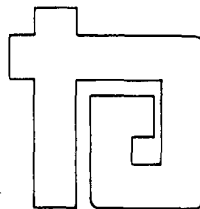
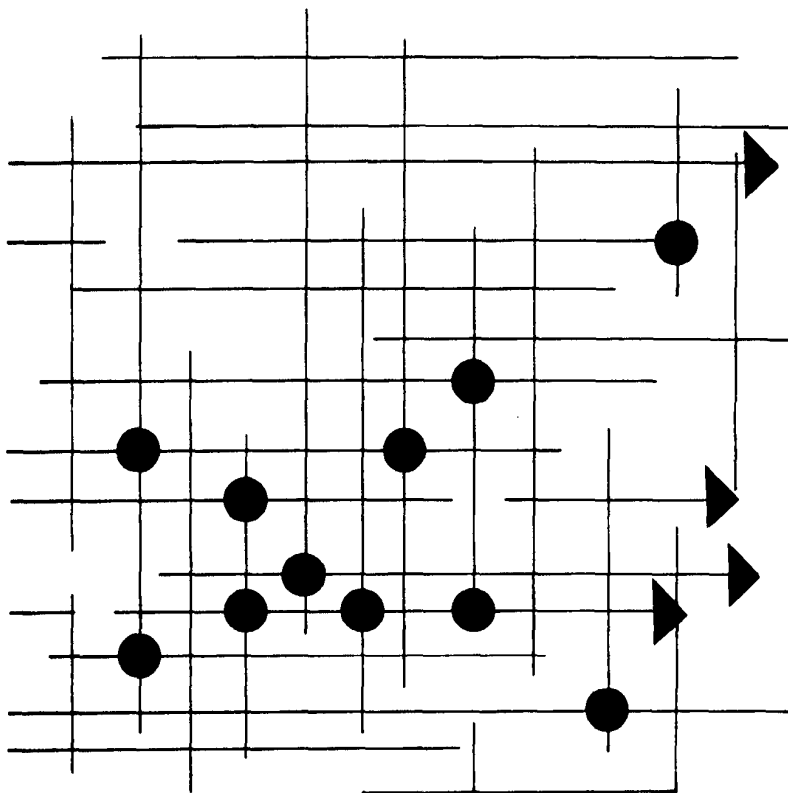


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In many countries academics, industrialists, government officials and growing numbers of the public are aware that there are ways man can assess the social, economic and environmental consequences of existing and potential technological initiatives. There seems to be acceptance of the idea that by means of analysis, planning and wise goal setting and policy making, man can enjoy more of the benefits of his advancing technology and less of its negative and unexpected effects. The name given this movement, or "social invention" as it has been termed, is Technology Assessment.

The International Society for Technology Assessment (ISTA) is a new world membership organization concerned with the conduct of these activities and studies. It is established as an international society with offices in Washington, D.C., U.S.A. The membership of ISTA is drawn from a variety of institutions, communities and persons all over the world, interested in the exploration and resolution of problems facing local, regional, national and international communities. Individual membership is \$28.00 (U.S.) per year and includes a subscription to the *Journal of the International Society for Technology Assessment: A Forum for Social Impact Evaluation*. The Society also sponsors a bi-annual International Congress and interim regional or topical meetings for which special rates are available to members. Reduced membership rates also apply to ISTA DOCUMENTATION, a paperback series of hard-to-get, new and timely TA literature. A newsletter featuring current happenings in the field is planned.

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Under the Cover

Cary Hershey and Elizabeth Sachter discuss the methods of baseline data collection employed by a Cornell University technology assessment of new mobile telecommunications technologies. The use of fieldwork and survey research in organizations where antecedent technologies are used is suggested as an efficient means, in many cases, to develop baseline data on newly emerging technologies.

J. Morley English presents a philosophical framework based on the view of the purpose of mankind as a part of the "grand design" of the universe. Because biological systems such as man are entropy accelerators, this leads to the suggestion that technology assessment should be made by examining the extent to which a proposed new technology contributes to the cosmic purpose of entropy increase. Morley notes that some entropy-increasing activities which threaten survival, such as pollution, require adaptive counter measures. These risks are the true costs which must be considered and weighted against the new technology.

George Humphries' article presents a view of the ISTA Regional Conference held in Ottawa, Canada, in February 1975. The subject of the conference was Technology and Growth, a topical subject then and now.

Danny A. Lubin's paper discusses the partially field-tested model (Techcom), which relates national resources policy actions to the attainment of social goals. In addition, recommendations are made for Techcom's implementation as a workable means of social evolution of public policy actions.

Frederick A. Rossini, Alan L. Porter and Eugene Zucker attack the problems which arise in T.A. due to the varying forms that a technology can take, and potential implementation in varying cultural and geographical contexts. They propose the concept of multiple technology assessments which consider these factors and which appear potentially more valid than the "one-shot" mode of assessment.

In February 1975, the National Academy of Sciences organized a working conference to explore the process of government decision-making to regulate chemicals in the environment. Edward J. Burger's paper presents a case study of the decision-making process regarding the regulation of polychlorinated biphenyls.

Philip L. Bereano's paper, "Technology, The Past and The Future", gives an overview of forecasting and social indicators and attempts to put them in a political context.

President's Message

Widely celebrated in America as the Bicentennial Year, 1976 also marks the end of Technology Assessment's initial decade of development. As such, 1976 offers a good opportunity to evaluate our progress and our prospects; the Second International Congress on Technology Assessment to be held in Ann Arbor, Michigan, in October, will provide the forum for such an evaluation.

Progress, at least according to superficial measures, is undeniable; the concept and the language of technology assessment have spread through much of the world; many national governments and international organizations have become involved in such policy-oriented analysis. The literature is vast, and still growing. Universities and other educational institutions offer courses in technology assessment. More importantly, there is now a respectable corpus of completed technology assessments, available in reports and books, which can be evaluated as to the soundness of methodology, the scope of analysis, and the potential utility of conclusions and recommendations.

Evaluating the actual impact of technology assessment on decision-making and on public wisdom is more difficult. For any decisions, it is difficult to identify, much less measure, sources, consequences, and wisdom with any confidence. Further, attitudes of the public and of the decision-makers have so clearly shifted in this decade of environmental concern, growing scarcity, political upheavals, international violence, and economic instability, that "public wisdom" is itself difficult to determine.

Yet those who closely observe the decisional and policy arenas can hardly doubt that technology assessment has had an impact. Here, although I seek and welcome all information as to what is developing on the international scene, I can most usefully speak from my vantage point in Washington as an observer of the American Government. The superficial signs of progress are again plentiful. The words "social impact analysis" and "potential secondary consequences" appear with increasing frequency in government research solicitations, statements of agency missions, and even job descriptions. Broader and harder questions are asked when technological projects and programs are presented for funding (e.g., the National Commission on Electronic Funds Transfer). Encouragement of innovation is phrased in terms of finding solutions to national problems. And in every federal agency at least a few people can be found, like leaven-

ing in the bureaucratic dough, seeking ways to make more prescient and sensitive decisions.

