conclusion it predetermines." A professor agreed and added that the problem of obtaining a hearing is by no means limited to one or a few individuals but is, in fact, quite widespread. Even a Committee staff member agreed:

> You are quite correct when you say that many times a Committee will decide what they want to find out first and then flush out the points of view they want to use.

An agency official noted that the adversary process used in Committee hearings provides an opportunity to "stack the deck; it does seem to be very difficult to insure that in every case the adversary process will be an open one." A Congressional staff member took issue with these points of view; he believed that committees are fair and that they adopt a policy that anyone can be heard. This, he said, is made clear in the public announcement of hearings. Another Congressional aide noted that when all witnesses are not permitted to testify, the cause is often the limited time of Senators rather than bias. The strong differences of opinion among those present over the partiality or impartiality of hearings are perhaps best exemplified by this brief exchange:

Congressional Staff Member:

"We're fair. We don't shut people off."

Participant:

"Some of you must deal with a different Congress than I do."

The controversy continued when a speaker remarked that he regularly finds in the announcement of hearings a requirement for submission of a

statement in advance, before the committee decides who is to testify. He concluded that

> we need, in whatever the structure, an opportunity for both sides, or all sides, of the issue to be included, with the requirement that it all be made public.

But a Congressional aide answered that the requirement of prior submission of testimony exists because some statements are clearly "way out" and the product of quacks. He continued:

> We can't just let somebody come in with a statement. We have to, in some way, get some sort of perspective before we put on our witnesses.

Another Committee staff member pointed out that experience with the Joint Committee on Atomic Energy, which had provided most of the examples up to this point in the proceedings, cannot really be generalized. The JCAE is the only joint committee with legislative authority and as such is a special case. In general, he held, the bicameral system allows interested parties two opportunities to obtain a hearing and thus provides some protection against exclusion from the proceedings.

An agency official pointed to the proposed ABM system as an issue, outside the jurisdiction of the JCAE, on which it was difficult (at least until that time) for scientists opposed to the system to gain a hearing. The scientists, he said, feel that "they were excluded by the Committee counsel and that they were systematically disallowed from testifying." Another agency official objected to this example; he claimed that controversies over weapons systems cannot be considered as purely scientific questions. "When you talk about weapons systems, you're talking a different game," he said, to which a speaker replied, "I think we've got to stop that game. We're doing things more and more in the name of national defense."

A professor claimed that

> certain Congressional committees, and I would define these as being mission-oriented committees which have mission-oriented agencies as their clients, are every bit as "gung-ho" for technology as the executive sponsors of the program.

It is thus vitally important that all members of Congress (and the public, too), as well as those members of interested committees, receive information from such sources as the Legislative Reference Service. A speaker pointed out that it is not true that all committees demonstrate this pro-technological bias and cited the example of Representative Fountain's committee and its relations with NIH. As for providing information to all Congressmen, an LRS staff member noted that the reports of the LRS are available to any Congressman who desires them, and that distribution is thus not limited to the committees which request particular studies.

Adequacy of Advice

Interest then turned to the question of the type and adequacy of advice received by Congress. This topic had been discussed at the first session of the seminar with no real conclusion or consensus having been reached, and the conversation continued in a similar vein. The lack of agreement should probably be taken not as an indictment but rather as an indication of the difficulty inherent in the problem.

A professor posed the question:

> Will independent scientific study groups in different agencies using the same methodology and science come to the same conclusion [on any given issue]?

He went went on to answer that he, for one, believed that they will. Another participant agreed, but a third challenged this view. This speaker, a staff member of the LRS, felt that the nature of the body performing a

study played a large part in determining what information is used in the analysis (and thus in determining the conclusions). He presented the example of a Department of Agriculture/Forest Service study of fire prevention methods in which "a great deal of research was buried simply because it negated the whole function of the Forest Service." Thus, some bodies of fact are hard to find, "even for the LRS," he added.

There was some comment about the role of professional societies in technology assessment. One speaker contended that societies should take a more active part in the assessment process and another, an agency official, agreed, although he noted that "you are asking for a great deal in asking the professional societies to step outside their traditional role of being oriented just toward the futherance of their scientific discipline." A Congressional staff member thought that it was important to make a "distinction between those subjects which are within the competence of the people in the society and broad social questions." He believed that the American Physical Society, for example, ought not make policy statements on problems such as "poverty in the South." Decisions about the needs of society are in the province of Congress alone and not in that of the APS or anyone else. This topic has provoked much controversy within scientific societies, but for the purposes of this seminar session, the participants agreed that this brief discussion was sufficient.

An agency official thought that before anyone can really understand the type of "bridge to Congress" which would be most successful, it is necessary to "disaggregate the term technology assessment." He identified two kinds of assessments. The first involves an appraisal of effectiveness in achieving specific program objectives and the second involves

"looking at ecological consequences" of technological applications. He classified the two assessment processes as the examination of "sought consequences and unsought consequences." For example, if one were concerned with removing stains from clothing, one kind of assessment would consider whether a given product will in fact effectively remove the stains. The other would examine the overall consequences of using the product (water pollution, for instance). The two types of assessments are totally different, and it is quite likely that different assessment mechanisms are appropriate for each. A professor, however, claimed that "this is the situation we have now and that's why we're in such trouble." It is precisely because assessment is disjointed that problems exist. Thus, stain removers are, in fact, evaluated on the basis of how well they remove stains independent of the environmental effects which their use can produce. Another agency representative agreed with the first speaker; he re-emphasized the point that feasibility is a question of a different order than the "trade-offs" involved in comparing benefits and risks and that "if you don't make these distinctions and try to answer these questions in one fuzzy blur, you'll find that you can't answer them." All participants clearly felt that it was crucial to examine overall consequences of the use of technology; the point of contention, which was left unresolved, was whether conceptually disaggregating the assessment process helps in achieving a complete analysis or causes people to ignore important parts of the problem.

A New Generation of Engineers

Because at least some of the information which Congress needs to make decisions concerning technological applications must come from those who

are technically trained and competent, a professor suggested that in the long run

> what is needed is the creation of a new generation of engineers who are trained so that in the forward design of the systems that they are creating they build in certain retrievable values, so that when the system accomplishes its primary mission it has either a receptive value or can find some recoverable value.

He charged that engineers are trained irresponsibly. The very people who will eventually become contract administrators helping to decide which systems should be adopted to obtain certain ends are not currently taught to be aware of social values. It was noted that a prototype of the training system for the "new engineers" has been developed and currently operated at Stanford University. An agency official suggested that the "new generation of engineers" might be called "public policy engineers." But not everyone was enthusiastic about the concept of new systems for training engineers. The following exchange demonstrates the reaction of one participant to the creation of "new engineers":

> Congressional Staff Member:
>
> "They won't be engineers anymore if you do that."
>
> University Professor:
>
> "Change the word--it's semantics."
>
> Congressional Staff Member:
>
> "That's not true. If you take this thing too far, you end up with people who are not going to do the nuts and bolts of engineering anymore."

The current engineering profession was discussed by two other participants. A professor, noting that the engineering profession is the vehicle through which scientific advance leads to technological change, wanted a clarification of the meaning of engineering:

> I must confess that despite somewhat diligent inquiry into this, I've never been able to quite figure out what the concept of engineering embraces. Is it only concerned with affixing the nuts to the bolts, or is it, on the other hand, a profession? If it is a profession, are there any ethical considerations which are relevant to the manner in which engineers behave as they translate science into technology or are they, to put it bluntly, prostitutes?

No direct answer was forthcoming.

An industry representative contended that the current use of the word "engineer" in the sense of one who operates an engine was unfortunate. He said that the European usage in which the term means one who exercises his ingenuity for private or public good or destruction gives a better understanding of what an engineer really is.

The Public Interest

The most important aspect of technology assessment, according to one agency official is the attempt to take an "ecological viewpoint" or a "general systems viewpoint." "What human society is about is the public interest and not the interests of science or the interests of technology." This immediately provoked the comment that "there is a difficulty in defining what the public interest is." Several participants volunteered to try to devise a definition. One, an agency official, thought that Congress decides the public interest through its actions. Another speaker defined the public interest as "opposition to any increment toward destroying the human race." Still another felt that questions about whether decisions are made in the public interest are "silly... --a democracy the most that you have to do is make the facts available to the public." If the public chooses not to take effective action based on the facts, then the government can do nothing. That is,

the government should not provide protection to the public if the public does not want it. (This point is further elaborated in the paper presented at the third session of the series.)

Need for Supplementary Institutions

To one participant, the primary question to be addressed is: "How do you organize social criticism effectively so as to affect public policy?" Organized social criticism can be quite potent in producing action; President Johnson, for example, was "brought down by the operation of intense... social criticism which affected institutions all through the society." With respect to technology assessment, one must determine how social criticism may be organized in the appraisal process. What type of organization will bring out the development of beneficial technologies without taking risks but also without destroying the confidence of entrepreneurs? The speaker pointed out that:

> The problem becomes one of looking at your institutions. We can talk all night about improving what we've got--like a new generation of engineers--which I don't have any fight with, except that I won't be around by the time it is produced and in the meantime God knows what will happen. It seems to me that the effective way to proceed is by developing supplementary institutions with the idea in mind that they will not just be made up of engineers or scientists but will be multi-disciplinary.

He proposed an independent institute of technology assessment. The independence of such an institute would allow it to avoid one of the problems this speaker sees in the operation of the Legislative Reference Service.

> What I suspect is part of the difficulty of the LRS is that... much of its traffic consists

> of being responsive to questions on which answers are wanted tomorrow. To remove the mechanism from the consequences of erratic and random demand would be a constructive thing.

An independent institute could provide a public, as well as a legislative, service. Financed by Congressional charter or by an endowment, the institution would serve as an independent voice of "exposure, disclosure, criticism, prediction, and early warning."

When asked by a Congressional aide, "Who would listen?", the institute's proponent admitted that he could not answer that question and that the question was one which "troubles me very much, because I think it says a great deal about the quality of intelligence in the society, and maybe we deserve it." A congressional staff member asked why the National Academy of Sciences and the National Academy of Engineering could not serve the purpose of the proposed institute. The answer was that these are membership organizations and, as such, have a corporate role which is not necessarily consistent with the goals of a technology assessment institute. An agency representative thought that the suggested institute already exists in the universities, but it was pointed out by a Congressional aide that university efforts are fragmented. It was further noted that, at least at present, the university is not publicly recognized as the institution which fits this particular problem. One professor commented that the proposed assessment organization was "the institutionalization of the Rachel Carsons and the Ralph Naders," but he was assured that the intent of the technology assessment institute was not the "construction of an asylum."

Most of those present agreed that the proposed institute would be a positive step toward the improvement of the technology assessment process,

but there were some questions concerning the mechanism whereby such an institute could report its findings. One participant, for instance, was concerned with "how this information generating capability, from wherever it comes, gets introduced into the political decision-making process." But, he continued:

> It seems to me that one usefulness of an institution [such as the one just described] would be that it might well create a national constituency against the kind of politics that we are accustomed to which could help in the decision-making process.

The problem of the "bridge to Congress" still exists, in his view, and he concluded that:

> Our decisions are made through representative government and it's likely to remain that we will be making decisions through representative government. Therefore, the linkage which Dick [Carpenter] proposes is still an important one.

3: THE ADVERSARY PROCESS IN TECHNOLOGY ASSESSMENT

Harold P. Green

My purpose in this paper is to show the importance of introducing an adversary process into the technology assessment mechanism in order to assure that the assessment function will properly and effectively protect the public interest.

At the outset, let me define my terms. When I speak of an adversary process I am not suggesting a formal adjudicatory process in which opposing parties contend through legal mouthpieces with a decision made on the record. Rather, I suggest only that a mechanism be developed which will permit and facilitate the articulation in public of all relevant facts, pro and con. And when I speak of technology assessment, I do not encompass the assessment of the full potential range of the social consequences of a technology. Rather, in this paper I am concerned about technology assessment solely from the standpoint of identifying and controlling those attributes of a technology which adversely affect basic individual rights which have traditionally been protected by the legal system, i.e., specifically those incidents of a technology which may threaten the health, safety, and security of the public. I believe, incidentally, that this aspect of technology on which I am focusing is its principal element and the very raison d'etre for the present public discussion of technology assessment.

Most of the discussion of technology assessment which has taken place to date has assumed the need for a new governmental assessment institution which would identify and quantify the benefits, costs, and risks of

technology, then strike a balance among these factors, and pass on its conclusions and recommendations in predigested form to Congress as a predicate for legislative action. This approach is reflected in Congressman Daddario's bill and was followed in Mr. Carpenter's paper last month. Mr. Carpenter's view was that Congress as the political assessment body in our society must have the output of technology assessment bodies in order to do its job properly. I have no serious objection to this approach. Subject to my concern that Congress already is the recipient of more information than it needs and can handle effectively, even with the aid of computers, I have no doubt that Congress will inevitably benefit from receipt of the balanced, objective views of any responsible body. But I do believe that this approach is not adequate, would not be effective, and is in derogation of the appropriate role of Congress and the public in policy formulation.

The assessment function is properly concerned with balancing the benefits of a technology to the public against its costs (including risks) to the public and emerging with a conclusion as to what government's role with respect to that technology should be. Unfortunately the benefits and costs (including risks) do not fall upon all segments and members of the public correlatively. There is, I suppose, a high degree of correlation if we are talking about lawn mower technology; but if we are talking about detergents, pesticides, or the supersonic transport plane, it is clear that those who enjoy the benefits of these technologies will not necessarily be the same persons, or in appropriate degree, as those on whom the costs (including risks) will fall.

Since the issue is one of benefits to the public versus costs (including risks) to the public, the focus of technology assessment should be to arrive at a conclusion as to what costs (including risks) the public is prepapared to assume in exchange for what benefits. In our democracy, such decisions cannot appropriately be made by an elite body of specialists and generalists (who are specialists in technology assessment). They should be made by the public itself expressing its views through its elected representatives in the Congress who are accountable to their constituents. This requires that the entire assessment process take place in the open with full articulation in language the public can understand of the benefits and costs (including risks). In short, I do not agree with Mr. Carpenter that there is any viable distinction between political assessment and technology assessment. Technology assessment is not an appropriate function for experts; rather it is a process which should be performed entirely at the political level. Those who question whether the public and the Congress have the competence to make the necessary sound assessments express a lack of faith in the democratic process to cope with modern and future technology, and if we act on the basis of such lack of faith we have a different ball game. In my view, the basic problem is to compel scientists and technologists to present the issues to the public in the language of ordinary public discourse rather than in the esoteric jargon of their disciplines, and if this is done I have no doubt as to the efficacy of the democratic process.[1]

Most public discussion upon technology assessment to this date has ignored a fundamental point. There is never any lack of articulation of the benefits of a technology. Every technology has powerful vested interests--

private and frequently governmental and political--who can be relied upon to press the benefits to the technology assessors. The problem is that the negative factors and the risks are never fully or even adequately articulated. The inability of the negative factors to surface effectively is attributable to a variety of circumstances. In some cases the risks are totally unappreciated until a later date; in other cases, there may be an appreciation of possible risks which have not yet been demonstrated to be real. The proponents of the technology may always be counted upon to minimize or suppress the risks. Although the proponents are usually well organized and well-financed in their articulation of the benefits, those who seek to advance the negative factors tend to be rather disorganized and to lack resources. Not infrequently--particularly in the case of government-sponsored technologies--it is difficult for the opponents to obtain relevant and adequate information about risks, and even more difficult, because the experts who are privy to the relevant information are usually pro-technology, to obtain experts to assist them in formulation of their contentions. The natural consequence is that the opposition is forced to state its case using information which is incomplete or not wholly accurate, and, therefore, is easily discredited. Frequently the establishment seeks to discredit the opposition ad hominem, and this exacerbates the situation forcing the opposition to take an extreme position which makes it even easier for the proponents to discredit their contentions on their merits.[2]

The basic problem of building an assessment institution is, therefore, to provide a means whereby the negative factors, particularly the risks, will be vigorously, effectively and responsibly pressed upon the decision

makers in a manner which will permit the Congress to make its own judgements and which will permit the public to make its own judgements so that its views will become known to the Congress. In a nutshell, the problem is to give equal time, opportunity, and attention to the negative factors.

It is in this respect that I think Congressman Daddario's initial proposal for creation of a Technology Assessment Board is deficient. The Board's findings, conclusions, and recommendations ex cathedra will not reflect what the public wants and what the public fears. The very expertness and authority of the Board will detract from public discussion and debate. I have the same concern about Mr. Carpenter's proposal. In both cases, incicentally, the suggested technology outputs will not be considered by the Congress in isolation. Congress and the public will still be faced with a barrage of propaganda from the technology's proponents, and we may be certain that they will attack and seek to minimize the negative considerations brought to light in the course of these assessment processes.

These considerations lead me to the conclusion that what is needed for the technology assessment function is an agency which would act as a responsible devil's advocate or technological ombudsman and play the role of adversary in the Congressional and public forums. This should be an agency charged solely with the function and responsibility to probe for the negative factors, to identify these factors, and to press them vigorously upon the Congress and the public. The agency should be either an agency totally independent of the government or one which, like the General Accounting Office, functions as a part of the Congress. As between these alternatives, my preference is for the latter, since the agency should have the right to

have full access to all relevant information within the control of the government.[3]

In discussing the manner in which such an agency would operate, it is necessary to distinguish between two classes of technology. On the one hand, there is technology which is essentially private and which is developed and introduced primarily as a consequence of private, profit-seeking investment. With respect to such technology, government's role is typically passive until problems arise which require the government to take action in the public interest. On the other hand, there is another class of technology which is developed primarily as a consequence of government investment. In this case, government has a strong affirmative interest in development of the technology and also in its subsequent practical application.