Nonetheless, little progress has been made on some fronts. There have been few advances in methodology, particularly in techniques of forecasting, measuring, or evaluating those possible impacts that cannot be translated into monetary units. Technology assessment has made little if any contribution to a theoretical understanding of the relationship between technological change and social change. The problems of translating analytical findings into useful alternative strategies for policymakers have barely been touched. The questions of appropriate scope for assessments - local, regional, national, international - and the appropriate function and mechanism for public participation, are as puzzling as ever. In short, the epistemological and theoretical underpinnings of technology assessment are still to be developed; it remains an ad hoc, pragmatic, and atomistic enterprise.

The prospects for the immediate future, again from the standpoint of an observer of the American Federal Government, are mixed. The National Science Foundation, which has up to now provided strong leadership, appears to be drawing back. As the economic situation tightened, the cry in Washington was for "action rather than studies" (for demonstrable results and quick payoff), and for research not vulnerable to the facile criticism of Congressional critics on grounds of "questionable" methodology or innovative approaches. Interdisciplinary applied research is highly vulnerable to disciplinary jealousies, which is a problem when a peer review system is used, as at the NSF. Until the 1960's the NSF was responsible *only* for basic, highly disciplinary research which could be adequately disseminated through scholarly journals; it has barely begun to develop mechanisms for actively disseminating applied research and policy analysis to the decision-makers, including the public interest groups, who are its potential users. Thus, the NSF is now handicapped in defending its technology assessment products on the ground of demonstrated utilization and impact.

The Office of Technology Assessment, which serves Congress, began its work in the midst of this sceptical environment. It has quite reasonably taken a very cautious approach, limiting its activity to responding to requests from legislative committees, and relying largely on conventional techniques, well-established research organizations, operating in tradi-

tional engineering/economic modes of analysis and narrowly defined subject areas. Thus it has broken no new ground in developing technology assessment approaches and techniques and is far from providing the "early warning system" for decision-makers which was originally envisioned for it. But the OTA is gradually but effectively building Congressional acceptance and confidence, which will ultimately strengthen technology assessment as a recognized approach to problem identification and attack.

Fortunately, the conservatism and caution of the lead agencies in technology assessment have come at a time when most of the line agencies of the Government are at last adopting the idea of technology assessment; thus the opportunity to bring TA techniques to bear on decision-making is broadening rather than narrowing. Until recently, there was little shared learning; each new assessment began almost from ground zero. Now there is a growing body of experience, duplication and overlapping, and we can at last begin to build productively on what has been

tried. TA has survived its infancy and the prospects for a useful future are bright.

ISTA's contribution to these developments has been substantial. Through our conferences in Holland, Japan, Canada, and Monaco, and through our publications, we have provided a network and mechanism for this shared learning to be communicated and absorbed. Our annual meeting this October in the U.S. will provide an opportunity to plan for the future of TA as a movement and ISTA as an organization. It is our hope that ISTA members and their colleagues in each country are already seeking support, where needed, from their national governments, industries, universities, foundations, and other institutions, to attend this meeting. Our goal is to have as many decision-makers and TA analysts as possible present, to actively participate in the many activities and consultations that are planned, thereby facilitating the fruitful sharing of their experience, their learning, and their problems.

PHILIP D. WILMOT

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A Fundamental Philosophical Frame of Reference on Technology Assessment

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ABSTRACT

How to make policy decisions to adopt new technologies that will influence the course of human affairs for a future beyond any time for which outcomes are predictable is a problem that requires a new philosophical basis. Conventional methods of discounting and comparing predicted benefit and cost streams are not satisfactory because benefits are innately long term and uncertain while a large part of costs are immediate and sure. A new philosophical viewpoint is presented for overcoming this difficulty. The approach requires that we conceive of man's purpose from a vantage removed from man's own introspective objectives. In other words, the reader is asked to view the purpose of mankind from the point of view of a grand design of the universe, into which the species fit just as any other biological component. From this perspective, it is observed that biological systems grow and adapt in such a way that, although neg-entropic within themselves, serve to increase the entropic rate of natural processes. Biological systems are entropy accelerators. This leads to a suggestion that technology assessment should be made by examining the extent to which a proposed new technology contributes to this cosmic purpose of entropy increase. It must be acknowledged, on the other hand, that the effects of entropic processes are recognized as pollution, and, as such, present threats to the survival of the organism. Such threats require adaptation-counter measures. These are the true costs, measured as risks, that must be considered and weighed against the new technology.

Technology assessment (TA) purports to evaluate the long term consequences of decisions to introduce new technology into society. The emphasis on the "New" poses one of the principal difficulties in applying con-

ventional economic methods to obtain good assessment results. Normally, new technology if it turns out to be viable, may be expected to affect the world for a very long run future. In a strict sense, adoption of a new technology initiates an irreversible process. Correspondingly this would imply the need for infinite foresight if we are to make accurate assessments but unfortunately our ability to predict the future in any detail is extremely restricted. In many cases, if we are able to look ahead 10 years we are doing remarkably well. Yet a new technology often does not have perceptible effects before that time. How then can we make technology assessment an effective instrument of policy?

This question indicates the need for a philosophical frame of reference against which new technology may be rationalized so as to obtain positive approval for undertakings that in the very long run will fit a larger purpose of mankind. Unfortunately present methods may more often lead to a negative bias. This paper presents a philosophical basis for TA from a somewhat different and contrary view than is presently conventional. The arguments presented are illustrated by the specific example arising out of the possible impact on the earth's climate as a result of stratospheric flight by supersonic aircraft.

A new technology often will take a significant long time to develop before its introduction into service will start to influence the environment. Following its introduction, it then takes a further long time before the system can grow to significant size to reveal any effects. If, then, the recognized and measurable effects arising out of implementation of the new technology are deemed to be adverse, the actions that world societies may take to reverse undesirable trends, already set in motion, will require a comparably long time again. Many effects that may, in the end, prove to be the most important might not be recognized for hundreds of years.

We are forced to recognize the fact that man's ability to project the future is extremely limited. There are a few things he can forecast with virtual certainty, such as the movements of planets in the solar system, but even within this essentially fixed physical reference system, ability to predict how such things as world climate will change, even without influence by man, is extremely imprecise. There is invariably considerable doubt about long-term underlying environmental trends. For example: Is the world currently in a warming or cooling trend?

Clearly even the problem of population prediction, which is a fundamental variable in projecting overall economic activity of the world, is fraught with enormous sociological and political uncertainties. Historical population predictions have generally missed the mark by wide variations even for relatively short run forecasts.¹ Thus when one attempts to predict a single component of the economy that is dependent on some new technology for which there has been no experience, the variation of the predicted outcome from reality as it unfolds, will be very large indeed.