In the first of these cases, the market place operates as a continuous technology assessment mechanism. A technology will not be developed or introduced unless its sponsor senses that there will be a profitable return on investment. The price that buyers are willing to pay reflects their assessment of the hazards which may be incident to the technology's products.[4] Both the sponsors of the technology and its customer-users also assess the potential costs to them which may result from liability to others arising out of such hazards. Liability itself results from an assessment process by the courts since the social utility of the activity producing the injury to the plaintiff is frequently weighed (sometimes explicitly) against the deterrent effects of imposing liability.[5] The estimated costs of potential liability may be a deterrent to one who considers developing and introducing

a technology or using a technology or its products. Liability insurance, which pools like risks and translates uncertain potential liability into fixed periodic premiums serves to offset this deterrent, but if adequate insurance is not available or is available only at prohibitively expensive rates, the deterrent remains.[6] These private assessment mechanisms involve a mix of incentives and deterrents which operate as people pursue their own self-interest. These mechanisms flash a green light or a red light which serves to control the rate of development and introduction of technology. It is only when the green light has been flashed as a signal for introduction of a technology that the problem of technology assessment passes into the hands of governmental institutions. Even after the technology has been introduced, government assessment does not occur until problems arise which seem to warrant governmental action.

The initial step in governmental technology assessment occurs when the legislature considers these problems to determine whether social control is required to protect the public against the technology's hazards and, if so, the form such controls should take. The mere existence of obvious problems does not mean that the legislature will act. The legislative process involves considerable inertia and is at best an uncertain and lengthy affair as the proponents of social controls battle the vested interests who stubbornly resist control.[7] Typically, the legislative struggle involves two issues: (1) are there hazards which justify social control? and (2) will the form of social control stifle the technology and deprive the public of its benefits? Where legislation results, it represents the striking of what the legislature believes is an appropriate balance between benefits and risks.

In many cases the social controls are implemented under statutory standards by an administrative agency. The agency's sole function in this respect is to protect the public interest under the statutory standards. These standards usually reflect the legislature's conclusion that the technology is useful and beneficial and should be controlled in such a manner as to preserve its benefits. As the administrative agency functions, it is required to assess the impact of its proposed regulatory actions in terms of benefit and risk. Because its institutional bias is in the direction of protecting the public interest, the regulatory agency generally functions as an adversary of the industry it regulates; i.e., its normal functioning imposes social controls, at the expense of increasing costs and reducing benefits, in order to maximize protection of the public against the industry's hazards.

We have then in this case an existing structure for governmental technology assessment. Obviously, it does not work perfectly. Legislative judgements are often inappropriately biased or otherwise unsound. Administrative agencies make mistakes and, as students of the administrative process have long recognized, they tend to develop unwholesome affinities to the industries they regulate and may become in effect their captives. Such deficiencies are inherent in the political and administrative process and are subject to corrective action if the public is aroused. On the other hand, a more difficult problem is raised by the fact that the assessment institutions frequently lack sufficient information and knowledge to function with optimum effectiveness. These institutions and the public frequently do not become aware of hazardous conditions associated with a

technology at a sufficiently early date, until after considerable harm has occurred and strongly entrenched vested interests have come into being. What is needed is an early warning system to trigger public and political awareness of potential hazards at a much earlier time.

The type of devil's advocate agency I have suggested is ideally suited to overcome these deficiencies. Its functions would include that of identifying possible hazards and ascertaining the extent to which they are real hazards. The agency would identify areas in which regulatory bodies should prudently force the technology to slow down and areas in which further research may be necessary. Hazards and potential hazards, when these are identified, would be vigorously publicized and pressed upon the Congress and the cognizant government agencies. Congressional inertia would be subject to the pressures of public opinion; foot-dragging by the administrative agencies would become more visible and subject to correction. A more substantial burden of proof would be thrust upon the sponsors of the technology. I do not suggest that this approach will result in a perfect technology assessment function. In a democracy, one cannot seek or expect a perfect solution to every problem; one can ask and expect only that the facts will be made known so that political forces can operate to produce the solution the public demands.

The second case,[8] that of government-sponsored technology, is quite different. These technologies develop with government investment which is in no way related to the forces of the market place; indeed they develop in defiance of the market since government investment is made for the very reason that the market does not provide incentives for development of the

technology on the time scale government believes is necessary. Thus the "deep pocket' of the government supports technology development merely because desirable benefits are foreseen even though there are no market incentives, while none of the restraints and deterrents which are present with respect to privately developed technologies are operative in this case.

It is apparent, moreover, that as the technology is assessed at various points (usually in connection with authorization of the program and appropriation of funds[9]) as it passes from the hands of the specialists-sponsors within the agency through the less specialized offices in the higher echelons of the Executive Branch to the generalists in the Congress, there is a natural tendency to minimize the existence and significance of any potential hazards associated with the technology. I do not mean to suggest that hazards are callously ignored. On the contrary, they are usually carefully explored and considered by the sponsors of the technological development. But the existence of even substantial potential hazards rarely chills the enthusiasm of the mission-oriented agencies who are eager to demonstrate that what is possible is feasible and will bring immense benefits to the public. Hazards and risks are characteristically rationalized away. The rationalizations take one or more of the following forms: (1) The hazards are not as serious as might appear; at least there has been no demonstration that they will indeed be harmful. (2) Even if there may be some hazard or inconvenience to the public, this may be "tolerable" or "acceptable" in view of the enormous benefits the public will receive from use of the technology. (3) We are conducting research to learn more about the potential hazards and research and development to provide a technological fix to

eliminate or reduce the hazards. (4) In any event, there is no need to worry about possible adverse consequences of the technology until its feasibiliby has been established. (5) Obviously, the government will permit use of the technology only subject to appropriate controls to assure that the public will not be injured, and if such controls are not adequate to protect the public, government will not permit use of the technology. QED.

One need only consider the history of government development of such technologies as atomic energy,[10] weather modification, the supersonic transport plane, and various military technologies such as biological and chemical agents to appreciate that existence of very substantial hazards has not deterred development of such technologies because of precisely such rationalizations. It is clear, moreover, that such rationalizations have been accepted at the higher levels of technology assessment, i.e., the Executive Offices, the cognizant congressional committees, and the Congress. The impulse to convert science into technology which will be of benefit to society seems to be irresistible at every level. In part, at least, this may be attributable to the fact that information about the adverse consequences reaches the higher and more generalized areas of technology assessment, if at all, in a highly distilled form which does not facilitate discussion and debate.

Although we do not have too much experience, outside of the military and space areas, with the processes through which government developed technology is introduced into practical application, some generalizations are possible. It seems inherent in the American governmental and political

process that government will have an irresistible impulse to see technologies developed by it put to practical use. For one thing, bureaucrats and politicians cannot lightly contemplate the prospect of having spent tens or hundreds of millions of dollars on a project which turns out to be a white elephant in the form of a feasible but unusable technology. Can it be doubted that weather modification will be practiced when the technology is developed even though interests of a substantial number of people will be substantially and adversely affected? Or that the supersonic transport plane, when and if finally developed, will eventually be permitted to fly in a manner which will result in effects which many members of the public regard as intolerable? Again, I do not want to be read as suggesting that government callously will foist hazardous technologies upon the public. There is really no such thing as a clear-cut dichotomy between "safe" and "hazardous". This is an area in which there is no black and white. Whether or not something is appropriately safe or unduly hazardous is an issue which lies in a gray area and the resolution of which is essentially a matter of judgement on which reasonable men can differ depending upon their outlook and biases. All that I suggest is that those who have a vested interest in a technology will inevitably be more relaxed about hazards than those who don't give a damn about the technology but who are primarily concerned with the public safety.

We do have substantial experience in one area which is instructive. The government has for many years sponsored and promoted the development of nuclear power technology, and has supported, subsidized, and promoted the introduction of the technology by private enterprise. This has taken

place despite the fact that the public will be exposed to very small increments of man-made radiation which, although never demonstrated to have resulted in manifest injury, are clearly regarded as at least undesirable.[11] The public is also called upon to assume the "exceedingly remote possibility" of a nuclear power reactor accident which could cause damages to health, life, and property of enormously catastrophic consequences, dwarfing by many orders of magnitude any other conceivable catastrophe which might result from a man-made cause. Protection of the health and safety of the public rests with a regulatory scheme which places reliances on "engineered safeguards", but, as we all know, man's engineering genius is far from infallible.[12] To further press this point, when the market place flashed a red light which would definitely deter private investment in the technology because of the enormous potential public liability (for which adequate insurance coverage was not available) in the event of an accident, government's response was to enact the Price-Anderson Act to remove this "roadblock." That Act superimposes upon $82 million of private liability insurance protection (the maximum available) a government indemnity of $500 million and cuts off any further public liability in excess of $582 million.[13] This completely eliminates potential liability as a deterrent, since it is not possible that any firm could sustain one penny's worth of liability out of its own pocket. And, finally, it is candidly admitted that the AEC regulatory program

> ...exerts all effort which could reasonably be expected to insure that there is no undue hazard to the public health and safety <u>while at the same time no crippling obstacle is placed in the way of development of [the] industry</u> . . . . (Emphasis added.) 14

There is, I believe, substantial reason to believe that the general pattern will be to entrust regulation of new government-sponsored technologies to the agencies which developed them and have an interest in their application.[15] Let me add, however, that I do not think separation of promotion and regulation into two separate agencies would be a panacea. There is also reason to believe that expert bodies, rather than the public itself, will make the decision as to what risks the public will be required to assume in exchange for what benefits. Experts will decide on how much sonic boom the public can stand; how much radiation it can tolerate in exchange for what benefits; when it should rain, shine, blow or snow in the public interest; what kinds of children the genetic engineers should produce to further policy objectives; etc.

I believe the only effective mechanism for protecting the public against the onslaught of new government-sponsored technologies is the type of devil's advocate mechanism I have proposed. Indeed, such a mechanism is much more necessary in this case of government-sponsored technology because it is the only effective means for building restraints and deterrents into the system. Such an agency would give the public a full opportunity to determine whether it wants the government to develop a new technology which involves potential risks and, if so, the conditions under which development should occur. It would force full consideration of potential hazards upon the government at the developmental stage; and it would compel regulatory agencies to give greater weight to the public health, safety, and security than they do to the benefits of the technology. I cannot conceive of any other technology assessment approach which would not involve the

cost of significant loss of democratic freedom in permitting an elite group of experts to determine the extent to which individual rights will be subordinated to the expert's conception of the public welfare in the name of technological progress.

Let me try to recapitulate very briefly. I am distrustful of the experts. Scientists and engineers have a bias in favor of accomplishing what they think can be accomplished. Their assumption that the problem of effective social control will take care of itself at an appropriate time is politically invalid. In a government whose executive and legislative branches are committed to achieving the benefits of science and technology, excessive reliance is placed on the judgments of experts because of the unfounded myth that ordinary mortals are incapable of understanding the issues. What is necessary is that there be injected into the assessment process a clear and vigorous articulation of the negative factors in language comprehensible to the layman. This will compel the proponents of the technology to present their case in similar language, and the decisions will be made in the rough and tumble of the ordinary political process.

I am fully aware of the principal argument which will be made in opposition to this proposal. It will run as follows. If the negative factors are presented to the public, to the Congress, and to administrative agencies vigorously and in an unbalanced manner, undue apprehension will develop because the recipients of this information will not be able adequately to evaluate the negative factors and place them in perspective. As a consequence, scientific and technological advance will be unduly retarded.

My answer to this is two-fold. First, the proponents of the technology

have greater resources and at least equal access to the eyes and ears of the public, the Congress, and the administrative agencies. Secondly, I can conceive of no reason why the public in a democracy should be forced to accept benefits it does not want, whatever the reason, rational or irrational.

Footnotes

[1] This point was effectively made by Harold L. Price, the Director of Regulation of the Atomic Energy Commission, in 1961. Responding to criticisms of the major role played by lawyers in the AEC's regulatory and licensing program, Price, a lawyer, said:

> These questions are not deep scientific questions that can only be resolved back in somebody's laboratory. Sure, we need and could not move without the help of competent technical people, and we get that help. We who are not technically trained cannot determine the calculations, and we cannot determine what the technical safety question is, and, therefore, what the risk is. But once that has been identified to us, you and we and anybody with reasonable training can make a commonsense judgement as to whether the risk is acceptable or not.

[2] This phenomenon is manifest in the flouridation controversy. For an example of the manner in which the establishment treated one dissenter who was permitted to testify before the Joint Committee on Atomic Energy in 1965, see Hearings before the Joint Committee on Atomic Energy on Proposed Extension of AEC Indemnity Legislation, 89th Cong. 1st Sess. 155-76.

[3] Special procedures would, of course, be necessary where classified information is involved.

[4] The demand side of the market will indicate the extent to which buyers will pay a particular price for a product with hazards; the extent to which they will pay a higher price for the product with more safety built in; and the extent to which they may accept the hazards at a lower price.

[5] For example, in 1931 the Wisconsin Supreme Court decided that a careful driver who splashes muddy water on a pedestrian on a rainy day should not be held liable to the pedestrian. The court balanced the benefits against the risks: "The benefit of allowing people to travel under such circumstances so far outweighs the probable injuries to bystanders that such conduct is not disapproved." Osborne v. Montgomery, 203 Wis. 233, 234 NW 372 (1931). This type of balancing operation is performed without pretense of nice mathematical precision. Rather, it is a gross process based on the informed and experienced judgement of judges who reflect community values.

[6] There is little direct evidence to support this proposition because, since a new technology when introduced is usually closely based upon and related to previous experience, insurance is generally available at reasonable rates. In the case of nuclear power, however, when the new technology represented a quantum jump over previous experience and previous levels of potential public liability, adequate liability insurance was not available at any price, and it is clear that there would have been no private investment in nuclear power in the absence of alternative arrangements to eliminate the threat of substantial uninsured liability. See infra.

[7] Admiral Rickover has described the pattern as follows: "Warnings of scientists are rejected as 'unproven' or 'exaggerated.' Later . . . the argument shifts to an attack on the legitimacy of any kind of protective legislation. Such legislation would violate basic liberties, it is claimed; it would establish government tyranny and subvert free democratic institutions. If all this is futile and legislation is imminent, there will be urgent demands that it be postponed until 'more research' can be undertaken to establish the appositiveness of the proposed law." A Humanistic Technology, address before the British Association for the Advancement of Science, London, Oct. 27, 1965.

[8] There is also an intermediate case--private development of a technology where related government-sponsored work makes a substantial contribution. The government contribution operates as a subsidy, tending to cause the market to flash a green light for development and introduction of the technology at an earlier date. The principal effect will be that adverse effects will be felt by more people to a greater extent at an earlier date, thereby heightening the need for effective governmental technology assessment.

[9] It is characteristic of most government-sponsored technology that assessments take place in the context of consideration or a relatively small line item in a large budget or money bill. Only rarely is the assessment made in terms of consideration of an isolated public policy issue on which full attention can be focused.

[10] I use atomic energy as my principal example in this portion of the paper. I do so because it is the most advanced of the government-sponsored technologies with an immediate impact on the public, and because there is more relevant information available as to the benefits and risks than for any other government-sponsored technology. I believe, however, that the atomic energy experience is typical of the manner in which other government-sponsored technologies have been and will be assessed.

[11] There is no evidence that exposure to low levels of radiation have produced manifest somatic injury; nor is there any evidence that there is a threshhold of exposure below which no somatic injury will occur. It is, however, generally accepted that any radiation exposure produces undesirable genetic mutations. These considerations lead to the general rule enunciated by the Federal Radiation Council that "there should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure." In actual practice, the amounts of industrial radiation to which workers and the public may be exposed are established by the National Committee on Radiation Projection on what is candidly stated to be a "philosophy of risk" or "calculated risk" basis as they assess benefits and risks. Despite the fact that the Chairman of the NCRP has stated that the setting of radiation protection standards is not "basically a scientific problem . . . . It is more a matter of philosophy, of morality, and of sheer wisdom," the people involved in the NCRP's standards-setting function are all specialists in the relevant scientific disciplines.

[12] Because the technology is new and leapfrogs experience, the engineered safeguards have little basis in experience and reflect primarily the predictions of experts that they will be effective.

[13] A 1956 Brookhaven National Laboratories report estimated, on pessimistic assumptions, that a serious power reactor accident might cause as much as $7 billion property damage in addition to substantial personal injury and loss of life. A more recent study, the details of which have been suppressed, led to the conclusion, as stated by the AEC Chairman, that because of additional experience the chances of such an accident are even more exceedingly remote, but because more recent power reactors are larger and are located closer to population centers, the damages that might result could be even more substantial.

[14] Report to the AEC by the Regulatory Review Panel, July 14, 1965.

[15] The difference in approach between the typical administrative agency concerned only with the protection of the public interest and the new-fangled agencies which try to mix protection of the public interest with promotion of technology is vividly illustrated by the example of radiation preservation of food. For many years the atomic energy establishment has been developing a technology for using radiation to preserve and sterilize food. It believes the technology is now ripe for practical use by food processors, and it is clear that if AEC had regulatory jurisdiction the technology would now be used. Through a fluke in the law, however, radiation is a "chemical food additive" subject to regulation by the Food and Drug Administration. The FDA has reduced the atomic energy establishment to a state of petulant

frustration by rejecting its claim that irradiation of food should be permitted because it has been tested with no indications that irradiated foods are harmful; the proper test, FDA insists, is that there be a demonstration that it is safe.

Discussion of THE ADVERSARY PROCESS IN TECHNOLOGY ASSESSMENT

Professor Green began the discussion with a review of the basic premises from which his argument proceeds. In his view, discussions of technology assessment tend to be imprecise because of a failure to separate distinct aspects of the problem before seeking solutions. One of the primary distinctions which must be made is that which exists between private technologies and the methods necessary for adequate assessment of such technologies on the one hand and government-sponsored technology and its assessment system on the other.