Frequently it may be desirable to make predictions based on upper- and lower-bound situations. If future environments can be bounded, policy decisions may be predicated, at least in part, on "worst case" conditions. However, even here the fuzziness of the worst-case prediction does not lead to an excess of confidence. No wonder then that forecasts of future environments are limited to small extrapolations of past trends.

This difficulty suggests that rather than start with a forecast of the system being considered, it may be much easier to extrapolate the broader general economic environment than it is the more specific new technology. Having accomplished the former, the new technology may then be predicted by relating it to the future economic environment in some plausible way.² Nevertheless one should have no illusion that the world of, say, 50 years hence will be anything approaching the projected description either of the economic environment or of the system which is embedded in it. While the analyst may consider a very long time, such as 50 years, even that may be all too short for making much of a judgment of the impacts of many new technologies.

This may seem to pose an impossible situation for making any rational decision to do anything. It clearly establishes an atmosphere in which emotional biases come to the fore as crystallized views which are often based on pseudo-rationales. These views lead to strongly biased opinions on what should, or should not, be done. For example, should an SST be per-

mitted to fly? Depending only on the most speculative futures, equally strong arguments can be presented on either side of such an issue. An SST is economically viable because of A, or an SST is economically unsound because of B, where neither A nor B is a very probable condition. Nevertheless, we always do have to make some choice about present actions. How do we do so? What is a rational procedure for choice when ultimate outcomes must remain not only undefinable but even unknowable? I submit that the answer to this question must be sought within some frame of reference completely exogenous to the particular system being considered. It is suggested that this answer may be found by considering the purpose of man himself.

A HYPOTHESIS OF THE PURPOSE OF MAN

Down through the ages, man's behavior has been explained in relationship to some divine purpose. In general, this was translated into a very personal set of goals related to a highly personalized God. Modern philosophy, in downgrading the importance of a Deity for explaining normative behavior, still tends to focus on personalized motives. Human actions are explained by what objectives are deemed to be desirable from either individual, or in some cases collective points-of-view. These objectives are related largely to what is perceived from the point of view of the individual in relation to his own well being. Likewise, collectively, we are inclined to view mankind from our traditional introspective view of man's purpose.

The same basic premise underlies economic theory which has been structured on the principle of maximization of the consumer's utility. While the economist is concerned with production functions, the motivation for production is centered in the driving force of a consumption need. A somewhat different view has been suggested by Galbraith³ who contends that consumption motives are stimulated by the industrial complex in order artificially to expand production activities. Also from a still different view the author⁴ suggests that the driving incentives, while explained in part by consumption needs, are largely centered in a need for production activity.

Because of the motivation arising from within man's perceived needs, the economist has largely focused on the mechanism of allocation of resources to consumers. In this context the market has served admirably, through pricing as an indexing mechanism, to accomplish this purpose. However, the market mechanism starts from a micro economic view. Macro measures can only be obtained through some device

¹ Page, W.: Population forecasting; in Cole, H.S.D. (ed) *Models of doom: A critique of the limits of growth* (Universe Books, New York 1973).

² English, J.M.: Economic concepts to disturb the engineer. *Engin. Econ.* 19: 3 (1974).

³ Galbraith, K.: *Economics and the public purpose* (Houghton-Mifflin, Boston 1973).

⁴ English, *op. cit.*

of aggregating. Furthermore, the market is a present-time device. It does not accommodate the future except to the limited extent that contracts for future deliveries enter present markets. The long-term future raises endless philosophical debates about inter-generational values. In essence, how should allocations be made today for values to be realized by those yet unborn and whose vote in the market can not be recorded? However, it is these very long term value problems that are at the root of TA. To solve this, it is suggested that a larger purpose of man must be examined. This larger purpose may only be considered if one is willing to view, from a perspective outside of man, the economic actions of men. In other words, we must question man's purpose from a cosmic stance and not from the personalized objective of individual men.

If we depersonalize our perspective of man and consider him as just another biological species, then interesting implications may be developed. It is not necessary to answer the question: Why does man behave in his economic interactions as he does? Neither is it essential to identify a unique Deity to explain men's actions; although this might be a more comfortable view for many. We can simply base our views on the universe as we have known it to be throughout time and on a reasonable expectation of its constancy. We might consider the physical world, or universe, in which we live as an overall design into which man fits as just another small biological component. This system may then be examined in terms of our concepts of natural phenomena.

Perhaps the most interesting concept for explaining the physical universe is that of entropy. Entropy is a measure of disorder or randomness of physical systems. Its original definition by R. Clausius, in 1867⁵ and its use in thermodynamics and thermostatics was used as a measure of unavailable energy. It was much later that Willard Gibbs demonstrated that the macro measure of entropy (an increment of heat divided by temperature) could be explained by the statistical distribution of the motion of molecules in a gas. Subsequently Shannon⁶ used the same concept in developing information theory. In all cases the fundamental concept can be shown to be the same. For our purpose the general concept of entropy may be taken as a measure of disorganization and its opposite, neg-entropy, as a measure of organization. The concept as used for explanation of energy may be

generalized to include the disorganization of materials.

For example, copper is available in a somewhat concentrated form as ore to be mined. By processing it into metal its entropy is decreased. By consuming it in products that end up in waste eventually, its entropy is increased to the point that its entropy is higher in the end than it was at the start of the process. The production process was entropy decreasing and the consumption process was entropy increasing. In the complete cycle operated by man, copper went from high entropy to low entropy and back to a higher entropy than at the outset.

A universal principle is that within any closed system, entropy tends to increase. Any one sub-system may exhibit a decrease in entropy but only at the expense of an even greater increase in the entropy of its environment.

Living organisms are highly organized systems that have come into being accompanied by a reduction of entropy. Indeed this neg-entropic nature of biological systems may be a fundamental characteristic of life.⁷ This amazing phenomenon is not only associated with the individual living organism, but perhaps even more significantly, the species as an organism in its own right. Man in particular, as the highest order of life system, exhibits continued evolution by an advancing social organization that has mobilized the specialized productive capabilities of individuals. Man, of course, not only conforms to the principle as characterized by his physical activity, but even more, is representative of a collective coordinated intelligence.⁸

A further interesting phenomenon of life systems is that a living organism, coupled with its entropic environmental system, serves to increase the rate of the overall entropic process. In other words a biological system is, innately, an entropy accelerator. Whenever a biological system fails over some extended time to maintain this role as an entropy accelerator, it may no longer be fulfilling its essential cosmic purpose and, accordingly, may be expected to die. At the same time the changing environment that the organism creates for itself by this entropy process, poses threats to its existence from another direction. It may not find the higher entropy environment compatible to its continued survival. In effect, the changed environment has been polluted. In this sense pollution may be defined as a change to the environment in a way that is unfavorable to the organism. It may well be that we regard pollution as something that is also unfavorable for the chances of survival to other life

⁵ Clausius, R., *The mechanical theory of heat*; translated by Hirst, T.A. (Van Nostrand, London 1967). And for a good description of entropy, see Tribus M.: *Thermostatistics and thermodynamics* (D. Van Nostrand, Co., Inc., Princeton 1961).

⁶ Shannon, C. A mathematical theory of communication (University of Illinois Press, Urbana 1948).

⁷ Lotka, A.J.: *Natural selection as a physical principle*. Proc. Nat. Acad. Sc. VII (1922).

⁸ de Chardin, T.: *The phenomenon of man* (Harper and Row, London 1959).

forms. However, if such threats to others are not really also perceived to threaten us in the end we are not likely to view the environmental effect as pollution. Survival of a dynamic organism depends on its adaptation to constantly changing environmental challenges. Thus a course must be charted between the Charybdis of too fast a change that produces new threats faster than our adaptability can tolerate and the Scylla of non-change that violates our essential entropic purpose. By increasing the entropy of the physical environment, man is necessarily increasing the environmental challenge to which he must adapt. His consumption patterns are entropic processes for which pollution is the manifestation of the corresponding environmental challenge. On the other hand inaction from fear of pollution-effects may induce economic stagnation, lack of challenge, and eventual decline into depression and despair. The notion presented here is compatible with Arnold Toynbee's theory⁹ of the history of civilization. Toynbee argues that civilizations have flourished only when challenged within rather narrow limits. Too severe a challenge, on the one hand, will arrest its development even with heroic effort on the part of the people to adapt. The Eskimos are an example of such an arrested civilization. Too bland a challenge on the other hand will be lacking in the essential stimulus for growth and development. The South Sea island peoples are examples of these.

ENERGY AND MATERIALS CONSUMPTION

The economic processes of production and consumption have been shown by Georgescu-Roegen¹⁰ to be fundamentally entropic. In fact, Georgescu-Roegen argues for a view of economics starting from this essential entropic principle rather than from the mechanistic concepts on which economic theory has so far been largely based.¹¹ The economic organization of society requires that the neg-entropic processes of production in order to accelerate consumption or entropy-increasing processes or, in other words, in order to transform low-entropy material sources into high entropy sinks. Material resources are finite and limited to the earth, whereas energy resources are es-

entially infinite if considered from man's finite perspective. We can perceive the reducing supplies of oil, copper, etc., but the energy of the sun is essentially constant. Furthermore, the process of decreasing the entropy of the earth's material resources, to organize them into more useful forms for man's use, requires ever increasing consumption of energy.

This implies that the ratio of the rate of entropy-increase of materials, may also have to increase. In other words, the trend of energy intensiveness of human activity must continue to grow. Whatever the damage to our environment from pollution implied by this dictum, we must learn to manage it - that is, to adapt to it. There may be no other choice except possibly to gamble on human survival by somehow maintaining economic growth just at the margin of viability, a boundary that is probably unknowable and may court a risk of disaster by skirting a non-change course.

THE CONCEPT OF EFFICIENCY

Efficiency is defined as a ratio of desired output to input. The important word here is *desired*. All of the energy input into any man-directed system is eventually dissipated into the background entropy of the earth and thereby becomes unavailable. What is important to man in the transformation is a purely intermediate and transitory effect that he considers to be useful work that he wanted along the way. The automobile will divide the energy used by the car between the waste dissipated by the radiator and the useful work of moving the car. From this point of view the efficiency is the ratio between the useful component that goes into moving the car and the total energy that was available in the organized molecular arrangement of the hydrocarbons of the gasoline in the first place. The difference between these energies is lost immediately in the heat dissipated by the radiator. However, from a larger perspective, both the useful work and the immediately dissipated heat, in the end, fade into the background entropy level of the earth. Thus, efficiency is a truly local, or micro, concept associated with a choice of means for accomplishing some transitory individualized objective as an intermediate effect.

In each such intermediate stage the striving for improved efficiency is desirable. However, this does not alter the more fundamental problem of increasing the overall consumption of energy. A man's choice between using more energy to drive his car or to heat his home represents a problem in allocation, not in efficiency. Price, as an economic mechanism, handles such allocation, but, whatever the choice is, the macro-economic system has the effect and I would say for the purpose of making even more resources available for allocation.

⁹ Toynbee, A.J.: *A study of history* (Oxford University Press, London 1934-1939).

¹⁰ Georgescu-Roegen, N.: *The entropy law and economic processes* (Harvard University Press, Cambridge 1971).

¹¹ Georgescu-Roegen in Daly's *Toward a Steady State Economy* (W. M. Freeman & Co., San Francisco, 1973), draws from this the exactly opposite conclusion from that presented in this paper. He contends that because of scarce or limited low-entropy sources of natural resources, including energy, that we should work to conserve them. His argument may be valid if viewed from the efficiency perspective discussed later.

TRANSPORTATION ENERGY

An important intermediate means of energy consumption is transportation, accounting for 26% of all energy-consumption in the U.S. in 1968.¹² Of course, from an efficiency viewpoint, we might wish to use as little energy as possible to transport one person one mile, or one ton of goods one mile, but in the overall macro-purpose of man's need to consume more, this personalized objective may be relatively unimportant.

Compared with the macro-purpose of using more energy, the trend of per capita energy use for transportation in the U.S. has increased steadily. This trend started out in the mechanical age with the railroad locomotive and steamship. The train gave way to the automobile and bus that, in turn, have been yielding to the much higher energy-intensive airplane.

It is interesting to note the relationship of efficiency in this process. While a transition occurs from one mode of transportation to the next more energy-intensive one, the effect of striving for efficiency produced corresponding reductions in the intensity of energy consumption.

It is also of note that as efficiency objectives reduce the potential energy intensiveness of any mode, the actual use of that mode is increased in a way to compensate for the efficiency gains. Thus, as the potential for energy intensiveness of the airplane has declined — measured by BTU/seat mile — the load factor representing a utilization ratio likewise declined. The automobile is another good example. As efficiency improved, the mass of metal moved with each person grew to more than offset the efficiency effect. This might lead to a suspicion that the present trend to small cars is a temporary aberration.

Little energy is used for space propulsion, but when one considers the possibility for further expansion, the space transportation component may eventually become quite significant. It certainly offers an outstanding opportunity for enormous expansion of our consumption of energy. At the same time its potential damage to the environment must be recognized.