Of the two, Dr. Green is less worried about assessment of private technologies. For such technologies "at the most basic level we find that the marketplace provides a set of restraints which in themselves operate as a form of technology assessment. I think it is clear that the system works because there are competing interests involved; buyers and sellers have their own self-interests." One element of the assessment system for private interests is the high degree of individual responsibility for hazards which is imposed by the legal system through liability provisions. This compels a great deal of thought and analysis on the part of the developer of a technology before he is willing to embark on a new project. On top of the marketplace, a system of governmental assessment affects the private developer; "legislative and regulatory processes are, in a very real sense, a technology assessment." Government regulation involves a high

degree of the adversary process. Dr Green noted that

> . . . the Administrative agency which is entrusted with regulatory responsibility really doesn't function properly unless it is, in a very real sense, an adversary. It is an adversary in most cases because it is charged with the single responsibility of pursuing the public interest . . . as opposed to the private interest in exploiting and using a particular technology.

Thus, in the case of privately-pursued technologies, mechanisms exist for effective assessment. Of course, these private and governmental institutions of assessment do not always function adequately. For the market system to operate with full effectiveness as an assessment mechanism there must be adequate knowledge on the part of the parties involved. That knowledge must be available before the effects of the technology are strongly felt. These conditions are not always met because of the difficulty of establishing a clear causal relationship between hazards and results. As for the governmental assessment, it is often ineffective due to "inertia and stagnation on the part of both legislative and regulatory bodies."

The problems of government-sponsored technologies are, in the speaker's view, more acute than those of the private sector. For one thing, government technology develops much more rapidly and this means that "to the extent that the technology is hazardous more people suffer more injury before it is possible to take effective action" to restrain the technology. No real restraints exist other than what Dr. Green characterizes as "self-restraint." Decisions to proceed are made on a calculated risk basis with determinations as to acceptable risk made "largely on the basis of judgements by scientists."

It is taken as axiomatic that benefits of technologies are always

adequately articulated. It is the purpose of the technology assessment mechanism proposed in the paper to correct this imbalance by "ferreting out the risks." The mechanism would also question the "uncritical acceptance" of expert opinion and the assumption that "our legislative bodies and the public are incapable of comprehending the information which is relevant to decisions (with technological components)" and would seek to make the important issues understandable to all of the interested public. This would compel proponents of technological application to respond in kind.

Dr. Green concluded: "I visualize that this will stir people up--that it will get people apprehensive and I think that this is useful."

He did not have to wait long to see his prophesy fulfilled. A seminar participant responded to the paper with surprising vehemence:

> I'm sure you've all heard the homily that it takes a carpenter to build a barn but any jackass can kick it down. This arrogant, gratuitous, and insulting paper by Professor Green is representative of all the jackasses in the world. His certitude in the correctness of his position is unmatched since the dogmatists of the Middle Ages. His nihilism would undo a million years of evolution for, make no mistake about it, what Professor Green is proposing here is nothing less than the complete destruction of civilization.

Later, this participant admitted that his wording was perhaps too strong but that a response of this sort was necessary in order to balance the extreme position taken in the paper.

This "intemperate attack" was criticized by another seminar participant. He rejected the notion that any efforts toward the regulation of technology lead to the destruction of the civilization that now exists and stated that "I don't believe that the jackasses are all wrong. Occasionally a jackass

stands up and kicks in the right direction."

There seemed, at this point in the discussion, to be some feeling among those present that the prepared paper might be a spoof or "a jesting probe to goad us into thinking," but most of the comments which follow were based on the assumption that it was meant seriously.

An agency official thought that the paper proposed, in essence, the "institutionalization of converatism." He expressed some concern with the manner in which society seems to establish different sets of evaluative criteria for new social technologies, of which the proposal in the paper is one example, than for new biological and physical technologies and asked the participants, "Are you willing to be as skeptical about new social technologies as (you are) about new physical technologies?"

The same speaker further characterised the proposed assessment mechanism as the "institutionalization of reasons for fear." This worried him because

> we all know that demagoguery is fueled by fear and it seems to me that you've proposed here the ferreting out and publication of fear.

Another agency official took issue with this point of view. "Is it not the ignorant who are stampeded by fear?" he asked. The proposal, in his opinion, seeks to reduce ignorance and to increase rationality. Dr. Green echoed this point, noting that the institution he proposes is to be a "responsible" body and would not go out of its way to frighten people.

The discussion turned to a consideration of some of the specific assumptions and points of the paper. A university researcher questioned the assumption that benefits of technology are always articulated. Citing

the example of the automobile manufacturers reaction to electronic car development he claimed that "large and powerful economic interests very often serve as a brake, rather than as an accelerator, for technological change." A Congressional aide agreed that very often technological advances require more effective articulation. Dr. Green conceded that there are cases in which industrial concerns choose, for some reason, to suppress innovations. His point was not to deny this but rather to emphasize that in those cases in which economic motivation exists, the benefits are always articulated. The problems raised by industries sometimes hindering innovation were, he felt, beyond the scope of the paper.

A professor could not clearly visualize the role of scientific experts in the proposed mechanism. Even this "negative agency" would be required to get its information from "the scientists and technologists in whom you've stated little reliance should be placed." How is the information to be used? "If you can't use their scientific judgements pro, why should you accept their scientific judgement con." Dr. Green responded that scientists would play a very important role in the kind of technology assessment mechanism he proposes but he insisted that scientists should not make decisions on problems of "philosophy, morality, and sheer wisdom."

An industry representative said that he could not agree that private commercial applications create less of a problem in technology assessment than do government sponsored technologies. And an agency official challenged the assumption that the market mechanism is an effective assessment device citing as examples the use of polyvinyl chloride containers and detergents as just two failures of the market mechanism. Dr. Green pointed

out that he had not claimed that the market was completely effective but felt that it was "useful." It fails to work effectively when it neglects the "externalities" such as long range environmental effects.

A university researcher believed that the value of an institution of the type proposed in the paper was that it provides a place for the citizen to go when he feels threatened by some technological advance. Now one can go to Congress, but effective action doesn't always result unless a willing champion for a particular cause is found.

A Legislative Reference Service staff member noted that it would probably be quite difficult to find people who would be willing to work for a one-sided organization such as the proposed assessment institution. Dr. Green agreed with this point when he stated that "the kind of organization that I propose is not viable for the reason that you could never get anybody to work for it." He even noted that while he had not intended his paper as a spoof or a "put-on" he felt that it might, in reality, be a spoof because of the difficulty of staffing the assessment body. Still, he felt that it was useful to discuss the concept of such an organization.

A significant polarization in the attitudes expressed during the discussion was noted and criticized by two participants. One, a university researcher pointed out that acceleration of technology without restraint and "reverting back to the aboriginites" are not the only two alternatives open to society. He hoped that we "could encourage and stimulate technology" while keeping it responsive to public demands. The other, a professor, felt that the proposal of an agency of the sort being considered without a careful

definition of "bad" effects on technology runs a risk of missing the "big middle." The "big middle" is composed of

> those things produced by technology which government agencies legally can't do a thing about because they don't harm, don't do you any good -- all they do is bleed your pocket.

Unless the agency broadens its definition of negative effects to include this middle ground it fails to protect the consumer.

An industry representative agreed with Dr. Green's faith in the man-on-the-street as a decision-maker. The essence of democracy is the ability of the people to decide upon actions to be taken in the public interest. A Congressional aide said, however, that the best you can expect from the public is that "they rise to the occasion once in a great while." The public would quickly tire of becoming involved in all technology assessments. But an agency official replied,

> I think you neglect the tremendous propensity of the American public for being engaged in a soap opera. There is no shortage of people who want to go out and belly-ache about any conceivable kind of bad thing that's going on.

Another participant, however, still felt that "the public has a limited capacity for indignation." He claimed that we can't expect all problems to be handled by public controversy and that in the long run new laws and institutions with clearly defined responsibility are necessary. Still another speaker noted that in many cases the public seems to take no action at all in the face of potential hazards (such as polyvinyl chloride bottles). "Are you saying that public inaction is a choice in these things?" he asked.

An agency official sought to examine just how far one can or should rely on the public to make decisions in its own interest. The question

which must be considered is similar to the one which asks whether a patient should direct a doctor on the form of medication he is to receive. Technology assessment is, in a sense, a professional endeavor and

> a very important function of a professional ethic is . . . (that it requires action) in the interest of the client . . . whether or not the client agrees that the action is in his interest.

Thus, for instance, we impose the requirement that all people be immunized against certain diseases without in each case consulting the person to be immunized. He asked Dr. Green whether he truly thought that the public should always be permitted to make decisions in its interests. For example, should the public be permitted to take action which could be destructive to itself? Dr. Green held that the example of a doctor's treatment of a patient was not really relevant to the question at hand and repeated his point that

> the question is entirely one of knowledge, of legislative responsibility, and of the public's ability to respond meaningfully. It seems to me to be axiomatic that if one is talking about a question of balancing risks to the public against benefits to the public, it is the public itself which ought to be the one to decide whether it wants those benefits in exchange for the risks.

Some of those present were concerned about the location of an institution such as the one proposed here. A professor and a Congressional staff member thought that a true adversary process would be best located in the Congress. But another Congressional aide disagreed. Congress, he held, is apt to be slow in getting mobilized on most issues and technology assessment, to be effective, often requires a rapid response. Further, Congressmen serve their constituents and often vote for programs which are

locally beneficial even if there are detremental aspects on a national scale. Another participant held that an effective technology assessment mechanism should be located near the President in order to best influence national policy. An agency official objected to any location within the governmental structure. An arm of Congress is subject to manipulation; an arm of the executive is ultimately subject to pressures such as those which confronted the National Bureau of Standards during the battery additive controversy. He concluded that the proper location is "in the public domain." Others believed that effective technology assessment requires more than one location and the discussion of this point concluded without any real consensus.

Dr. Green asked those present whether there could be any conceivable objection to allowing the public to possess full information on all matters. A university researcher agreed that information availability was to be desired but questioned whether a mechanism whose sole function is the determination and dissemination of information concerning the detrimental aspects of technological applications really provided a means for giving the public all of the relevant information. To this Dr. Green responded that the public is certainly not fully informed now (although a congressional staff member insisted that in this country we are better informed than those in "any other society on the face of the earth") and that his proposed institution would help to fill some of the gap.

A university researcher said that the objections which had been expressed concerning the "negative" assessment mechanism had perhaps been overstated.

> We probably need quite a multiplicity of new institutions and mechanisms and ways of dealing with this (technology assessment). I don't see anything incompatible between an agency doing so-called objective detailed analyses looking at all sides of a question and another group which is trying to bring out certain of the negative aspects ... and to present them in an effective way that everyone can understand.

He proposed experimenting with numerous types of social institutions in order to develop effective mechanisms for technology assessment.

It was a consensus of the participants that a comprehensive assessment system is necessary and that some sort of adversary process can play a role in such a system. A participant summed up the feelings of the group by noting that almost everyone present thought that an objective agency is needed somewhere in the system and that a smaller number felt that an "adversary institution" of the kind proposed by Dr. Green could also play an important role in a truly effective assessment system.

4: THE MANAGEMENT OF TECHNOLOGY ASSESSMENT

Louis H. Mayo

I. Introduction

This is not the first time in history that various societies have been concerned about technological innovation and the dire impact, actual or prospective, of new applications on existing interests, institutions and value schemes of such societies. Some think, however, that we are now faced with a technological intrusion of such magnitude that it threatens devastation not only to the environment but to our fundamental social values and institutions. We can no longer easily assume that technology is routinely absorbed into the social matrix, in turn modifying social attitudes and practices. In the view of some serious observers, the new technology may very well obliterate the social matrix. In a most provocative article in the Saturday Review of March 2, 1968, Wilbur H. Ferry of the Center for the Study of Democratic Institutions posed the question: "Must We Rewrite the Constitution to Control Technology?" He came out with an affirmative answer. Mr. Ferry concluded his piece with a quote from Robert L. Heilbroner:

> (T)he coming generation will be the last generation to seize control over technology before technology has irreversibly seized control over it. A generation is not much time, but it is some time . . . .[1]

One may or may not agree with Professor Heilbroner's blunt assessment, but few would disagree that the misuse of technology can produce swift and tragic harm. Such an assertion, however, does not move us far toward the design of technology control mechanisms which will be most compatible with our preferred

social values. We must work from, or out of, the existing context of conditions, trends and resource constraints, whether we like it or not. Surely, we would not wish to discard every element out of existing technology assessment structure, even though some drastic revision may urgently be in order. At least it would seem advisable to assure ourselves as to why and in what respects our present assessment arrangements are inadequate. In any event, we have little choice but to recognize and work from the base of existing social institutions, eliminating, modifying or adding assessment mechanisms and processes as necessary for the development of a "controlled technological system, capable of producing benefits by design rather than by accident."[2]

The basic thrust of this paper is to analyze the frequently advanced notion of a Total Problem Approach to technology assessment. A tentative suggestion is offered of one type of institutional arrangement which might produce a close approximation to the Total Problem Assessment approach. Such an arrangement would supplement and coordinate the Existing Technology Assessment Function; it would not supplant it.

Several terms and expressions are used throughout this paper which require tentative definition. Technology Assessment Function is employed to refer to technology assessment activities in a general sense. Technology Assessment refers to the identification of the effects (direct and derivative-immediate, intermediate and long-term) and the evaluation of the social desirability or undesirability of such effects as related to particular technological applications. Mechanism(such as a Congressional Committee or

the OST or a Special Study group) refers to the organizational entity conducting the assessment process. Process refers to the decisional/ operational procedures (adversary process, panel discussion, research study) utilized by the assessment mechanism. A particular mechanism and its customary decisional process constitutes an Assessment Sub-system. The term Assessment System refers to all assessment sub-systems which have relevance to a given technological application (flouridation, aircraft noise abatement) or a pattern of similar applications (food and drug assessment system). Social Sub-system is used to refer to the social interactions and social effects taken into account in the assessment of a given technological application. Normally, Assessment Sub-systems for a given application will consider only limited interactions and impacts of the Total Social Sub-system affected by such application.

II. The Technology Assessment Function: A Brief Overview

If we accept as a tentative definition of technology assessment, the identification of the effects (direct and derivative--immediate, intermediate and long-term) and the evaluation of the social desirability or undesirability of such effects as related to particular technological applications, one is probably safe in asserting that the decision process in every substantial technological project involves to some degree technology assessment.

While "technology assessment" seems to be an expression of recent origin, examination of the literature will disclose innumerable examples of technology assessment as defined above even though most instances are obscured within other frames of discussion. The volumes of Singer (Ed.) on A History of Technology; Derry and Williams, A Short History of Technology (1961); Kranzberg, Melvin and Carroll Pursell, Technology in Western Civilization (1967); Bronowski and Mazlish, The Western Intellectual Tradition (1960); Elting E. Morison, Men, Machines and Modern Times (1966) and Dupree, Science in the Federal Government (1957) are rich sources of information.

From earliest times we can gain some perception of the interaction between developing technology and society and the various means employed to evaluate the social impact of applications. We are advised by R. J. Forbes in Technology in Western Civilization that in ancient Mesopotamia " . . . on occasion technical projects were submitted to the scrutiny and advice of learned bodies of priests who formed advisory boards."[3] The

military has often been the social organization taking the initiative in the assessment and application of new technologies. Surely the major technological projects through history have involved tremendous efforts in planning, resource allocation and implementation which have inevitably required some evaluation of benefits and costs, whatever the value system might have veen against which such impacts were measured. Societies have been concerned with the interrelationship of technological applications on such social values as health and well-being, the physical environment, national prestige, the economy and certainly with the impact of scientific and technological advance on systems of belief and thought processes.

Assessments are usually intertwined with an on-going decision process which renders it difficult to make "clean" extractions of assessment from other phases of such processes. For descriptive purposes it may be useful to apply the following rough distinctions among assessments: reactive (evaluations of impact after the application has been made); projective (evaluations of probable impact prior to the application of the technology) and reactive-projective (evaluations made through time from early to advanced applications of developing technology).

There is an almost endless list of technology assessments on a "grand scale" where massive commitments of resources have been required. One can easily imagine the magnitude of the effort in terms of debate, analysis, planning and implementation which was involved in such engineering projects as the separate and elaborate aqueduct and sewer systems of the city of Rome, the extensive land-reclamation projects in the Netherlands during the late

Middle Ages, and the construction of the Suez Canal in the 1860's. Several "assessments" were made of the technical feasibility as well as the probable political and economic implications of the Suez Canal.[4] It is of interest to note that the assessment and planning of a complete national transportation network was carried out in our early history. The scheme, though never enacted, was put forward in 1824 by the Corps of Topographical Engineers under the War Department. Professor A. Hunter Dupree states in Science in the Federal Government:

> Despite constitutional scruples, the Congress increasingly appropriated money for roads and harbor improvements. One offshoot of Monroe's straddling position on the constitutionality of internal improvements was the Survey Act of 1824, under which the Corps of Topographical Engineers made a comprehensive plan for canals between the Chesapeake and the Ohio, along the Atlantic seaboard, and for a road from Washington to New Orleans. This plan, the only one the government ever attempted to make for the country as a whole, required considerable technical competence, and had it been executed, would have required even more.[5]

Technological applications have almost always had their detriments as well as their benefits and this is particularly evident with respect to environmental encroachments. For example, in the 1500's "dwellers in the iron-working districts of England and Northern France were complaining bitterly of the shortage of fuel and demanding checks upon the activities of the ironmasters"[6] who were cutting down acres of surrounding forests to supply their fuel needs for smelting iron, thereby depriving the local people of both easily accessible firewood and recreational areas. In the mid-1800's, English citizens protested loudly over the noisy, smoky locomotives. Many land owners arranged for intermittent firing of guns across their ground to

keep out railroad surveyors. "Parliament, exercising the right of eminent domain, eventually overcame these difficulties for the railroad companies, but only at a price: as a concession to objectors, a change was included in railway charters requiring that locomotives must not emit smoke."[7] And the public reaction to large steam carriages "brought forth in 1865 the famous RED FLAG ACT which required a flagman on foot to precede each steam vehicle."[8] The manufacture of explosives such as nitroglycerine posed serious hazards. "In Britain the most satisfactory conditions for explosive manufacture were codified in the Explosives Act of 1875, and similar legislation was introduced in other countries to safeguard the workers in the industry."[9]

The experience of this country with reference to efforts to protect the health, safety and general welfare of its citizens as well as the natural environment, is given detailed treatment in Dupree's Science in the Federal Government. Congress has been intimately concerned with an extremely broad range of matters which have in some substantial manner involved technology assessment, as for example:

1) In the early 1800's, Dr. James Smith of Baltimore proposed the free distribution of cowpox vaccine as a protection against smallpox. Congress in 1813 "passed a law naming him vaccine agent and giving him the privilege of using the mails without paying postage." In 1820 it was proposed that a "national vaccine institution" be chartered by Congress. But an unfortunate mistaken shipment of smallpox scabs instead of cowpox vaccine to North Carolina resulted

in the inevitable spread of the disease. Subsequent objections by a North Carolina Congressman defeated efforts to provide federal aid to the institution and led to the abandoment of the idea of free national distribution of the vaccine.[10]

2) Certainly one of the most interesting technology assessment incidents in our history involved steam boiler explosions. Between 1816 and 1848 "a total of 233 steamboat explosions had occurred in which 2,563 persons had been killed and 2,097 injured, with property losses in excess of $3 million."[11] While it was not until 1852 that stringent and effective laws were enacted regulating boiler construction, operation and inspection, the Franklin Institute had researched the problem in 1836 and made recommendations at that time which embodied most of the recommendations finally adopted in 1852.[12]

3) The rapid railroad expansion after the Civil War brought with it some public health problems. "Cattle brought from the southern states, though remaining healthy themselves, infected northern animals in large numbers with a disease that often proved fatal (Texas cattle fever)." Congress appropriated $15,000 for the Commissioner of Agriculture to investigate the problem of livestock disease, but the results seem to have been unsatisfactory. A similar problem arose later with the introduction of refrigerated ships for the exportation of American meat to Europe. Hog cholera and trichinosis was the result. In response to this "crisis"

Congress created a new Bureau of Animal Industries to investigate, regulate and prevent the transmission of livestock-carried diseases.[13]

4) In the early 1860's, Spencer F. Baird of the Smithsonian noticed the "great diminution in the numbers of the fish which furnish the summer food supply to the Coast" resulting from fishing in the breeding grounds. He insisted that federal regulation was necessary and that it should be based on a research program to ascertain "not only the biology of each species of fish, but . . . the ecology of life in the ocean." The independent Fish Commission was created in 1871 which was changed to the Bureau of Fisheries of the Department of Commerce and Labor in 1903.[14]

5) In the 1850's the introduction of the English sparrow upset the ecological balance in an unexpected way. Private scientific societies such as the American Ornithologists Union began to survey the nation's wildlife and assess ecological factors in wildlife distribution. The national scope of such problems brought in the federal government which in 1886 established the Division of Economic Ornithology and Mammology in the Department of Agriculture.[15]

6) The conservation plans of John Wesley Powell of the Geological Survey in the 1880's with respect to irrigation and Western land settlement met great hostility inside and outside the government. As Dupree states: "The irrigation work was dead, and with it Powell's great plan of orderly settlement based on facts of environment as determined by science."[16]

Perhaps the crux of the historical import of technology assessment, relevant to present purposes, is that in the Western countries there has been a strong presumption that the impact of scientific inquiry and technological advance is socially beneficial. From Francis Bacon on we seem to have accepted the "science is good in itself" notion. Certainly the scientific approach, however superficial, pervaded the outlook of the philosophers of the Enlightenment, that high point of belief in human rationality and the potential of man to perfect himself and society on earth. The Royal Society (chartered 1662) and similar organizations promoted the idea that "investment in science was an investment in prosperity."[17] Such organizations as the Lunar Society (1775-1791) were more "practical minded" and socially sensitive to impact of science and technology than the more prestigious Royal Society.[18] Even the human wastage and misery inflicted by the early 19th century Industrial Revolution did not greatly diminish our infatuation with science and technology.

But many voices were raised over the abuses of expanding industrialism supported by technological development. Not only were alarms sounded of the degrading human situation resulting from industrialism, but in some instances rather far-sighted action was taken to curb such abuses.[19] Yet the over-riding attitude continued to encourage technological development. This was particularly true in America during the 19th century where resources were abundant, the population was dispersed, transportation needs were critical and individual initiative was given the widest scope. According to the

authors of a Short History of Technology the technological progress achieved by the end of the 19th century was prodigious. They state: "For technology exists to produce goods and services, and the western world had marvelously increased its productivity, measured in terms of human labor." They continue: "by 1900 . . . the unskilled laborer in all the western countries was earning more and had a shorter working day than the privileged class of skilled workers before the Industrial Revolution."[20] But there were some who expressed misgivings as the following quote from Men, Machines and Modern Times indicates in reference to Thomas Huxley:

> He came to Baltimore toward the end of the last century to say that he remained unimpressed by all the power, natural resources, knowledge and machinery that had so greatly extended man's competence over his physical environment. "The great issue," he went on, "about which hangs a true sublimity and the terror of overhanging fate is, what are you going to do with all these things?"[21]

Nevertheless, the industrialism supported by coal, steam and a burst of inventiveness and motivated by the excitment of "progress" and personal gain reflected a social attitude raised to a Constitutional right through the doctrine of "freedom of contract."[22] Furthermore, many of the truly dedicated efforts to protect a broader and longer term concept of the "public interest" were blunted or defeated by the reluctance of the federal government to encroach upon the traditional bounds of the State "police power" over health, safety and general well-being.[23]

As some of the preceding comments have indicated, this nation has applied various assessment mechanisms since the early 1800's although we have relied primarily on the "market" system for guiding and shaping the nature of new

technological applications. There have been notable exceptions, however, as with the long agitation for improved public protection from adulterated foods and drugs.[24] Further, the telegraph represents an early instance of initial government support for the "demonstration" phase of a new technological application.[25] Governmental regulation has, in general, been gradual and piecemeal and--as in the case of transportation--usually evolved as a reaction to public demand for correction of specific and severe adverse effects of particular applications. The Judical, Legislative and Executive branches have all been participants in this assessment function, as have numerous business, civic and professional associations.

Although the Interstate Commerce Commission was established in 1887 and the first Pure Food and Drug Act was enacted in 1906, many of our more prominent technology-based regulatory agencies and statutory measures to control technological applications were not established until well in the 20th century.[26] For the most part, these agencies represent reactive measures rather than prospective efforts to assure development of a new technology in the public interest. Even broadcasting was not brought under regulatory control until 1927 after frequency interference became intolerable.[27] The development of nuclear energy represents perhaps the most outstanding example of new technology whose development began under government supervision and for which a reasonable well-ordered assessment structure has been maintained.[28] The Marine Resources and Engineering Development Act of 1966[29] was a noteworthy example of the establishment of special assessment sub-systems for a pattern of interrelated technological applications. This represented

an effort to develop coordination among all relevant governmental agencies and to design an overall national organizational structure for the advancement of the marine sciences and the rational exploitation of ocean resources for both national and international social goals. Pursuant to this Act, the Council on Marine Resources and the Commission on the Marine Sciences, Sciences, Engineering and Resources were organized to undertake these tasks.

Increasingly, since World War II, technological developments have been initiated and supported by the government or through combined government and industry efforts or government-university arrangements. Such government-initiated and supported programs are normally subject to a formalized assessment system which includes the following sub-systems (mechanisms and review/decisional processes):

- One or more Agencies or Departments
- Federal Council for Science and Technology
- Office of Science and Technology
- President's Science Advisory Committee
- Bureau of the Budget
- Congressional authorizing committees
- Congressional appropriations committees
- Congressional oversight committees
- Originating Agency or Department once the program in in operation
- General Accounting Office
- Official ad hoc commissions or study groups

. Government contractors or grantees

. Continuing cycle of annual or periodic reviews of on-going programs by the Bureau of the Budget and other of the aforementioned mechanisms.

The interaction among these sub-systems even with respect to one area of technology can be extremely intricate. But the assessment is not likely to be limited to governmental entities. Assessments may also be made by:

- Users and operators of the technology involved
- Community groups affected by a technological application
- Mass media commentators
- Specialized journals in science and technology
- Scholars in various journals
- Professional association committees and study groups
- The National Academy of Sciences and National Academy of Engineering
- Independent policy and program analysis groups
- Private standards-setting organizations
- Etc.

III. Fragmented Assessments and the Total Problem Approach

In part I of this paper it was stated that the basic analytical concept to be examined would be that of a Total Problem Approach to Technology Assessment. The Daddario Statement on Technology Assessment speaks of examining technological applications in terms of the "total social framework."[30] Senator Muskie in commenting on Senate Resolution 78 to establish a Senate Select Committee on Technology and the Human Environment uses the expression "total impact of scientific and technological change."[31] The Staff Report supporting the Muskie Resolution states in part:

> The Subcommittee expressed its conviction that the "big issue" of the future will be the ability of government and particularly the Congress, to see and to cope with each technological problem in its entirety, and to join the social sciences with the physical sciences and engineering to solve such problems.[32] (Italics added).

Attention should be given to what this concept means--or might mean--in the context of the existing Technology Assessment Function. Technology assessment must usually be considered within a time frame spanning years. Most technologies develop gradually. Hence, the social implications may not be immediately perceived. The social impacts become more evident through time. The means of evaluating the consequences may change through time. As applications increase and the technology affects a larger segment of participants, the larger the number of interest groups that become involved as operators or otherwise as receivers of benefits or absorbers of costs. As participants increase, the number of assessment sub-systems (assessment mechanisms and assessment processes) increases. Such assessment sub-systems will normally be concerned with one special aspect of the problem. Only a

few will give attention to the larger social sub-system affected by the application or pattern of similar applications.

There are various reasons why assessments by particular sub-systems are truncated. The authority to deal with given aspects of a problem may not be with the mechanism; or the sub-system may have a capability for dealing with only a special aspect of the problem; or the data may not be available for it to make a useful assessment at a given point in time even within its special area of competence. Even if the data is available to establish the "present state of the art," an apparent lack of feasible alternatives for advancing the analysis toward a proactical solution of the problem may inhibit any genuine assessment effort. One of the obvious and difficult barriers to reliable "public interest" assessments is the bias, overt or hidden, of most assessment sub-systems.[33] All of the essential elements for a fully adequate assessment (one analyzing all of the variable interactions within the total social sub-system) can be brought into focus only at certain points in time. Hence, assessments are almost necessarily incremental and cumulative with only periodic complete assessments being made or even feasible.

A most useful study could be made on the strengths and weaknesses of various assessment sub-systems. For example, a court case usually deals with an after-the-fact situation and declares rights and duties flowing from a technological application with respect to some highly restricted issue. It is basically reactive as contrasted with a prospective assessment. Initiation is not within the control of the court. The problem

definition or scope of the assessment is largely determined by the issue in contention. Information is selected and limited by relevance to the specific issue. In other words, the range of alternatives that can be considered is extremely narrow.

Executive Departments and Agencies usually have their scope of authority and responsibilities spelled out by a statute. Such authority may be a narrow mandate for a special type of R & D with respect to a given technology. It may be reasonably broad as where the mandate calls for the administration of a given technology, such as broadcast communications, in the "public interest." Further the rule making and policy declaring authority of regulatory agencies provide a projective dimension to the assessment function. Congress, it would seem, of all the permanent governmental entities, has the broadest authority and flexibility to make inquiries and assessments. The charter of special ad hoc study groups can vary from an inquiry into a specific issue to a Total Problem Assessment.

An illustrative sampling of assessments of the so-called Aircraft Noise Problem may give some specificity to the foregoing remarks. Some aspect of this problem has been treated by the Judiciary, Congressional Committees, the Executive Office of the President, Executive Departments and Agencies, local government units, private engine and airframe manufacturers, special ad hoc study groups, individual scholars and many other assessment sub-systems.

In the United States v. Causby, 328 U.S. 256 (1946), military aircraft flying as low as 83 feet over a chicken farm of the plaintiff, "caused the

chickens to fly into the walls in fright, and destroy(ed) the use of the property as a chicken farm."[34] It was held that such diminution of property value was a "partial taking" which required compensation under the Fifth Amendment, and thereby clarified certain specific rights and liabilities.[35] Griggs v. Allegheny County, 369 U.S. 84 (1962), involved a similar "taking" through noise from civil aircraft to or from a municipally-owned civil airport and controlled by a government control tower. The court was faced with the narrow question of determining the party liable--here the airport controller.[36]

An extract from the Report of the Senate Committee on Commerce, Aircraft Noise Abatement, No. 1353, of July 1, 1968, sets out in rather explicit and succinct form the fragmentation of the assessment and decision function, stating that its immediate concern was with noise abatement at the source.

> The concern with aircraft noise has not, of course, been confined to agencies of government. The several segments of of the aviation industry have participated over the years in numerous efforts looking toward solutions for noise and sonic boom problems. Engine and airframe manufacturers have maintained programs in noise research.
>
> This investment by the industry is representative of one of the avenues of approach to aircraft noise reduction, that is, the development of aircraft which generate less noise. Another approach to noise reduction is through the establishment of special flight operating techniques and procedures. The third principal control technique which merits serious consideration is the planning for land use in areas near airports so as to make such use compatible with aircraft operations. This is a matter largely within the province of state and local governments. While all these techniques must be thoroughly studied and employed, the first order of business is to stop the escalation of aircraft noise by imposing standards which require the full application of noise reduction technology.[37]

In its Notice of Proposed Rule Making on "Noise Standards: Aircraft Type Certification," issued by DOT/FAA on January 3, 1969, the FAA undertook as its first order of business to concentrate "on the aircraft that are most likely to raise aircraft noise levels in airport neighborhoods. These aircraft include subsonic transport category airplanes regardless of means of propulsion and sub-tonic turbojet powered airplanes regardless of category."[38]

The Committee on Environmental Quality of the Federal Council on Science and Technology (September 1968), "Noise--Sound Without Value," stated in its report:

> The objective of the Task Force was not an exhaustive treatise on the technical aspects of the noise problem; but rather an exposition of its dimensions and a proposal for a more adequate federal program directed toward elucidating the effects of noise on man and his environment and developing means for abating the problem.[39]

The comprehensive staff report on "Policy Planning for Aeronautical Research and Development," prepared for the Committee on Aeronautical and Space Sciences of the Senate by the Legislative Reference Service of the Library of Congress (May 1966) gave the noise problem very brief attention, referring primarily to NASA responsibilities, but noted the then recently published OST Report on "Alleviation of Jet Aircraft Noise Near Airports," including the broad scope and detailed treatment given the aircraft noise problem in the Report.

Two studies have undertaken to place the aircraft noise problem in a relatively broad social sub-system. The Summary Report of the Aeronautics and Space Engineering Board of the National Academy of Engineering (August 1968)

entitled "Civil Aviation Research and Development: An Assessment of Federal Government Involvement," did not make noise the focal point of the study but did consider noise in its relationship to other major variables in the context of the general civil aviation program of the nation. And the Report of the Jet Aircraft Noise Panel, Office of Science and Technology (March 1966), entitled "Alleviation of Jet Aircraft Noise Near Airports," provided a multi-dimensional perspective to the problem. This Report probably more closely approximates a Total Problem Assessment than any of the others referred to above.

A reasonably complete representation of the Aircraft Noise Assessment System, including the various types of operations in the Policy Analysis, Project Planning and Program Implementation Continuum that might be assessed, and the range of sub-systems making up the assessment system is provided by the Aircraft Noise Contextual Matrix (Appendix B to this paper). One might start here with transportation or environmental pollution as the broad Social Sub-System involved. If we commence with environmental pollution, it is readily apparent that this area can be broken down into air pollution, water pollution, radiation exposure, aesthetic debasement, noise and so forth. Taking noise as the primary problem, sources can be identified as surface transportation, construction, aircraft engine noise, etc. The source of aircraft engine noise can be reduced further to types of aircraft or by a division between civil and military aircraft. The alleviation of the problem may be viewed as one of reducing engine noise, devising noise abating take-off and landing techniques, or of land use management.

These three primary noise abatement target areas can be reduced further into numerous sub-problems. If we select civil aircraft, it can be noted that there are at least 35-40 entities or assessment sub-systems (mechanism plus the decisional processes of such mechanisms) which are relevant in the aircraft noise problem context. Each will have its own perspective (interests or objectives), special capability, and on-going and planned projects. Now: Who has the responsibility for the assessment of the Total Aircraft Noise Problem? The Senate Report referred to above states that "the Secretary (of DOT) is now the focal point for Government-wide activity in the field of aircraft noise abatement."[40] But the Secretary clearly does not have authority over all aspects of aircraft noise abatement.

The import of the foregoing is that only infrequently, if ever, during the evolutionary period of a given application will there be a comprehensive social impact approach taken by one of the assessment sub-systems. Even when a supposedly total social sub-system approach is taken (an effort is made to appraise all of the significant factor-variable interactions within the relevant social sub-system), it will necessarily be based upon the information available at that time. While this may be extremely useful for continuing program planning in connection with future applications of the given technology, as by identifying probable hazards which might be avoided, such assessment is still only a stage of a continuing process of assessment--at least until the technology has reached full utilization or the social problems created by the technology have been eliminated or minimized by an innovative "technological fix."[41] Hence, a Time Dimension must be incorporated in a

workable approach to the Technology Assessment Function. More will be said on this point later, but it might be noted that Congress first gave serious attention to the aircraft noise problem in 1959 (many years later than the courts), but it was not until 1968, after several interim hearings and special studies, that Congress apparently felt sufficiently confident to specifically authorize the FAA to establish maximum noise standards under new Section 611, Control and Abatement of Aircraft Noise and Sonic Boom, as an amendment to the Federal Aviation Act of 1968. Further, the assessment went primarily to the abatement of aircraft noise at the source rather than to the total aircraft noise social context. But the point here is that the assessment of a relatively low priority social problem such as aircraft noise can involve a variety of Assessment Sub-Systems, each having a different set of objectives, capabilities, practices, feasible alternatives, and forums (formal or informal) for making its contribution. Such assessment sub-systems make up, by definition, the Assessment System for the particular technological application. But the critical question is: Do they all intersect at sufficiently frequent intervals to effectively combine assessment outputs, and, even if they do, does this add up to a complete assessment of the impact of the given application on the social sub-system affected? Who has this responsibility for assuring a Total Problem Assessment other than Congress? The OST? Do we need a new entity or a structure of new assessment arrangements for this purpose?