When one considers the potentials for expanded consumption of transportation energy, some interesting constraints become immediately apparent. In the first place, we move from a two-dimensional world constrained by physical boundaries of linear networks to a virtually unconstrained three-dimensional space. This means that the potential for expansion by rising above the earth's surface is a function of cube to square. Furthermore, the greatest propor-

tion of travel now is urban. The possibility for expansion of urban transportation energy intensities are limited. The annoyances and inconveniences associated with moving about in the private car have been increasing to the point where now people have been forced reluctantly to reconsider the desirability of mass rapid transit systems that are innately less energy intensive. Whether or not ways will be found to devise other urban transport systems, such as people-movers, remains to be seen. In any event new urban systems may be less energy intensive rather than more energy intensive. Furthermore, private automobiles are not likely to grow larger, if for no other reason than the problem of limited space in the city in which to fit them. The networks on which the automobile moves, are approaching saturation. By means of various new technologies, density of traffic may still be increased, but under even the most optimistic conditions, this will be a small factor change and not an order of magnitude change.

Ocean freight transport is also limited by its flat topography. Higher speeds, using surface-effects devices, may account for a tremendous increase in energy intensity. However, there may be a break-even point for surface-effects machines beyond which it will pay to leave the surface and fly.

This virtually leaves the field open to air transport for intensifying energy use, at least until such time as space travel begins to supplant air transport in its turn. But space travel, as a commonplace, may be part of a future we cannot visualize as yet. In the meantime, the only effective way for increasing energy intensities in air transport is by speed — supersonic and hypersonic aircraft.

The proportion of total energy devoted to transportation could decrease in the future, relative to energy-use for other things, but from the point of view of efficiency, the amount of energy used directly in many other applications is likely to decline. Perhaps the best example is in space heating or cooling; as better methods of insulation are developed the energy demand will decline.¹⁴ On the other hand, industrial needs will grow because of two things: 1) Our needs for materials as part of our consumption growth will expand; and 2) As we exploit our low entropy sources of materials, we are forced to seek even higher entropy sources all the time. This latter requirement, in turn, has two aspects. The newer substitute materials require more energy to transform them for use (e.g., titanium to replace aluminum) and secondly, we have been using up our higher grade ores and are increasingly forced to resort to lower grades, requiring even greater units of energy to reduce the ores to finished metals.

While it may be difficult to assess how the growth of energy-use will divide in the long-run future between transportation and all other needs, based on the principle of insufficient reason, it may be reason-

¹² Fisher, J.C.: *Energy crises in perspective* (John Wiley and Sons, New York 1974).

¹³ Fisher, op. cit.

able to assume the split will remain essentially unchanged for a very long time to come.

THE CONCEPT OF COST

Cost may be viewed as disbenefit. One may be expected to accept any cost as long as the expected benefit marginally exceeds the expected disbenefit. However, this is an individualized rather than an aggregate concept. It is a perfectly legitimate exercise to add individualized costs arising from a choice of social action in order to assess a total or social cost that may then be compared with a corresponding social benefit provided that two things hold true: 1) Consideration of the total cost is being addressed as something to be minimized, given no change in total benefit; and 2) Prices are not affected by the proposed change in the system. The latter condition holds reasonably true for an individual or even quite large collectives of individuals in present times, but at some level of aggregation and certainly for an unknown future it does not apply. For both conditions, this concept of cost derives from the individualized or introspective viewpoint. It does not fit into the framework of an externalized view of mankind and his entropic purposes in the cosmos. While it may be an acceptable way of assessing a partial cost of a new technology, such as stratospheric flight in a short run of 25 years, it does not afford a satisfactory long-run measure. It may be best, and perhaps the only thing we can do in the short run. However, it should be observed that present methods of benefit-cost analysis would most likely result in assessing a net cost to any change, be it good or bad in the long run. The reason lies in the problem of prediction. Our ability to assess costs is limited by our ability to predict future demands as well as supplies. As pointed out above, under the most favorable circumstances we can only look a few years ahead. At some point the variances of our estimates become so large that we cannot differentiate between a net benefit or net disbenefit. At the same time, this net difference will be far more significant than the shorter range costs or benefits. For example, in considering stratospheric flight, the short-range effects of change will always be revealed as net costs. Therefore, any change at all will show an assessable cost which we will never be able to judge in conventional ways against the unknown future. This alone might suggest that we should look for a better way to arrive at a decision to adopt a proposed new technology.

In order to consider cost in the long run, we are forced to start with a macro or societal view rather than the individualistic view of cost. Here the measure of GNP with its acknowledged shortcoming¹¹ may still be the best measure. In effect, GNP is a proxy measure of the economic organizational out-

puts and, as such, may be taken as a measure of the societal entropy output. From this perspective, any activity that increases GNP may be good provided only that it does not induce instabilities that may threaten long-run growth of GNP. However, this always runs into two dilemmas. One is that much activity that is economic in nature, is simply not measured in GNP (such as the work of the housewife). The other is that some things measured in GNP are costs of acknowledged disservices. For example, more crime would increase GNP but while more crime does satisfy the need to increase entropy, its undesirable feature is that of a societal inefficiency and, at the same time, it is destabilizing. In other words, we decry crime not because it increases entropy, but because of the way in which it increases entropy: it represents a threat to the viability of the social order.

Turning again to the question of flight in the stratosphere, we may examine this technology from a macro viewpoint. Clearly, the potential of stratospheric flight for increasing the rate of entropy growth is manifest and, in fact, it may be the only practical way for the transportation component of energy consumption to expand significantly. On the other hand, it must be acknowledged that like all other entropy-expanding systems, supersonic flight may, by increasing pollution faster than we can adapt, present too great an environmental threat.

These are the horns of the dilemma: We do not expand transportation into the stratosphere with supersonic aircraft and so perish because we fail to meet our cosmic purpose of entropy-expansion or we do expand into the stratosphere without being able to cope with the induced pollution effects and perish because of the hostile environment we have created. I would suggest the first choice with confidence that we can adapt, simply on the principle of not bucking the established trend of adaptation over countless centuries.

The costs of stratospheric flight in the context of this philosophy, then, are not money costs, but rather risks expressed as probabilities of survival resulting from an inability to adapt. If we were to try to place such costs on a monetary scale, the only way the risks would then be acceptable is essentially on the basis of the same choice faced by any individual. Insofar as there is a marginal net benefit associated with an action, from the individual's viewpoint, it is worthwhile for him to take that action. Likewise from a societal viewpoint, if the GNP increases incrementally as a result of stratospheric flight over what it would do without stratospheric flight, then the answer is to fly in the stratosphere. The diseconomies net out to be the risks of a non-reversible change in trend

¹¹ Ralph D'Arge, *Economic and Social Measures of Biologic and Climatic Change*, Monograph VI, U. S. Department of Transportation (Review Draft), U. S. Government Printing Office, Washington, D. C., 1974.

which are costs — associated with spending on monitoring and control-measures — that are also GNP increasing (as, for example, police protection in the analogous counter example of crime). In other words, the costs are the control of the pollution effects.