The point of our Total Problem Assessment deficiency is well made by Karl D. Kryter in his recent article, "Sonic Booms from Supersonic

Transport,"[42] wherein he states:

> In view of the costs and commitments of aviation facilities involved in producing and operating the SST, it would seem prudent for various governmental and scientific bodies, if not the general public itself, to examine closely the pertinent data from psychological and sociological research and their relation to arguments for and against the overland operation of the SST. The general unavailability of an integrated interpretation of the implications of the psychological, sociological, and acoustical research related to the acceptability of sonic booms to people has prompted the publication of this paper. In the last analysis the sonic boom is a psychological-sociological problem, and it would perhaps be regrettable if all relevant information, such as it is, from these scientific disciplines were not available and discussed in the practical context of the problem.[43] (Italics added.)

IV. Concept of Adequacy in Technology Assessment

Reference to the Provisional Schematic: Technology Assessment Function (Appendix A herein) will show the basic operational phases of a particular assessment. The assessment is initiated by some requirement (formal or customary) or some non-regularized stimulus such as a "crisis" situation. The task of problem definition may be "given" or it may have to be formulated by assessment sub-system. The Assessment Function, of course, involves a continuous interaction among the various operational phases noted rather than a mechanical first phase, second phase, etc., procedure. Most assessments of a particular technological application involve periodic assessments through time, the same assessment sub-system often making several specific assessment inputs into the continuing assessment function.

In most assessment situations involving a problem of any complexity, the establishment of the "definition of the problem" or the "objective of the assessment" or the "context in which the problem is to be analyzed," or, in short, the social sub-system encompassing the social variable interactions and effects to be assessed, there will be interplay among all of the operational phases shown on the TAF Schematic. Starting with a given assessment sub-system and the institutional mechanism (Congressional Committee, for example) which is undertaking the assessment, then the formulation of the problem definition will or may depend upon the initiating stimuli, the character (authority, capability, practices, etc.) of the assessing mechanism, the availability of data relevant to an analysis of the social sub-system to be assessed, the decisional procedures which the assessing mechanism is

competent to employ, the possible followup actions which may result, and the various impacts of alternative actions (social effects--immediate or remote, direct or indirect--on various participants, societal values, and community institutions and practices).

There are various concepts of Adequacy that might be applied. Approaches will differ with the perspectives of particular "adequacy evaluators." Two different approaches will be given brief attention here. First, one might accept the social sub-system or problem definition posited by the assessing mechanism and then measure Adequacy by the extent to which a full analysis has been made of the social relationships, interactions, and effects within the social sub-system posited. In this approach, one is primarily concerned with the Information Selection and Decisional Procedure phases of the assessment. The second approach would begin with an analysis of the Adequacy of the social sub-system posited. It would be necessary to take into account such factors as the general nature of the problem (social impact of a given technological application or applications), the urgency with which attention should be directed to certain adverse effects, the formal obligations and capability of the assessing mechanism, the availability of data relevant to various dimensions of the overall problem, and the probability of useful application of the assessment results to maximize social benefits and minimize social costs. The question would then be asked: Might a more comprehensive model (social sub-system) have optimized the utility of the assessment? Or conversely, might a less comprehensive model have been a more sensible "problem definition" in view of the factors mentioned above (such as capability

of the assessing mechanism) or in view of the fact, in a given instance, that other assessment sub-systems with high level capabilities had previously assessed or were currently assessing all of the relevant dimensions of a social sub-system co-extensive with the "total problem" and the remaining need was only for a specialized assessment (within a constricted social sub-system in which the particular assessing mechanism has a recognized capability) in order to complete the full assessment of the "total problem?" In the Second approach it is evident that the "adequacy evaluator" would have to make an analysis and evaluation of the Information Selection and Decisional Procedure phases in order to be assured that the information sources and the decision capabilities of the assessing mechanism can support a thorough analysis in the optimum social sub-system proposed.

It will be noted that both approaches to adequacy evaluation suggested that the Adequacy of the overall assessment is largely dependent upon the quality of performance of the operations within the Information Selection and Decisional Procedure phases. The following criteria are relevant to measuring the performance of the operations within these two phases:

Information Selection Phase [44]

1) Availability and timeliness of data
2) Economy (cost of obtaining related to value)
3) Dependability (accuracy, reliability)
4) Comprehensiveness (contextuality, systematic)
5) Openness (opportunity for participation)

Decisional Procedure Phase [45]

1) Problem Definition

2) Specification of goal-objectives

3) Controlling contextual factors--recognition of

   Demands of participants
   Resources available
   Relevant institutional framework/legal process
   Customary practices
   Major movements and trends

4) Invention of alternative courses of action

5) Projection of more probable outcomes for each

6) Description/prediction of specific consequences of each alternative

7) Evaluation in terms of goal-objectives

The foregoing indices are to some extent objectively measurable. There are, of course, other criteria which would be applied in the evaluation of Adequacy of assessment. Judgments will certainly be made on the "quality" of the analysis, as well as on the "operations" of the analysis. The skills of those performing the assessment and the methodologies used will also be matters for evaluation. Further, as given assessment sub-systems are observed through time, reputations will emerge as to the quality level of performance.

One might say with considerable confidence that the problem of Adequacy of Assessment presents both a tremendous challenge and opportunity for conceptual and analytical study.

Previously, the fragmentation of the Technology Assessment Function was mentioned in connection with the frequently stated need for Total Problem Assessments. This is a fine notion, but the concept should be pursued a bit

further. Assuming that "one-shot," Total Problem Assessments are needed (which they are), it is not at all evident that such efforts are feasible with reference to certain applications at particular times. The assessment system simply may not have all of the necessary sub-systems to produce the essential data, or the data may be available but there exists no mechanism within the assessment system for assembling and analyzing the full data input. Therefore, the alternative concept of a Total Problem Assessment Through Time should be considered with outputs of the various sub-systems being cranked into the continuing assessment as feasible. Such continuing approximations to a Total Problem Assessment would be responsive to changing social demands and to new data developed on previously recognized and significant interactions in the Social Sub-System affected by the application. Further, the concept of Total Problem Assessment Through Time provides the means for applying the sharpest possible focus to the selection of the Social Sub-System to be assessed. In other words, it provides an excellent means of testing the Adequacy of an assessment in accord with Adequacy Approach #2 described above.

The evolution of the assessment function with respect to the Highway/Motor Carrier Social Sub-System may serve as a useful device for illustrating Adequacy Approach #2. We are here concerned with the assessment function--not with the merits of the issue. During the last Congress, Senate Bill S.2658 brought to the focus of attention the prospect of Federal establishment of increased maximum sizes and weights of motor carriers operating in the Interstate Highway System. It is clear from the Report of the Senate

Committee on Public Works that the assessment supporting the favorable recommendation of the bill was narrowly limited with primary focus on the physical capacity of highways to accomodate the larger vehicle. Under "Purpose of the Legislation" it is stated:

> S. 2658 as reported with amendments will facilitate a more efficient and economic use of the Interstate System and insure that the vehicles using that system will not unreasonably and unnecessarily impair its serviceability or durability.

In making this recommendation the Committee was supported by the Bureau of the Budget and the Secretary of Transportation. In the letter of the Secretary of DOT to the Chairman of the Senate Committee it was noted that pursuant to the Federal-Aid Highway Act of 1956 the Secretary of Commerce had undertaken to "determine future maximum desirable dimensions and weights for vehicles operating on the Federal-aid highway systems"[47] and that a report had been made to Congress on August 18, 1964.

The Committee Report also stated that "highway safety will not be jeopardized as a result of the proposed maximum allowable sizes and weights."[49] In support of this conclusion the Report stated that the "evidence presented . . . with regard to highway safety did not demonstrate a meaningful relationship between the sizes and weights under consideration and the incidence of traffic accidents."[50]

Nevertheless, even though some attention was given to highway safety and even to increased "user charges" in addition to increased maintenance and construction costs, one might view this assessment as inadequate in terms of a Total Problem Approach to assessment. The overall Social Sub-System

affected in some manner by this proposed legislation was hardly touched in this assessment. Why wasn't the motor carrier size and weight factor considered in a Social Sub-System, as for example:

1) A component of a national transportation "system" (all types of carriers for people and products) including an assessment of the impact (on participants, values, and institutions) of the interaction of the transportation sub-system with other major social sub-systems.

2) A component of a national freight transportation "system" including all modes of carriers with an assessment focused primarily on the implications for speedy and economical service to all relevant distributors and consumers.

3) A component of the national highway program of primary and secondary roads, such sub-system including a consideration of the implications of the national highway program for all highway transporation activities and an analysis of the social, economic, and political impacts of such activities on other social sub-systems (excluding, for instance, other modes of transportation).

4) A component of the special 41,000 mile Interstate Highway only--otherwise as in 3) above.

However, in a letter from the Secretary of Commerce of August 18, 1964, to the Speaker of the House the point was made that such a proposal should be considered as only a phase in a continuing process of progressive implementation[51] in adapting vehicular standards. Therefore, it would seem prudent to appraise the assessment function with respect to Highway/Motor Carrier applications in the time dimension of our developing highway program. We might start in 1956 when Congress enacted major Federal highway aid legislation which reflected the request of President Eisenhower for:

> (A) grand plan for a properly articulated (highway) system that solves the problems of speedy, safe, transcontinental travel--inter-city transportation--

> access highways--and farm-to-market- movement--
> metropolitan area congrestion--bottlenecks--and parking.[52]

A special Presidential Advisory Committee of which General Lucius Clay was Chairman, had submitted a Report which the President attached to his message to Congress on "A 10-Year National Highway Program." While the President's Message directed attention to the "Nation's highway system" rather than to a social sub-system including all modes of transportation, the Social Sub-System posited by both the Advisory Committee study and the Congress clearly showed the intention to include all significant social interactions and effects of this proposed "National highway system."[53]

Analysis of the Congressional Committee Report shows that an extremely wide range of engineering, financial, and social factors was considered.[54] From our present perspective, however, we would note that some factors were given relatively little consideration and that others were given no attention whatsoever. The Advisory Committee and the Congress seemed to be much more concerned with matters bearing upon the efficient implementation of the highway program rather than with cumulative and qualitative social impacts, particularly those which might be detrimental. One might feel, of course, that the exclusion of other modes of transportation was sufficient to disqualify the assessment supporting this legislation as a Total Problem Assessment. The Clay Report did explicitly state, however, that:

> This Committee was created to consider the highway network, and other media of transportation do not fall within its province. This relationship between the several modes of transportation is under study by other Government agencies and special committees fully informed of these views.[55]

Accepting this limitation, however, it is still to be noted that no consideration was given to increasing environmental pollution which would result from the growing traffic volume: air pollution from exhausts, engine noise, resulting aesthetic debasement, or the derivative health hazards from the foregoing sources. Nor was a great deal of attention given to the relationship between the increased number and size of motor freight carriers and the possible increased hazards to private auto drivers and passengers. Further there were several factors which the Congress could not treat adequately for lack of relevant information.[56] In view of these gaps, must one conclude that the assessment was inadequate? A negative conclusion without further analysis is not necessarily warranted. In the 1956 social context of urgent highway transport needs, coupled with the relatively low priority then given to certain social values which now have been drastically upgraded, one might reasonably conclude that Congress posited an extraordinarily broad social sub-system for assessment. But whatever view one might take of the 1956 assessment, our primary concern here is with the scope of the assessment that should have been made of the proposed increase in motor carrier size and weight as set forth by Senate Bill S.2658 in the last Congress. One might find it difficult to justify the extremely narrow scope of interaction (Social Sub-System) considered in connection with S.2658, limited, as noted, primarily to an inquiry of the ability of the highway network to withstand the wear and tear of the larger motor carriers. But if we view this assessment in the sequence of assessments made by Congress between 1956 and 1968, we may get a different perspective. Taking the assessment supporting the 1956 National highway

network legislation as the basic assessment, the following legislation is illustrative of Congressional action (and assessments) during the interim period:

- Federal Highways, Billboard Regulations (1958)
  Further legislation in 1959, 1961, and 1963[57]
- Air Pollution from Motor Vehicle Exhaust Fumes (1960)[58]
- Clean Air Act (1963)[59]
- Motor Vehicle Air Pollution Control Act (1965)[60]
- Air Quality Act (1967)[61]
- Interstate Compacts on Traffic Safety (1958)[62]
- Specifications for Hydraulic Brake Fluids (1962)[63]
- Minimum Standards for Seat Belts (1963)[64]
- Provision for State Highway Safety Programs (1965)[65]
- National Traffic and Motor Vehicle Safety Act (1966)[66]
- Highway Safety Act (1966)[67]
- Standards for Bridge Inspection (1968)[68]
- Highway Beautification Act (1965)
  Additional legislation in (1968)[69]
- Establishment of the Department of Transportation, including the National Transportation Safety Board (1966)[70]

Further action relevant to the National Highway Program includes provision for broader community participation in highway planning.[71]

In view of the manner in which Congress has approached the Highway/Motor Carrier issue (and perhaps, must approach the problem, that is, in terms of specific bills), can it be plausibly maintained that Congress has been in effect making an organized Total Assessment on a cumulative, sequential basis?

Has consideration by Congress of the various aspects of the Highway Program been "programmed" in such manner as to assure the closest possible approximation to a Total Problem Assessment through a reasonable period of time? To put the matter more explicitly: Was there any need for a broader Social Sub-System to be considered by Congress than the Senate posited in connection with S. 2658? Was it not a wholly adequate supplementary assessment in the context of previous related assessments? After this bill breezed through the Senate, it ran into heavy opposition in the House. The AAA launched a national advertising campaign against House passage.[72] The treatise of Professor John W. Fuller of Washington State University on "Current Issues in the Regulation of Motor Vehicle Sizes and Weights" was inserted in the Congressional Record for the apparent purpose of inviting attention to a much broader scope of social effects, primarily "social costs," than had been given attention by the Senate.[73] In short, some people clearly felt that the scope of the Social Sub-System posited by the Senate Report was not sufficiently comprehensive to assess properly the significant social impacts of this proposed legislation. But what should the scope have been in light of the many previous Congressional assessments relating to Highway/Motor Carrier activity?

Several questions emerge from this recital of the legislative history of S. 2658 which seem highly relevant to the improvement of the Technology Assessment Function. In continuously developing programs involving substantial scientific and technological applications, how does one determine the Optimum Social Sub-System to posit for examination at a given point in time? To what extent does the Optimum Social Sub-System depend upon the nature of the

initiating or carrier issue (or proposal such as S. 2658) which invites or compels the positing of the Social Sub-System to be examined? Surely, every time some aspect of Highway/Motor Carrier activity needs attention, it is not feasible nor necessary to conduct a Total Assessment involving the consideration of every conceivable decisional factor and social impact (direct, indirect, immediate, and remote) that might flow from such action. There is hardly a limit to the scope of social impacts that can be investigated. What kind of assistance might be useful to the relevant Congressional Committees in determining the "scope of the social sub-system" to be evaluated prior to action on such a proposal? If the specific bill itself sets the limits of the inquiry, then we in effect beg the question we are supposed to be exploring and thus fail to advance beyond our current level of fragmented. unrelated and inadequate assessments. Should Congressional Committees request from the responsible agency or agencies explicit and systematically organized suggestions as to the scope of the social interactions that should be explored in connection with specific legislation taking into account previously developed data from assessments from all relevant sources? Is there a continuing and critical question of positing the Optimum Social Sub-System to be examined in a given Congressional Hearing assessment? Or do organized community interest groups in conjunction with comments of relevant Government agencies assure that an adequate scope of social interactions and impacts is considered?

Since we have a time dimension to consider and an assessment system composed of a diversity of assessment sub-systems, it would seem that we might accept as one provisional model of the assessment function the notion

of an Aggregative Approach to Total Problem Assessments (Total Problem Assessments Through Time). This is roughly what the Congressional model of Assessment amounts to. It will at intevals bring together the various assessment sub-systems to a greater or lesser degree. Whether such periodic efforts do in fact bring together all of the relevant sub-system outputs is, of course, another question. Even if so, there is still the further question of whether the combined outputs are utilized in such a manner as to extract a complete social sub-system assessment as of that time. The final question is whether in many assessment patterns the full matrix of relevant assessment sub-systems, even if properly utilized, add up in their complete contribution to what amounts to a Total Problem Assessment of the applicable technology.

Periodic study groups or standing intergovernmental committees or even Congressional subcommittees very seldom assume the responsibility for making a Total Problem Assessment with any degree of thoroughness. Even if this is the objective, limitations on authority, time, information, or other essential resources preclude a wholly satisfactory total problem assessment, including such elements as the scope of the social sub-system that should be treated, what has been done which contributes to the analysis of such a social sub-system, and what still needs to be done in terms of policy analysis, project planning (including research and development), and program implementation. Surely we need a more systematic and reliable mode of managing this kind of inquiry.

What would seem indispensable to our getting into a position of "confident control" over such social sub-systems, as for example, that encompassing

the aircraft noise problem, is an activity which will construct a Comprehensive Matrix of the Total Social Sub-System in which the aircraft noise problem is located, and maintain a continuing appraisal of the assessment status of the problem. Such a Matrix Function would necessarily include:

1) Identification of the participants (operational and affected) within the Total Social Sub-System.

2) Characteristics of the various participants (which are to be considered as Assessment Sub-Systems).

3) a) Perspectives (demands, associations, etc.)
   b) Formal authority (if any)
   c) Resources--general
   d) Capabilities having specific application to aircraft noise problems
   e) Practices relevant to this problem
   f) Proposed future activities relevant to this problem
   g) Etc.

3) The relationship of the activities of particular participants to the various components of the Policy Analysis, Project Planning, Program Implementation Continuum, noted in the Aircraft Noise Contextual Matrix.

4) Particularization of:

   a) Significant controlling conditions and trends in the social sub-system posited.
   b) Present and prospective social impact of existing or prospective practices related to the problem context.
   c) Research and Development done, in progress, or proposed.
   d) Governmental regulatory measures taken or proposed.
   e) Alternative means available or in prospect for aircraft noise abatement (whether with reference to source or affected participants and activities).

5) Ways in which the total social sub-system posited can be reduced to more limited social sub-systems for purposes of treatment by particular assessment sub-systems.

6) Modes of coordinating specific assessment outcomes so that at appropriate intervals the full effort can be combined into the equivalent of an assessment of the Total Sub-System posited.

The mechanics of constructing, maintaining, and monitoring the Matrix Function is open, but clearly all of the new analytical, communications, and managerial concepts, as well as automatic data processing and simulation techniques can and should be utilized. The resultant would be the establishment of means for effectively relating capabilities to needs. The Aircraft Noise Contextual Matrix is a rudimentary representation of what would be involved in this task.

It would seem that the OST Panel Report on "Alleviation of Jet Aircraft Noise Near Airports"[74] reflects one of the closer approximations to the Comprehensive Matrix approach. But even the enlightened effort of the OST Panel should be appraised for its limitations in terms of the Comprehensive Matrix Function. First, the Report represents an ad hoc rather than a continuing effort. Further, while the range of content is remarkable, one is left, nevertheless, with some uneasiness as to whether all of the major significant social interactions and relevant assessment sub-systems were identified and their perspectives, capabilities, practices, and prospective future contributions fully appraised. Perhaps the critical question, for purposes of analyzing the Technology Assessment Function, is why this special ad hoc group had to be set up in the first place. Does the persistent practice of either establishing or recommending the appointment of Special Assessment Sub-Systems (groups, task forces, committees, commissions and so forth) provide most persuasive evidence that a much greater degree of "regularity" needs to be brought into the Technology Assessment Function?

V. Tentative Suggestions to Strengthen the Technology Assessment Function

While recognizing that attempts to give systematic and comprehensive treatment to the Technology Assessment Function are of fairly recent origin and that current study projects are yet to report, a few tentative notions are suggested below which might usefully be given some critical attention.

Initially, we can probably agree that several identifiable conditions have and continue to contribute to the inadequacy of present assessments:

1) Only recent emergence of interest in developing effective appraisal systems for Social System Analysis as contrasted, for example, with economic-market analysis.

2) A strong disposition to react to crises rather than to anticipate outcomes and evaluate consequences in terms of alternative schemes of social indicators.

3) The fragmentation of Technology Assessment Sub-Systems; the truncation of assessments made and the concomitant lack of management and informational systems for assuring Total Problem Assessments.

4) The lack of conceptual thinking on the Technology Assessment Function, including alternative notions of Adequacy of Assessment, which reflects current deficiencies in the Professionalization of the Function.

5) The failure to utilize the resources (methodology, techniques and professional skills) for technology assessment we now possess, including the lack of support for the level of effort required to assure the effectiveness of such utilization.

6) An inability to translate intellectual discussions or analytical findings of future detrimental consequences of given technological applications into a Public Perception that Problem exists.

7) Alarm on the part of some segments of society that undue emphasis on technology assessment will inhibit technological innovation and hence, limit the range of individual opportunities and social progress.

The previous discussion has stressed that the Technology Assessment Function is both pervasive and fragmented. One would hardly expect the situation to be otherwise in our pluralistic society. Furthermore, the magnitude of this function is enormous. This fragmentation reflects many conditions that work against the Total Problem Assessment approach: continuing specialization of knowledge and skills, highly compartmentalized jurisdictions and authorities, narrow assessment foci, and so forth. Since many of our traditional values are supportive of divisiveness in assessment activities, progress toward the effective management of Total Problem Assessment will require strong and substantial efforts. Emphasis must be given to new professional skills, institutional arrangements, and value re-orientation to some extent.

For the general support of a more adequate Technology Assessment Function there is need for strong encouragement of greater professionalism in this activity. Efforts in the universities toward the development of problem-oriented, policy analysis professionals are rather limited. While some progress is being made, the traditional disciplinary boundaries and the surge toward greater and greater specialization makes it exceedingly difficult to introduce a Total Problem Perspective. Concepts of "Systems thinking" and techniques of information and simulation management do, however, provide new and effective means by which those disposed toward problem-oriented approaches can utilize specialized knowledge for policy analysis. Further, there is clear evidence that an increasing number of young professionals are interested in breaking out of the constrictions of

a traditional discipline or profession in order to deal with social problems in a broader context.

One of the more critical deficiencies is the lack of a satisfactory information system for dealing with the appraisal of public programs, including major projects having significant technological components. There is much in the existing literature bearing on Technology Assessment: court decisions, regulatory agency hearings on rule making and policy positions, special task group reports, studies of the National Academy of Sciences and Engineering, scholarly studies, industry R&D reports, and so forth. But this is not well organized for effective use in terms of the problem approach. It is an extremely time-consuming and inefficient process to bring together relevant and important work that has been produced in the past. Many significant reports of special commissions and committees established to assess a techno-social problem context are almost impossible to obtain.

The materials could be set out in various ways: digests of case studies, reports of relevant entities, Congressional hearings, Agency appraisals, etc. But the emphasis must be placed on a problem approach rather than a rule approach as in the legal references. In other words, the organization should emphasize Alternative thinking rather than Rule-Deductive thinking. We must have materials which will enable us to compare and contrast problem definitions, social goals, descriptions of existing conditions, influential trends, available resources, alternative means of achieving objectives, and the predicted impact of alternative means on various schemes of social values. The establishment of such an information management system would be a major

step forward in a systematic approach to technology assessment. It should be designed both to support systematic inquiry into techno-social problems and to utilize fully the concepts and analytical tools of the new technology such as systems analysis, automatic data processing, and advanced techniques of simulation.

Other conditions will require some modification. Economic Market Assessments are no longer suitable for many technological projects. It is therefore essential that forums and decisional arenas be provided wherein the full range of social values can be expressed and alternative courses of action judged on the basis of the fullest information and analyses it is possible to obtain. So long as the predicted consequences of technological applications differ among the "experts," as will surely be the case, and so long as value priorities differ among various segments of the community, there will obviously be differences of opinion as to the feasibility and desirability of technological applications. Whether early warning should be made of possible beneficial or adverse effects will be debatable with reference to many applications. Provision should be made for a vigorous "adversary process" in the broadest and most legitimate sense. Confrontation should be expected in providing alternative views of social objectives, problem definition, existing conditions, influential trends, courses of action, and the probable consequences flowing from each such course. The "open forum" approach is the means of soliciting the broadest community participation and assuring that the full assessment resources of the nation are drawn upon.

There is need to assure a continuous upgrading of the performance of technology assessment systems, to see that new systems or sub-systems are initiated when necessary to cope with new or projected technological applications, to see that useless duplication is eliminated where feasible, and to see that distorted and irrelevant outputs of sub-systems are noted and dismissed. In this task, criticism of poor performance and persuasion to improve performance will probably be a better technique than any type of formal control.

A highly fragmented Assessment Function, however, has the inherent characteristic of rendering it extremely difficult to assure that the essential data and analyses are available at appropriate times, periodically or through socially permissable time spans, for a Total Problem Assessment or an Optimum Assessment (which may not be a Total) of a given technological application. Hence, a coordinating or programming function is needed which is lacking in many techno-social problem contexts today. Reference to the Aircraft Noise Contextual Matrix should demonstrate the difficulties in making a Total Problem Assessment even with respect to this relatively low priority social problem (as compared to other National Problem areas). No entity now has the authority (in view of Federal-State-Local-Private divisions of power and responsibility in this problem context) to assure a Total Problem Assessment.[75] Congress has been reluctant to intrude into traditional areas of State powers as is vividly illustrated by the treatment of aircraft noise and the various problems associated with the continuing development of Highway/Motor Carrier technology. Hence, a Total Problem Assessment

requires persuasion and appeals to mutual interest in order to obtain the essential cooperation and support from state and local government entities as well as private sector organizations in the task of assembling all relevant information.

Pursuant to this point there may be a need for Interim Organizing Mechanisms where it is not clear which existing agency has the ultimate responsibility for the initial assessments of a developing technological application. In this way Congress would have better means than it now has for securing the best assessment feasible at any given time.

One matter which must be given attention is the relationship between technology assessment and the follow-on decision process. The two are inextricably related. Most technology assessment sub-systems are decisions. Technology assessment (looking at alternative ways of applying technologies to determine what the impacts will be in terms of social goals) is a part of every consideration of a new technological program unless the decision process is totally lacking in rationality. Our basic interest is in assuring adequate assessments upon which the socio-political decision can be made. It is therefore important that all public and private entities (assessment sub-systems) and all segments of society affected by the probable action participate in the decision process. With certain exceptions, as with some Presidential Commissions having a broad charter to inquire into a given problem, Congressional Committee hearings now provide the most satisfactory forum for approximating a Total Problem Assessment. Usually, though not always, most of the governmental, industry, and community entities having relevance to the problem either

as direct data input assessment sub-systems or as a segment of the affected public have an opportunity to participate. The contribution of such participants is normally, by virtue of the nature of the Technology Assessment Function, truncated and directed to a special aspect of the problem context. Special interests of one kind or another are advanced as should be expected. Even the particular Committee may be a promoter of certain types of technological projects. Assuming, however, that the outcome in deciding what action to take is based upon the resultant of the conflicting views advanced, one must ask whether this procedure provides for a fully adequate assessment. We have noted that the assessment system for any particular technological application is made up of sub-systems, each with differing objectives, resources, capabilities, and projects, and can supply only a partial assessment of the total problem. Since so many of the techno-social problems with which we must deal today are extremely broad in their social reaches, is it not absolutely essential that we recognize an additional dimension in the concept of an adequate assessment?

Congress, as has been noted, is at the apex of the Technology Assessment Function. Congress is, in general, less constricted in its capability to approximate a Total Problem Assessment than is the Judiciary, the Executive, the Regulatory Agencies, private assessment entities, the economic market, or even ad hoc commissions established for the explicit purpose of making a total assessment. Congress has the ability to extract or compel almost a full spectrum of informational inputs, despite such occasional obstacles as Executive Privilege. In this connection, it has persuasive powers beyond

strict Constitutional authority. It is the ultimate authorizing, funding, and oversight branch, a fact hardly necessary to mention. Congress translates assessments into action-projects and programs. But the question remains as to whether information and analysis of the comprehensiveness and reliability needed for a Total Problem Assessment of many techno-social problems is now available. It seems doubtful.

Perhaps through greater effort to systematize the continuing oversight of the adequacy of assessment systems Congress could improve the quality of the data it receives and acts upon. Congress could probably obtain additional assistance from the Executive and Regulatory Agencies if it demanded more comprehensive submissions of data, including the range of interactions and social impacts that should be examined in connection with any new proposal. At the least, response to this demand would be interesting. But in fairness, it would be necessary to provide many agencies with resources for policy analysis they do not now possess. Even so, while improved in-house assessments might be helpful, there would seem to be an imperative need for a separate structure of assessment mechanisms and processes (assessment sub-systems) which would directly support the Total Problem Assessment approach. This notion has been referred to above as adding a new dimension to the "public interest," one independent of any special, partisan interest. The assumption made is that there may be a "public interest" that, in some instances, will be something more or different than the resultant of the usual partisan interest conflict. At least this is an assumption which might be explored. Some assessment sub-systems now make a significant

contribution of this nature, as for example the Science Policy Research Division, Legislative Reference Service, of the Library of Congress.

But again, the technology assessment function in this country is vast and complex. It seems unlikely that one monolithic evaluator, however well supported, can do the job. Such an arrangement would obviously have many other disadvantages. One might think of a structure of several entities, or Assessment Centers, possibly but not necessarily being associated with other community institutions. Wherever located or however financed, they would have several common and indispensable characteristics: They would be independent, devoted to the Enlightenment Process--not Power. Their ultimate responsibility would be to the Public, even though their assessments might be utilized primarily by legislative bodies, particularly the Congress. With respect to those patterns of techno-social problems each might undertake to assess, the approach would be in terms of Total Problem Assessments. They would also monitor and appraise the adequacy of relevant assessment systems. They would develop the data banks essential to this task. They would be neutral forums for soliciting the fullest range of relevant views in the selected problem areas. They would report fully on the basis of assessments made in terms of information sources, assumptions made, and identifiable decisional components so that such assessments could be critically and systematically compared with other assessments. They would not be merely an "on call" activity, subject to any and every agency's demand for an instant response to a request. A basic purpose of such an institutional arrangement would be, however, to anticipate emerging problem areas so that useful assessment information could be supplied in a timely and orderly fashion.

Clearly, there would be some difficult problems relative to the operational procedures. What would be the ground rules for obtaining essential material if classified by a government agency? What procedures might be developed to obtain relevant information from resisting private sources? What information might be relevant but (for reason of other strong social purposes such as encouragement of economic competition) not available to such entities? Who would support such Centers? Would it not be in the public interest for Congress to do so even at the risk of occasional embarrassment to particular Committees or to other agencies of government? But support should probably be diversified if possible. In any event, it will be necessary that substantial support be supplied to perform the job properly. This must be a Continuing function. Further, a long learning curve is to be expected and it will take time to organize the resources and engage the quality of professionals who can cope with this type of task and who are dedicated to the importance of the function.

But Congress cannot perform the entire technology assessment function alone. What Congress does need is the competent, comprehensive, and continuously current assessment data upon which it can confidently take action with reference to programs involving particular technological applications. The suggested structure, or a similar one, might very well provide the means by which the Congress can be confident that it is continuously aware of the status of the many dimensions of the Technology Assessment Function

A group of Assessment Centers stressing the Total Problem Approach to assessment would provide the type of support essential both to the needs of

Congress and to the general public. The Assessment Centers would assume the major burden for data collection and organizational analysis relieving Congress of the necessity of having to resort to limited staff resources for this purpose. Instead of having to rely upon the relatively haphazard procedure of picking up bits and pieces of hopefully relevant assessment information on particular applications, or at best, having to rely upon the partial assessments of a fragmented assessment system, the Congress would have an orderly way of keeping informed on all significant techno-social problem contexts, existing and emerging. The loci for Total Problem Assessment would be fixed. While the various Centers would cover somewhat different areas of the Technology Assessment Function, Congress would know which one was giving attention to what Assessment System (meaning to which technological applications--existing and prospective).

Such Centers could not only provide timely and reliable inputs into the final Congressional assessments but would be continuously sensitive to signals of impending or prospective severe detrimental impacts of technological applications. The Assessment Centers would contribute to continuity of the assessment function with reference to particular techno-social problem contexts. With such continuity should come a higher degree of reliability, less waste in terms of duplication of effort, and a higher level of confidence in the assessments made. The adequacy of performance of the assessment systems for the more significant technological applications would be appraised, including pointing out deficiencies in the assessment sub-systems--whether a lack of assessment mechanisms or weaknesses in the evaluative processes of

such assessment mechanisms. The Centers could identify the necessary outputs needed from various assessment sub-systems before a Total Problem Assessment would be feasible. They could bring to the attention of Congress the need for timely consideration of given applications instead of leaving such assessment efforts to chance, or to the challenge of one or more influential participants, or to the necessity of confronting "crises" where technology has "run wild," or to mere routine statutory or customary responsibility for oversight. The Centers could further indicate the scope of the social sub-system that could optimally be considered--range of relevant social interactions and effects. Or, in instances of prospective technological applications where a regularized assessment system does not exist, the Centers could recommend either the establishment of a new entity or an ad hoc commission as an initial approach to a Total Problem Assessment.

In any event, there is no escaping the need for the foregoing assessment tasks if the Congress is indeed concerned about the adequacy of the National Technology Assessment Function. It appears highly unlikely that we shall ever gain confident control over technological development and technological applications until we have provided the means by which the closest possible approximations to Total Problem Assessments can be made. But this will remain an elusive goal unless certain entities are given the responsibility for Total Problem Assessments (including formal authority insofar as essential to the assessment function) and the resources necessary to adequately perform this enormous task of assessment information management.

VI. Concluding Remarks

The diversity of approaches that may be taken to the analysis of the Technology Assessment Function and the multiplicity of alternative arrangements which may be devised for the management of this Function suggest the need for some further clarification of the assumptions upon which the suggestions of Part V rest. The Total Problem concept of technology assessment is the approach herein adopted. This concept involves a Comprehensive Information Management activity having an "objective" orientation to the assessment function. It would not assume a prosecutorial, partisan stance, one primarily concerned with seeking out adverse impacts of technological applications. On the contrary, the Total Problem approach to technology assessment would be concerned with monitoring the performance of technology assessment systems relevant to each of the major Techno-Social problem areas, recommending Optimum Social Sub-systems for interim assessments, identifying opportunities for the application of technology to the solution of social problems and seeking out and publicizing existing or prospective detrimental impacts, especially in those problem contexts where such information is unlikely to come to the attention of relevant users or other affected members of the public through normal information channels. The stance of such an activity would be neutral. Its information management functions would be comprehensive. An assumption is made here, which is certainly open to debate and testing, namely, that even "shocking misapplications" of technology can more readily and reliably be identified and avoided through continuing monitoring of all significant techno-social problem areas than by a "hunch-sampling"

technique. In time, however, systematic selective sampling may be an adequate substitute for the Total Problem Approach both with respect to identifying opportunities for the effective application of new technologies to social problems as well as identifying probable detrimental impacts of new applications.

One basic purpose of this paper has been to examine certain notions such as Fragmentation of Assessment Systems, the Total Problem Assessment Approach, Optimum Social Sub-System for examination in particular assessments, and Adequacy of assessments. A second basic purpose has been to pose two critical and interrelated questions: 1) What is the magnitude of the Technology Assessment Function? and 2) What is the level of support required for the effective performance of this function? It has not been the purpose of this paper to propose a final organizational structure for the execution of the function. Hopefully, feasible alternative structures will follow from an inquiry into the two questions posed above. In this connection, the Assessment Centers described are primarily intended to suggest the level of effort and the quality of performance that would be required to maintain Total Problem Assessments of all major Techno-Social Problem areas rather than to reflect a hard and fast proposal for an organizational structure that could accomplish the overall assessment task.