In conclusion, it must be pointed out that such an argument in favor of the stratospheric flight example has not encompassed alternative ways for increasing GNP. This becomes a matter of overall economic efficiency. There may be better ways to direct our resources for increasing the rate of the entropic process but these must be not only economically demonstrable but also politically acceptable. Whether these better ways will permit a marked change in the energy intensity of transportation, relative to other economic activity, is an open question.

The principle developed in this paper is that we must adopt new technologies that, in one way or another, serve to fulfill man's purpose as an entropy accelerator. The approach does not serve to answer the question as to which of a number of ways is best.

For example, the development of an SST may not represent the best allocation of limited and scarce resources but, we cannot make that decision simply by comparing the costs and benefits of an SST only in the context of its environmental impact. We must go further and examine what the effects might be by allocating those resources instead, into expanding some other technology (for example, increased automobile travel) to a comparable energy intensity of the SST. The important point is the inexorable need to expand must be recognized and if we don't exploit one technology we must find another.

In conclusion, it must also be pointed out that the paper does not address the question of an optimal rate of expansion. It certainly is likely that some moderate rate may prove to be better than the rate of development we have witnessed in this century. We may well discover that we can fulfill our destiny as agents of the entropic process at a more relaxed pace than what we have been maintaining. This remains to be seen.

Technology and Growth: An Exploratory Dialogue on Technology Assessments and Limits to Growth

An ISTA Sponsored Regional Conference

George E. Humphries

In February 1975, one of the most successful ISTA Regional Conferences was held in Ottawa. The subject of the conference was Technology and Growth, a topical subject then and now. Although reported on briefly in the *TA Journal's* sister publication, *TA Update*, the nature, subject and success of the conference warrant fuller exposition. This article attempts to give that expanded view.

Sponsored jointly by ISTA and the Canadian Government, the conference was organized and run by the Business Planning Group of the Bell Telephone Company of Canada, and a consulting firm, Datacap Limited, of Ottawa.

ISTA provided guidance on program and speakers through Immediate Past President Walter Hahn, Chairman for International Meetings Derek Medford, and Chairman for Corporate Affairs Larry Day. Larry Day, as Head of Bell Canada's Business Planning Group, also spoke for one of the Organizers, and acted as Co-Chairman of the Conference. Peter Charsley acted for the other organizing group, Datacap Ltd., and was the other Co-Chairman.

The sub-title of the Conference tells the general purpose of the meeting "[to provide] An Exploratory Dialogue on Technology Assessment and the Limits of Growth". As the Conference brochure put it:

Technology assessment has been defined as the search for unanticipated secondary consequences of proposed technologies, the identification of affected parties, evaluation of the social and environmental impacts, and the consideration of feasible technological alternatives.

World wide support for the broadening of technology assessment comes at a critical time when the human race is neither master nor slave of technology, and we are faced with increasing pressures of population growth, voracious demands for, and possible despoliation of, terrestrial reserves of natural resources, instabilities in social, ecological and economic environments, and increasing dependence on technology.

The purpose of this conference is to provide a forum in which to explore the problems and prospects of technology, resources, institutions, and social objectives. A secondary purpose is to stimulate communications among a wide audience of practitioners and observers on major issues of the next two decades.

In addition to this brief statement of purpose, a Conference Background Paper (by Co-Chairman Peter Charsley) was furnished to each registrant. The paper is an excellent summarization of the important issues facing Technology and Growth in general and for which the Conference was convened to deal with in particular.

The Conference was held in Ottawa, the capital of Canada, at the request of one of the Sponsors (the Canadian Government) in order to attract as many Canadian Government personnel as possible. As a result it was possible for several Members of the Canadian Parliament to attend specific sessions of the Conference.

The meeting was held in the Government Conference Centre, a mammoth hall that was, in times past, the main concourse of the Ottawa railroad station. The hall was quite adequate, however, inasmuch as simultaneous translation was given in French-English, and the only sound system available was through ear phones.

French-English translation was necessary because of the bilingual politics of Canada; however only the Keynote Speaker (Canadian Minister of Science and Technology, the Hon. C. M. Drury) used French in his remarks, and this was limited to token paragraphs interspersed throughout his presentation.

The formal sessions of the Conference were from 9 a.m. until 5 p.m. on each of the two scheduled days, however there were useful meetings among planners, panelists and speakers, and others on the day preceding, as well as late into the evening on all three days.

Of particular interest was a voluntary, or self-organized session held from seven until 11 p.m. on

the subject of social impact analysis, policy capturing, and public participation in general. This "rump session" was triggered by a regular presentation, given by Marvin Cetron of Forecasting International about which there is more discussion later. This extra session, however, was extremely useful to the 45 people who attended and participated, in that it broadened their perceptions of TA and its methodologies, and deepened their understanding of the goals and limitations of the art of TA.

The Conference was attended by approximately 400 people, all but a few of whom were regular paying participants. This number could well have been larger had the size of the hall permitted - there were only 400 chairs and thus the organizers were careful about exceeding the physical capacity of the hall.

An overwhelming percentage of the people attending was from the Canadian government: 36% (including provincial governments: 45%); Canadian corporations: 24%; U.S. Corporations: 12%; Canadian Universities: 9%; U.S. Universities: 6%; and miscellaneous others.

The participation of the audience was lively, sceptical, sometimes critical, often well informed, but indicated a lack of complete audience understanding of the issues involved in technology, growth and technology assessment.

The purpose of the conference, of course, was to mitigate these deficiencies, and to every indication it succeeded admirably in doing just that.

The conference opened with gracious remarks of welcome by the Executive Vice President for Operations of Bell Canada, Mr. J. C. Thackery, by whose organizational largesse Bell Canada's Business Planning Group participated in the planning and execution of the affair.

The principal keynoting remarks were made for the Government of Canada by the Minister of State for Science and Technology, the Honorable C. M. Drury, MP. Billed as a "statement of conference objectives and their relevance to national and international priorities", Mr. Drury's speech was an excellent and thoughtful opening barrage in an intellectual tour de force of both magnitude and depth.

Mr. Drury noted the responsibility of science for the consequences of its acts, cited the systemic and international, if not global, implications of science and technology, and commended the nascent technology of innovation consequence estimation called technology assessment. The Minister described the secrecy of proprietary science and the inevitable lack of complete information on which to make decisions. These limitations, he asserted, are no excuse for avoiding thoughtful policy decisions.

Mr. Drury decried the uselessness of post mortem analysis as a means of forestalling disaster, and he wished the conferees well in their pursuit of a better

understanding of disaster prevention through technology assessment.

In the first conference session of the morning, Conference Co-Chairman Larry Day introduced and coordinated the colloquy following prepared statements by John McHale, Director of the Center for Integrative Studies at State University of New York, Binghamton, and Walter Hahn, immediate Past President, and Chairman of the Board of ISTA.