It follows from the comments in the preceding paragraph that it was not the purpose of this paper to give attention to the complex of questions that arise in designing a mechanism or combination of mechanisms that might be employed in establishing the linkage between the assessment function (informa-

tion management) and the official decision function--the Congressional political arena. This problem involves many intricate dimensions which are now being considered by other study groups.

Footnotes

[1]Saturday Review, March 2, 1968, pp. 50 and 54.

[2]See Congressional Record, 91st Congress, 1st Session, Wednesday, January 29, 1969. Senate Resolution 78, Vol. 115, No. 19.

[3]R.J. Forbes in Technology in Western Civilization 29 (1967).

[4]See, e.g., Mange, Alyce Edythe, The Near Eastern Policy of Emperor Napoleon III, University of Illinois Press, Urbana, Illinois, 1940; Hallberg, Charles William, The Suez Canal: Its History and Diplomatic Importance, P.S. King and Sons, Ltd., London, 1931.

[5]A. Hunter Dupree, Science in the Federal Government 36 (1957).

[6]A. Rupert Hall, "Early Modern Technology to 1600," in Technology in Western Civilization 83 (1967).

[7]Eugene S. Ferguson, "Steam Transportation," in Technology in Western Civilization 301 (1967).

[8]Ibid.

[9]Derry and Williams, A Short History of Technology 548 (1961).

[10]Dupree, supra, note 5, at 38-39.

[11]John G. Burke, "Bursting Boilers and the Federal Power," Technology and Culture, Winter 1966, Vol. VII, at 18.

[12]Id. at 13-23.

[13]Dupree, supra, note 5, at 164.

[14]Id. at 236-238.

[15]Id. at 238.

[16]Id. at 235.

[17]A. Rupert Hall,"Culture, Intellectual and Social Foundations, 1600 - 1750," in Technology in Western Civilization 114 (1967).

[18]Id. at 114-115.

[19]See Singer, E.J. Holmyard, A.R. Hall, and T. Williams, A History of Technology, Vol. IV (The Industrial Revolution 1750 to 1850), Section on Effects of Technology on the Conditions of the People 831-835 (1958). "The passing of Lord Shafesbury's Mines Act in 1842 and of a series of Factory Acts from 1802 onwards helped to prevent some of the worst abuses." Id. at 831.

[20]Derry and Williams, supra, note 9, at 709.

[21]Elting E. Morison, Men, Machines and Modern Times, 208 (1966).

[22]The doctrine of "freedom of contract" had its source in the Due Process Clause of the Constitution. The 14th Amendment, making the Due Process Clause of the 5th Amendment applicable to the States, prohibits the deprivation of liberty without the due process of law. The notion of "liberty" was interpreted to include "freedom of contract" in the sense (highly over-simplified) that governmental intervention would not be tolerated in the making of contracts even in those instances wherein the contract was between an individual and a hugh corporate enterprise (person). Many early attempts by the States to protect industrial workers through minimum wage and maximum hour laws were defeated by the invocation of this doctrine. Innumerable articles have been written on this topic. See, e.g., McCloskey, Economic Due Process and the Supreme Court, in Supreme Court Review 34 (P. Kurland, ed., 1962). Early "political" efforts to place some curbs on rampant industrialism included the Interstate Commerce Act of 1887, the Sherman Anti-trust Act of 1890, and the active policy of Presidents Theodore Roosevelt and Taft to prosecute the "trusts." See Morris, Great Presidential Decisions 323-325 (1960) (including the First Annual Message of President Roosevelt of December 3, 1901). A "positive" thrust was given to due process interpretation in the case of West Coast Hotel Co. v. Parrish, 300 U.S. 379 (1937), (involving minimum wage regulation for women), wherein the Supreme Court (Chief Justice Hughes) stated:

> But the liberty safeguarded is liberty in a social organization which requires the protection of law against the evils which menace the health, safety, morals, and welfare of the people. Liberty under the Constitution is thus necessarily subject to the restraints of due process, and regulation which is reasonable in relation to its subject and is adopted in the interests of the community is due process. Id. at 391.

See discussion in Miller, "Toward the Techno-Corporate State: An Essay in American Constitutionalism," 14 Villanova Law Review 1, 35-37 (1968) (Program of Policy Studies Reprint No. 3).

[23]This theme has infinite variations, and in some respects may seem, and is, inconsistent with the prior proposition supported by active intervention of the Federal Judiciary in striking down State legislation designed to protect the health, safety, and general welfare of its citizens. Further, the Federal Government had taken control over inter-state railway rates from the States and placed it in the ICC. But there have been many areas in which the Federal Government has been slow to move such as establishing control over adulterated foods and useless or harmful drugs. Dupree's Science in the Federal Government, supra note 5, provides many examples. The delicate relationship that exists between Federal and State/Local control over transportation activities is vividly demonstrated in statements from the Report of the Committee on Public Works of the U.S. Senate on S. 2658, March 27, 1968, Report No. 1026 at 1 (re highway and motor carrier regulation) and the Report of the Senate Committee on Commerce to accompany H.R. 3400 on "Aircraft Noise Abatement," Report No. 1353 of July 1, 1968, at 6-7 (re air transportation).

[24]See Dupree, supra note 5, at 177-181.

[25]Id. at 48.

[26]For example, the Motor Carrier Act of 1939, 49 Stat. 543; the Civil Aeronautics Act of 1938, 49 U.S.C.A. S.401; Federal Power Act of 1935, 49 Stat. 847, 16 U.S.C.A. S.824 (FPC). (CAB); See generally, Kauper, Constitutional Law 151-155 (1960); Davis, Administrative Law (1965), Cha. I.

[27]See Network Broadcasting 53 (1958). House Report No. 1297, 85th Congress, 2nd Session. Report of the Committee on Inter-state and Foreign Commerce. The Communications Act of 1934, 48 Stat. 1064, 47 U.S.C., S.151 et seq. (1934) was an attempt by Congress to consolidate the various statutes by which Congress had previously supervised various modes of communication. The 1934 Act, insofar as it related to broadcasting, essentially incorporated the Radio Act of 1927, 44 Stat. 1162 (1927). The Federal Communications Commission was established pursuant to the Communications Act of 1934.

[28]See Mayo, "The New Technology and National Goals: Some Implications for Legal-Policy Decision-Making," 37 Notre Dame Lawyer, 33, 42 (1961)

[29]The Marine Resources and Engineering Development Act of 1966, Public Law 89-454.

[30]U.S. Congress, House Committee on Science and Astronautics, Subcommittee on Science, Research and Development, "Technology Assessment," Statement of Emilio Q. Daddario, Chairman, July 3, 1967, Committee Print, 90th Congress, 1st Session, at 14.

[31]Congressional Record, 91st Congress, 1st Session, Wednesday, January 29, 1969. Senate Resolution 78, Vol. 115, No. 19.

[32]Id. at 7.

[33]Illustrative of this point is the following extract from the Report by the Jet Aircraft Noise Panel of OST:

> In recent years an industry-wide organization, the National Aircraft Noise Abatement Council, has been engaged in developing a broad program of studies and research aimed at reduction of jet aircraft noise. However, a major difficulty in developing practical approaches has been inhibition of initiative by any one of the several groups involved because of conflicting economic and other interests. For example, it is difficult for engine manufacturers to initiate costly engine modifications because airline operators claim they cannot afford to pay for them; for economic reasons, some airline operators insist on maximizing the payload to be carried with a specific engine/airframe combination in spite of resulting take-off noise levels objectionable to communities near the airports; some local governments in communities bordering on airports are not willing to accept the economic consequences of zoning constraints or the exercise of eminent domain and argue that aircraft noise rather be reduced by improving engines, off-loading aircraft and steeper take-offs and landings; and many affected residents object to being uprooted, and having to give up long-time personal and community associations.
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> (Report of the Jet Aircraft Noise Panel, Office of Science and Technology (March 1966) entitled "Alleviation of Jet Aircraft Noise Near Airports" at 4.

[34]See James D. Hill, "Liability for Aircraft Noise--The Aftermath of Cuasby and Griggs," 19 Miami Law Review, 1, 15 (1964).

[35]Id. at 15-20.

[36]Id. at 20-22.

[37]Report No. 1353 to accompany H.R. 3400 at 2. 90th Congress, 2nd Session.

[38]DOT/FAA Notice of Proposed Rule Making, Docket No. 9337, Notice No. 69-1, "Noise Standards: Aircraft Type Certification," of January 3, 1969, at 2.

[39]Section of the FCST Report entitled: "Objective of the Task Force."

[40]Report No. 1353, supra note 36, at 2.

[41]See discussion of the concept of "technological fix" in Weinberg, "Social Problems and National Socio-Technical Institutes," in Applied Science

and Technological Progress 415 (1967) (Report to the Committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences).

[42]Science, January 24, 1969, at 359.

[43]Ibid.

[44]Jones, "Systems Approaches to Multi-Variable Socioeconomic Problems: An Appraisal" at 23-24 (Staff Discussion Paper, Program of Policy Studies in Science and Technology, The George Washington University, 1968).

[45]Mayo and Jones, "Legal-Policy Decision Process: Alternative Thinking and the Predictive Function," 33 Geo. Wash. L. Rev. 320, 349-351 (1964).

[46]Report of the Committee on Public Works, U.S. Senate, of March 27, 1968, entitled, "Vehicular Weights and Dimensions," to accompany S. 2658, at 1. (Hereinafter referred to as Report No. 1026).

[47]Report No. 1026, supra note 44, at 12.

[48]House Document No. 354, 88th Congress, 2nd Session, "Maximum Desirable Dimensions and Weights of Vehicles Operated on the Federal Aid Systems," of August 19, 1964.

[49]Report No. 1026, supra note 44, at 12.

[50]Id. at 3.

[51]House Document No. 354, 88th Congress, 2nd Session, "Maximum Desirable Dimensions and Weights of Vehicles Operated on the Federal Aid Systems," of August 19, 1964.

> To solve the serious problems developed by the analysis of the available but incomplete data in the report, a policy of utilizing progressive steps to implement any findings with regard to vehicle standards has been adopted. It is contingent on the continued support by the Federal and State governments of existing levels of funding. This policy of progressive implementation provides an adequate interim solution for States; an upgrading of standards after a reasonable period on the basis of present knowledge; and a program for developing a further improved approach to this increasingly complex problem. (Italics added.) Id. at 17.

[52]Presidential Advisory Committee Report, "A Ten Year National Highway Program," at 1, attached to the Message of the President, "National Highway Program," of February 22, 1955. Referred to the Committee on Public Works, 84th Congress, 1st Session, House Document No. 93.

[53]See President's Message, supra, note 50.

[54]See Report of the Committee on Public Works, House of Representatives, to accompany H.R. 10660, on the Federal Highway and Highway Revenue Acts of 1956, House Report No. 2022, April 21, 1956. Committed to the Committee of the Whole House on the State of the Union.

[55]See "A Ten Year National Highway Program," supra note 50 at 3.

[56]See for example in House Document 93, supra note 50, at 24, in reference to fact that the President's Advisory Committee "made no attempt to evaluate possible revenue from rentals to concessionaires serving the traveling public nor has it attempted to estimate the additional tax revenue which will result from the creation of new values in real property resulting from the improvement."

[57]P.L. 85-381, 72 Stat. 89 (1958); P.L. 86-342, 73 Stat. 611 (1959); P.L. 87-61, 75 Stat. 122 (1961); P.L. 88-157, 77 Stat. 276 (1963).

[58]P.L. 86-493, 74 Stat. 162 (1960).

[59]P.L. 88-206, 77 Stat. 392 (1963).

[60]P.L. 89-272, 79 Stat. 992 (1965).

[61]P.L. 90-148, 81 Stat. 485 (1967).

[62]P.L. 85-684 (1958).

[63]P.L. 87-637, 76 Stat. 437 (1962)

[64]P.L. 88-201, 77 Stat. 361 (1963).

[65]P.L. 89-139, 79 Stat. 578 (1965).

[66]P.L. 89-563, 80 Stat. 718 (1966).

[67]P.L. 89-564, 80 Stat. 731 (1961).

[68]P.L. 90-495, 82 Stat. --- (1968).

[69]P.L. 89-285, 79 Stat. 1028 (1965); P.L. 90-495, 82 Stat. --- (1968).

[70]P.L. 89-670, 80 Stat. 931 (1966).

[71]DOT (Bureau of Public Roads) Policy and Procedure Memorandum of January 14, 1969.

[72]The American Automobile Association launched a full page ad attack on the bill which exibited a cartoon of a trucking "road hog" with the caption: "Mr. Congressman: Will you let the trucking lobby run over 104 million motorists?" See Washington Evening Star, July 15, 1968, back page.

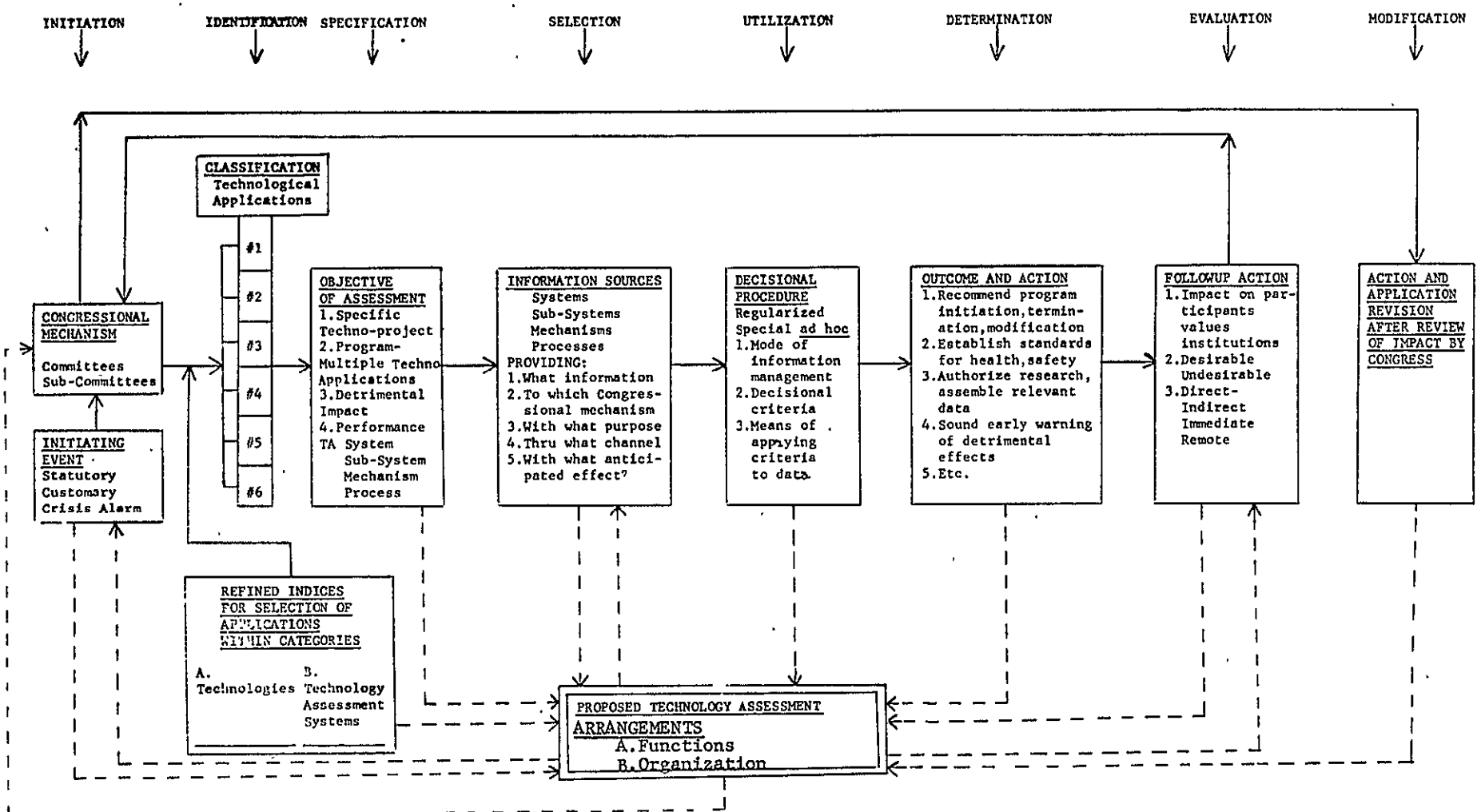
[73]Vol. 114, No. 124, July 18, 1968, at E. 6622.

[74]See note 32, supra.

[75]Nor should any one agency necessarily have the formal authority as contrasted with having the essential resources and the responsibility for Total Problem Assessment. Formal authority here refers to the official decision function (authorization and program implementation) whereas responsibility refers to the information management (assessment) phase.

TAF Congress - Provisional Schematic

Chart A



Question: How can the proposed Technology Assessment Arrangements improve the performance of each of these phases or operations in the Technology Assessment in terms of time, cost and reliability?

AIRCRAFT NOISE CONTEXTUAL MATRIX

REPRESENTATIVE ANALYTICAL APPROACH TO
1) Technology Assessment
2) Utilization of R&D Capabilities
3) Organization for Technological Innovation

NATIONAL PROBLEM AREAS	SPECIFIC PROBLEM CONTENT	POLICY ANALYSIS / PROJECT PLANNING / PROGRAM IMPLEMENTATION
(Illustrative)	(Specification of Social Sub-System)	(Illustrative)
A. Urban Affairs	A. Aircraft Noise	POLICY ANALYSIS
1 Transportation	1. Civilian A-C	Problem Context
a) Rail	2. Source Abatement	Conditions
b) Highways		Objectives
c) Waterways		(Specific)
d) Airways		Alternatives
e) Etc.	B Social Sub-System	Model Construction
2. Environmental Quality Control	1. Initiating Event	Outcome Projection
a) Air Pollution	2. Conditions and Trends	Impact Prediction
b) Water Pollution	3. Goal-Objectives Public Interest	Evaluation
c) Radiation	4. Participants Operating Affected	PROJECT PLANNING
d) Aesthetic Debasement	5. Perspectives of Participants	Program Definition
e) Noise	6. Capabilities of Participants	R&D
f) Etc.	7. Practices of Participants	Needed
	8. Other Relevant Characteristics	Completed
2.e) Noise		In Progress
1) Construction		Proposed
2) Automobiles		Prototype Testing
3) Aircraft		Simulation
4) Etc		Experimental Operations
		Program Organization
		Government
		Private
		Other
		Resource Development
		Administration
		Funding
		Facilities
		Skills
		Assessment Mechanisms and Processes
		PROGRAM IMPLEMENTATION
		Program Authorization
		Program Initiation
		Program Operations and Management
		Program Monitoring
		Feedback Links to Preceding Phases

ASSESSMENT SYSTEM →
Assessment Sub-Systems Mechanisms

DOT/FAA · NASA · OST/FCST · BOB · HOUSE COMMITTEES · SENATE COMMITTEES · DOD · HEW · HUD · INTERIOR · CAB · JUDICIARY · NATIONAL TRANS. SAFETY BOARD · TRANSPORTATION AUTHORITIES · ENVIRONMENTAL CONTROL AUTHORITIES · LOCAL GOVERNMENT UNITS · FOREIGN NATIONS · AIRCRAFT ENGINE MANUFACTURERS · AIRLINES · FOREIGN AIRLINES · AIR TRANSPORT ASSOCIATION · PRIVATE AVIATION · AIRFRAME MANUFACTURERS · AIRPORT OPERATORS · FUEL PROCESSORS/DISTRIBUTORS · NAT. AIRCRAFT NOISE ABATEMENT COMM. · ADJACENT LAND USERS · CIVIC ASSOCIATIONS · NAS/NAE · SPECIAL STUDY GROUPS · PROFIT/NON-PROFIT PFP · UNIVERSITIES · SPECIAL ADVISERS · CRITICS—GENERALLY

SUB-PROBLEM CONTEXTS
(Illustrative)

- Engine Design
- Airframe Design
- Flight Operations
  - Techniques
  - Patterns
- Noise Level v Safety Precautions
- Formal Noise Standards
- Continuing Noise TAF
- Land Use Management
  - Analysis
  - Planning
  - Program Implementation
    - Zoning
    - Building Codes
    - Insulation
  - Incentives to Noise Abatement Measures
- Financing A-C Noise Abatement Programs
- Psychoacoustic R&D
- Educational Programs
- "Lead" Agency Designation
- Matching PFP Capabilities to A-C Noise Abatement Needs
- Aircraft Noise Litigation
- Military Aircraft and the A-C Noise Problem

COMMENT

In order to analyze, for example, the probable degree to which any of the noted participants might contribute to the assessment of the aircraft noise problem or apply R&D capabilities or other capabilities to the abatement and control of the problem, accurate data must be secured and analyzed with respect to each of the participants, such as:

1) Perspectives (Objectives, Associations, Etc.)
2) Formal Authority - if any
3) Resources in general, including the extent of investment in the technology
4) Capabilities having specific application to aircraft noise abatement and control
5) Practices relevant to this problem
6) Proposed future activities relevant to the technology or to the noise problem

Discussion of THE MANAGEMENT OF TECHNOLOGY ASSESSMENT

Dr. Mayo opened the discussion with a review of some of the more important points in his paper. The technology assessment function, he held, can be thought of as lying between two extremes. In the first, the assessment process is viewed as "highly selective, restrictive, investigatory approach" which focuses on trying to uncover the serious adverse effects or potential benefits of particular technological applications. In the other, the assessment function involves

> ...taking a comprehensive information management approach to technology assessment which would attempt to do some initial appraising and...continuing monitoring of all of the major techno-social problem areas in society.

Although there "...clearly are any number of alternative ways in which one might go about treating technology assessment," Dr. Mayo chose to start from the broad base indicated in the second extreme mentioned above.

Dr. Mayo made a brief reference to the isolation of various study efforts directed toward the understanding of the assessment process when he noted the need he had found to include some definitions of the terminology used in the paper. "It seemed to me," he commented, "that a bit of standardization of certain components of the technology assessment function is helpful in trying to analyze these problems."

He then introduced the notion of the total problem approach to technology assessment. This involves looking at a technological application with the intent of examining all of the significant impacts of that application on society. Such an approach was contrasted to the system of

truncated or partial assessments which characterize current attempts at the appraisal of technology. Truncated assessments occur because of various factors including the limited authority of most bodies engaged in the assessment process, limited capability, and scarcity of resources. Dr. Mayo noted that

> ...it is very infrequently...that we have a situation of a total problem assessment being made. We do not have entities in our technology assessment structure which have the responsibility, formal or voluntarily assumed, for total problem assessment.

The paper discussed one example of this lack of overall responsibility: The aircraft noise problem. The example of congressional consideration of truck size and weight regulation demonstrated another failing of the assessment process, the lack of any central information centers which are capable of providing Congress with the kind of information necessary to discern a broad range of social impacts of a given technology. This in Dr. Mayo's view is a glaring deficiency but one which can hopefully be remedied:

> There is a possibility that even if it is not feasible to do any substantial reorganization of the government (and) even with the fragmentation of authority for programs..., the information base upon which these programs operate and upon which decisions are made...can be coordinated in some way.

He suggested the need for new kinds of mechanisms in support of Congress to provide an effective information base. To this end he proposed a number of assessment centers with the capability to take a total problem approach to technology assessment.

The Need for A New Organization

An agency representative was concerned that the paper might be

attacking the wrong problem in attempting to find a way to introduce a broad, total problem approach:

> I'm not sure that the question is most fruitfully formulated in terms of whether there is any place that Congress can go to get information. I suspect that...if one combines the Legislative Reference Service and the resources available through NAS, NAE, and the National Research Council that there is structurally no dearth of places that Congress can go to get specific answers to well formulated questions....

Congress' problem, in his view, is the lack of any "coherent focus for all of the diverse pressures that exist" so that the correct questions can be asked in a timely way. The need, then, is for an improvement in the ways that Congress formulates the questions that must be answered for effective assessment.

It was noted by a professor that it is often difficult to separate the group asking a question from the kind of answer which is received. He claimed that under the current system the "...group that asks the question knows pretty well in advance what the answer will be." He felt that somehow "...the group that answers the questions must be divorced from the group that asks the questions" and decides who will answer them. (A dissenter, a Congressional staff member, interjected, "Then nobody will pay any attention to the answer.")

A Legislative Reference Service researcher agreed that the problem of framing questions is a crucial one but he noted that one needs some basis to ask a good question and to screen frivolous and inconsequential concerns. Some information, perhaps even some research in advance of the emergence of an assessment problem, is thus necessary to allow the Congress

to understand the issues involved and investigate all of the important aspects of a problem.

An industry representative, however, was not happy with the proposal to establish technology assessment centers:

> When I read about a suggestion of creating a new body of any sort to add to the multiplicity of bodies we already have, I tend to throw up my hands. We have more than enough already.

A Congressional aide agreed that the concept of a new body or bodies was not workable. He saw any such body as merely another power base and claimed that Congress would never be willing to support another political power base. Another participant took issue with this view. He contended that Congressional interest and support would depend only upon "...how high on the list of society's worries" technology assessment comes. In his view it is quite likely that Congress will soon recognize the magnitude of the task it must perform in this very rapidly changing world and will "someday begin to array itself with supporting institutions with quite diverse characteristics."

A Congressional aide pointed out that the problem of securing scientific advice for Congress is not a new one. Various proposals for obtaining such advice have been brought before Congress, particularly in the late 1950's and early 1960's. The issue was resolved at that time through the creation of the Science Policy Research Division (SPRD) of the Legislative Reference Service. The speaker was careful to point out that such a location was chosen for the new body because of the control which Congress could have over the work done by the Division. "Congress pays the salaries," he noted, "but they (the LRS) have absolutely immutable

ground rules...as to how they operate." Another participant didn't feel that the SPRD represented an adequate solution of the problem. He believed that the staff of twenty-five was not sufficient to handle the job of providing scientific information to Congress. The National Academy of Sciences was suggested as a possible source of information; it has the advantage of being able to draw on a "broad and deep body of expertise." But a professor questioned the effectiveness of the NAS as an assessment mechanism because "...the Academy has no continuity, or very little, in given areas." An industry representative, however, found the lack of continuity "...a plus because I would hate to have the same guys passing judgement on everything."

While expressing agreement with the broad thesis of the paper, another participant commented that he "...would not quite be prepared to come down strongly on the point that ... total problem assessments don't occur under the present system." He cited flouridation and nuclear testing in the atmosphere as two examples of problems which were assessed on the issues involved. An agency representative noted, however, "...that one might take the two examples mentioned and make something of a classic case study of the inadequacy of the existing assessment method." The two cases demonstrate the typical problem of assessments carried out by agencies which are committed to the advancement of given technologies, in these cases the Public Health Service and the Atomic Energy Commission. He conceded that

> ...in neither case can one say that the system was wholly a disaster but I think that in both cases it is fairly clear that a more objective kind of assessment might have been obtained if there were a more neutral source of funds and of evaluation.

To this, the first speaker replied that he had not meant to convey the impression that technology assessment is in good shape in government but only to indicate that he thought that, on occasion, something approaching a total impact assessment is attained. He added that he is "...in favor of creating more effective and organized and focused machinery to serve society" in the appraisal of the consequences of technology.

The Role of Ad-Hoc Studies

Dr. Mayo asked the group to consider the current method of commissioning ad-hoc studies when assessment needs arise. He mentioned the recent establishment of commissions to study the effects of DDT and SST and asked what the purpose of such action is:

> Why hasn't somebody been in a position to have gathered (the information)...so that we would have the data right now on what we know and what we do not know.... Is there no place that you can go to find the accumulated information that gives you all the data on the prospective impacts...?

Several participants did not seem as concerned with the commission method of assessment and pointed out advantages that can accrue from ad-hoc assessments. An agency representative pointed out that new assessments are necessary after a change in administration because previous "...alleged fact-finding studies were affected---by judgements of people who no longer hold responsibility." In disagreement with at least one other seminar attendant, he held that these reviews of the facts and conclusions of prior studies are not diversionary or stalling tactics but are the results of a new administration taking its responsibility seriously. A professor believed that repetitive assessments were necessitated by the nature of the information available. He found no fault in a system which examines

"exactly the same problem over and over again in terms of new criteria and new data that are available." The "continuing process of re-evaluating the same problems...probably is desirable." He thus took issue with the implication that if we only had a way to gather all of the information our assessment problems would be solved. Varying criteria and new ways of looking at old information necessarily make assessment a continuing process.

One speaker, an industry representative, went so far as to suggest that the commission mechanism be the principal method of assessment:

> I would propose that each question, as it comes up, should be approached by an ad-hoc collection of specialists with knowledge relevant to what the problem is.

In this way the problem of aircraft noise, for example, would be examined by different people from those who study the DDT problem.

Public Participation

The discussion turned to the recurrent topic of the role of the public in the assessment process. An agency official noted that the paper did not clearly indicate to whom the assessment centers were to report, Congress or the public. It was suggested that any assessment mechanism could report to the public while at the same time its findings could be useful to the Congress. The agency representative stressed the important role which the public must play. Congressional interest in assessment problems, he noted, is not without public impetus. He was thus concerned with the emphasis on Congress as the focal point of technology assessment; the public impetus for Congressional action, unles it is fostered, could conceivable die away. A brief discussion of the role of magazines such

as Environment followed; the importance of such a public information service was agreed to by most of those present.

The Problem of Bias

A Congressional aide raised another thorny point which recurred throughout this series of seminars. He was concerned with the neutral or objective role which was proposed for the assessment centers mentioned in the prepared paper:

> How would your (Dr. Mayo's) system bring out the negative effects unless the centers were, in fact, to adopt other than a weighing or neutral stance as you imply?

The resources of the proponents of most technologies enable them to marshal large numbers of facts whereas "those who are opposed generally are in a weaker position." The speaker thought that only through the establishment of some kind of advocate for the public interest could the assessment system make certain that all aspects of a technological application would be surfaced. Dr. Mayo commented that this proposal did not preclude the establishment of such an ombudsman or advocate; that role may in fact be necessary but it is only one step toward the implementation of a total problem approach to assessment. Another participant emphasized the need for more than one approach to the problem:

> I think the problems of technology assessment, social responsibility, and social accountability have to be exercised in a multiple context with all the limitations that go with it. You cannot lean on any one crutch....(What is needed is) a variety of efforts and energies directed toward a multiplicity of critical points of power, and hopefully when the need is there they will converge to produce an outcome that affects the quality of society.

A Legislative Reference Service representative noted that it is

crucial to recognize that technology assessment has two levels, one of which is connected with a technical problem and another which is involved in political matters. These must be separated in order to obtain effective assessments. In particular, the technical problem must be solved before the issue is thrown into the "political hopper." He claimed that this separation is really an easy one to perform if only the principals involved would put their minds to it. This point brought disagreement from several participants. Everyone present agreed with the desire to separate facts from value judgements but a university researcher noted "...in order to ascertain the technical situation you have to make many assumptions which are colored by political points of view" so that the suggested separation may, in fact, be impossible. An agency official agreed; one cannot always determine the technical facts before the political process begins to operate because the answers to technical problems often come late. The separation of technical and political is impossible since often "to generate support for needed research you need political muscle."

Conclusion

During the discussion period an agency official sounded a warning that can serve as a conclusion to this discussion and to the series of seminars in general. He noted that

> ...the range of possibilities in conducting a scientific investigation is almost infinite and that a scientific investigation is never conducted in a vacuum but is always guided by some kind of conjecture.

In technology assessments, the conjecture concerns the possible consequences of a new or existing technology. One must be wary of such

conjecture, the speaker warned, because almost always

> ...the problems people worry about at any given time turn out in retrospect,...not to have been the problems they should have been worrying about.

It should be the intent of those who study technology assessment to attempt to find ways of anticipating the correct and important problems which accompany the use of technology. Only then can decision-makers begin to devise policies which will maximize the beneficial impacts of technology while minimizing the detrimental consequences.

EDITOR'S COMMENT

One conclusion that can be drawn from this seminar series is that there is no one solution to the problem of finding adequate means of evaluating the effects of technological advance upon our society. No single proposal can close all of the gaps in the existing system. Information management centers, "negative" assessment boards, the Legislative Reference Service, and ad hoc commissions all solve parts of an existing problem but none, alone, can yield a truly adequate overall assessment. As several of the participants noted, what is needed is experimentation with a multiplicity of mechanisms that together can approach something like the total problem assessment discussed by Dr. Mayo in the final paper of the series.

Much of the study of technology assessment has been directed toward the development of a Congressional capacity to adequately appraise the consequences of technological applications. Although there was clearly a consensus among the seminar participants that Congress needs some help in this area, it became quite clear in the discussions that many people are unwilling to accept Congress as the focal point of technology assessment to the exclusion of other sectors of society. There was, for example, great interest throughout the series of discussions in the role of the public in the assessment process. The views expressed ranged widely, from those of some who believed that, in a democracy, all that is necessary to protect the public interest is a fully-informed general public to those of others who thought that the understanding of technological progress is beyond the ability of the lay

public and that meaningful decisions can be made only by scientific experts. The place of public participation has perhaps been neglected in most analyses of technology assessment. If this series of discussions provided no clear indication of the public's role, it at least raised some questions which should be answered. Can technological progress be explained to the public? What measures can be taken by interested laymen to make their point of view known in the face of the great amount of data and resources accumulated by vested interests? Can the public interest be stimulated by the impacts of any but the most pervasive and hazardous technological applications? How can a true public interest affect the decision-making centers of government? Who can fund and who will listen to advocates for the public interest? Mere statements that the public should play a part in the assessment process do not suffice; it is necessary to examine how the public can have an impact upon policy decisions which affect the public welfare. The questions raised are difficult without doubt but they have been neglected for too long.

Not all technologies pose the same sorts of assessment problems. As was noted several times in the discussions private and government-sponsored technologies must be approached differently. The seminar participants were by no means in agreement as to which was the more critical problem. Some contended that government-sponsored developments, particularly large-scale, highly accelerated programs, pose problems of scale and timing while operating independently of the market system which provides a check on private technological applications. But others noted that the market mechanism has failed in such cases as the manufacture of non-degradable detergents or pollution-producing automobiles (with the accompanying failure to produce an

alternative to the internal combustion engine) and expressed concern with the difficulty of finding ways to assure that private enterprise does not lead to widespread social and environmental problems. In an age when technological developments from any source can potentially cause irreversible changes in our way of life, it would seem that no single aspect can be neglected in the complacent belief that solutions to potential problems already exist or can readily be found.

There is an additional point which was implicit throughout much of the seminar series but which was never fully developed. "Technology assessment" has been gaining a reputation as an essentially negative endeavor. In the view of the editor and of many of the participants, this is unfortunate. It would seem that technology, if wisely applied, has the potential to solve more problems than it will create and to provide mankind with a fuller and richer life, free from the struggle for subsistence which has characterized earlier generations. But it cannot be denied that many new technologies carry with them dangers, often unforseen, which may threaten the very existence of civilization. If men are swinging from a view that technology is infallibly good to one which looks warily upon potential detrimental effects, this is perhaps because the missed opportunities resulting from a failure to apply a particular technology are not as clearly visible as the environmental degradation which results from the unchecked progress of other technologies. It must be recognized that consideration of <u>only</u> the potential benefits of technology can lead to irreparable harm. But at the same time, it must also be noted that emphasis on <u>only</u> the potential risks of technology can lead to technological stagnation with a concomitant loss of opportunity for the

improvement of man's way of life. To be worthwhile, technology assessment must have a dual goal. It should seek to identify the ways in which technology may be utilized to fulfill the needs and desires of man while it seeks to minimize or eliminate the dangers and harmful impacts of technological application.