In his charming Glaswegian accent, and his best pedantic manner, Professor McHale held forth on the general theme from *Porgy and Bess*, "It Ain't Necessarily So", or as the Program summarized it, "A discussion of the fallacies of extrapolation and the need for more thorough conceptual reorientation in relation to present problems and future alternatives", which, upon close semantic analysis, is a very near approximation of the content of McHale's provocatively aphoristic disdain for the predictions of others which his assertions disparaged. This presentation, as did his more substantive one later in the program, evoked considerable adverse audience response. Since controversy was McHale's apparent intention, he evidenced delight in the mental combat, and demonstrated his prowess in an extremely dry intellectual appreciation of the art of Steven Potter.

Walter Hahn, a Senior Specialist in the Science and Technology Division of the Congressional Research Service of the Library of Congress, as well as an ISTA director, reviewed the history of TA and recounted the several sets of definitions and tabulations of unresolved issues applicable to the evolving technology of providing data for policy formulation. In the best Congressional Research Service fashion, Hahn's presentation was the antithesis of McHale's vocal provocations, in that it presented in an even handed manner all of the yet unresolved issues of technology assessment and wished the Conference well in their discussion of them.

In the second morning session, Professor John Woods, Chairman of the Department of Political Science of the University of Calgary chaired a session on the International Imperatives of Technology. Of particular interest, among several stellar presentations, was ISTA Chairman for International Meetings, Derek Medford's, comprehensive review of what international organizations such as the UN, OECD, EEC, Europeans and the EVAF, are doing in the way of TA and related subjects.

Other sessions in the two day conference included the following subjects: Cases in Technology Assessment, Social Values and the Politics of Technical Change, Energy, The Institutional Condition, and Technology and Growth. A full review of each of these sessions is impossible, however some random impressions should provide the reader with a feel of the conference, and encourage him to obtain a copy of the Proceedings which are in press.

The session on Energy, while a little uneven, was of course very timely. And the presentation by Amory Lovins of the Friends of the Earth was a masterful collection of ironies concerned with power generation and the environment.

Harold Linstone presented a very concise and cogent discussion of his theory of discounting the future. He postulates and then demonstrates the human tendency to devote less attention and resources to impending crises as a function of time, regardless of their magnitude, importance or certainty. And he insists that knowing this proclivity, planners should compensate for it.

Harold Green of the George Washington University Law School reviewed the inevitability of adversarial proceedings when values conflict and laws are applied.

Joe Coates, Assistant to the Director of the Congressional Office of Technology Assessment, after assessing the (in)adequacy of the hall for the intended purpose of the meeting, well described the existing institutional arrangements for TA in the U.S. government.

One of the best descriptions of an actual technology assessment conducted for Bell Canada was given by Larry Day.

One of the most inciting presentations of the Conference was made under the heading of Social Values and the Politics of Technical Change. Chaired by Joel Goldhar, a Program Manager in the Office of Science Information Service of the National Science Foundation, this session consisted of a comprehensive description by Marvin Cetron of how social forecasting is done by Forecasting International, using Sweden as a precursor to social change in the U.S., followed by a dialogue with Discussant Professor Murray Turoff of the Newark School of Engineering and some heated colloquy with the audience. Coming as it did at the

end of the first day, the controversial exchange was continued after dinner and well into the night. From a learning standpoint, this was certainly one of the most profitable events of the conference.

The closing session on Technology and Growth was chaired by Rodney Dobell and included Derek Medford, Dennis Meadows of Limits of Growth fame, John McHale again and James R. Bright of the University of Texas at Austin and Director of the Industrial Management Center.

Although not very well interrelated, these strong personalities made for a suitably provocative closing dialogue with the audience. Meadows was particularly good at fielding questions that stemmed from a lack of knowledge of what his book had said.

In total, the conference was very successful. Random sampling of attendees indicated that the goal of raising the awareness and understanding of the nature and utility of technology assessment was well accomplished. The issue of the necessity for and desirability of continued exponential growth was less well addressed, but it was better than could reasonably be expected of a two day conference.

As noted above, the Proceedings (including much of the discussion) will soon be available, and they will be a valuable addition to the TA literature. It is, however, worth observing that as good as proceedings may be, there is no substitute for attendance at conferences.

Technology Assessment (as a movement) is burgeoning, and one cannot meet the personalities, make the personal contacts, carry on the arguments, and get deep into a social technology merely from reading the published proceedings of conferences. A book about circuses lacks (as the title of a recent play puts it) "The Roar of the Greasepaint, the Smell of the Crowd".

MONS 085082

Techcom: An Evaluative Model for Comprehensive Assessment of Public Policy

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ABSTRACT

This paper presents a comprehensive description and critique of what is considered to be a major accomplishment in devising a reliable means for generating probable social impacts resulting from projected change. Designed for water resources planning purposes, the Techcom model described below is readily applicable to other situations in which the interplay of diverse human values must be taken into account.

INTRODUCTION

The Technical Committee of the Water Resources Research Centers of the Thirteen Western States has for the past four years been engaged in the development of a methodology for comprehensive evaluation of water resources development and use (Techcom) for the Office of Water Resources Research, U.S. Department of the Interior. The final report of the Technical Committee, released on 31 December 1974,¹ describes a partially field-tested model which relates natural resources policy actions to the attainment of social goals. The basic structure of the model is both flexible and modular and has the potential of providing an evaluative framework for the comprehensive assessment of public policy actions in general.

This paper presents a brief description of the Techcom system with recommendations for its implementa-

tion as a workable process for comprehensive social evaluation of public policy actions.

THE ASSESSMENT STRUCTURE

The Techcom Model consists of a hierarchical array of elements called (social) goals, subgoals, social indicators and action (or decision) variables. The goals and subgoals are derived through a group consensus approach (e.g. Delphi, surveys) and are specified in words. The actual process of selecting a primary goal-set is arbitrary; however, the approach taken needs to be comprehensive in the sense of capturing the aspirations, needs and desires of contemporary American society.

The procedure adopted by the Technical Committee in field-testing the model, relied on a synthesis of public and "elitist" inputs. An initial set of primary goals was established by a panel of experts, and consisted of:

- 1 Collective Security
- 2 Environmental Security
- 3 Individual Security
- 4 Economic Opportunity
- 5 Cultural and Community Opportunity
- 6 Aesthetic Opportunity
- 7 Recreational Opportunity
- 8 Individual Freedom and Variety
- 9 Educational Opportunity.

Each primary goal was then disaggregated into a finite number of word stated subgoals. This stage of the Techcom development process was facilitated by a lexicographic analysis, i.e. content analysis of interviews with public representatives. Additional levels of subgoals were utilized to add definition to immediate.

¹ The Technical Committee of the Water Resources Research Centers of the Thirteen Western States, 1974: Water resources planning, social goals, and indicators: Methodological development and empirical test. Prepared by the Office of Water Resources Research, Utah Water Research Laboratory Publication PRWC 131-1, Utah University, Logan, Utah.

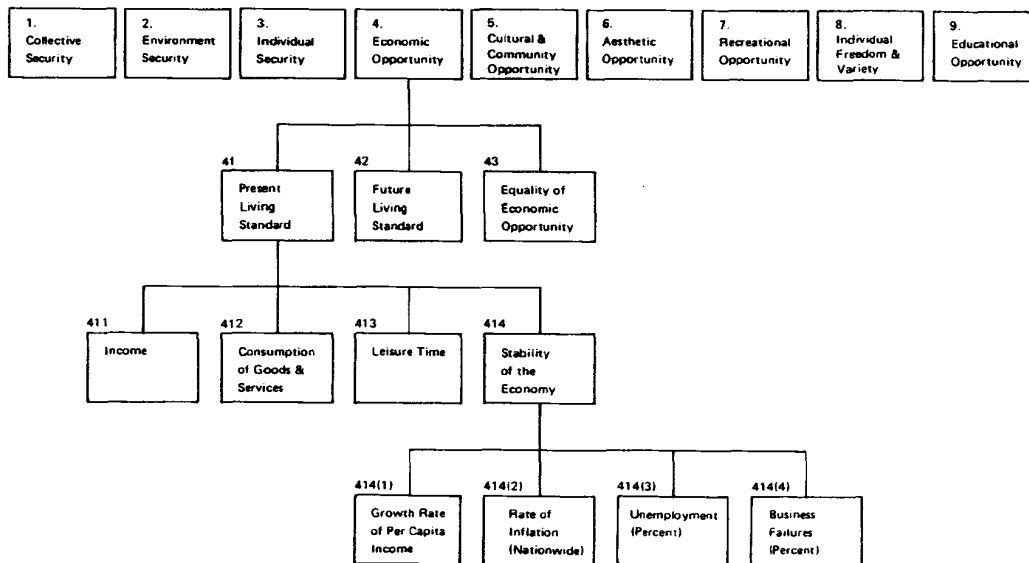


Figure 1. Structure of the Techcom System.

ly superior subgoals. This definitional process yielded a tree-like goal structure illustrated in Figure 1.

At the lowest end of the hierarchy one finds quantifiable properties which collectively describe conditions relevant to the achievement of a subgoal. These variables are referred to as social indicators. For example, the Technical Committee describes (defines) subgoal 414 "stability of the economy" as some combination of the following set of social indicators:

- 414 (1) growth rate of per capita income
(2) rate of inflation
(3) unemployment
(4) business failures as a percent of total businesses.

The first digit of each subgoal index number refers to the primary goal; each successive digit indicates the subgoal number; the level of the hierarchical echelon is indicated by the position of the digit in the index number. For social indicators, the last digit is parenthesized. The various elements in the hierarchy are linked by a network of mathematical "connectives", where a connective refers to a scalar, vector or set of coefficients of functions. Connectives express the effect of: "A subgoal on an overarching goal or another subgoal; a social indicator on a subgoal, a set of subgoals, or another social indicator; or, an action variable on a social indicator or set of social indicators" (Technical Committee, 1971).²

Public actions result in changes in social indicator variables which in turn affect the achievement or non-achievement of social goals. These actions or policy changes are referred to as action (or decision) variables. For example, construction of a nuclear power plant will induce changes in social indicators which will probably relate to one or more subgoals under all or most of the primary goals. By predicting changes in social indicators for various actions, considering policy options, one can judge the relative effects on subgoals and primary goals. Techcom provides a methodology for quantifying these effects.

SPECIFYING THE CONNECTIVES

The tremendously complex and painstaking process of formulating connective relationships between the various elements in the hierarchy has in no sense been either alleviated or diminished by the Technical Committee. However, several unique approaches to the problems of deriving relationships and aggregating connective measures have been proposed.

Connectives can and should be formulated from a broad base of scientific, economic, and social theory. Further, the search for and modelling of connective patterns should not be restrained by the availability of empirical data. In several instances a degree of value judgment may be required in estimating connectives between measured or measurable social indicators and goals and subgoals. In the latter case, the Technical Committee suggests the use of a modified Delphi approach.

The expert consensus approach (Delphi) offers a viable mechanism for obtaining a description of the functional relationship between achievement of subgoals and changes in social indicators, by questioning experts and technicians about the impacts of those changes. Operationally, indices are constructed for each lowest-level subgoal, which, based upon the values of pertinent social indicators, describe quantitatively the achievement of that subgoal. These social indicators are of the form $P = \sum W_i Q_i$, where P is the value of the index, W_i is the unit weight of the i th indicator, and Q_i is an expression of the achievement of the subgoal as a function of the value of the i th indicator. The social indicator weights (W_i) are obtained by normalizing the median responses of a panel of experts who are asked to assign weights to each of the indicators of particular subgoals so as to express the importance of each indicator relative to the achievement of the subgoal.

Information required to generate the Q_i functions can similarly be obtained via the Delphi approach. For each indicator, experts can be asked to draw a graph of the achievement of the subgoal on a 0-100 scale across a range of indicator values. The median values of selected points on each graph can then be normalized and used in an interpolation procedure to yield a Q value for each of the social indicators. Alternatively, the data points could be used to construct regression equations from which the Q values could be obtained using computerized regression techniques. Many of the logistical problems in using the Delphi method — e.g. performing the necessary statistical calculations, and writing and reproducing successive rounds of questionnaire — can also be solved through the use of a computer.

Indices of superior level subgoal achievement can be formulated by utilizing public opinion survey techniques to generate simple numerical coefficients as perceived by various audiences (parties of interest). As ratio comparisons of preferences are essential to Techcom in terms of the mathematical requirements of the system, the Technical Committee suggests the use of Metfessel's (1947) General Allocation Test³ as an appropriate weighting methodology. With this or a

² The Technical Committee of the Water Resources Centers of the Thirteen Western States, 1971: Water resources planning and social goals: conceptualization toward a new methodology. Prepared by the Office of Water Resources Research, Utah Water Resources Publication PRWG 94-1. Logan, Utah. NTIS No. PB 2042228.

³ Metfessel, M. A proposal for quantitative reporting of comparative judgments. *J. Psychol.* 24: 229-235 (1974).

similar tool (e.g. Thurstone-Likert models), the determination of empirical preference scores (weights assigned to lowest level subgoals for purposes of aggregating into measures of higher order goals) can be accomplished through mail questionnaires to representative cross-sections of the impacted population. This questionnaire-instrument can be easily adapted to yield measures of the desire for improvements in subgoals within each goal hierarchy and in goals. A biographical information section affixed to the mail questionnaire will also facilitate the specification of preference weights cross-classified by major general interest groups as well as for the general public. The built-in flexibility of the Techcom system permits continual modification of the connective relationships, as well as numerous unique approaches to their derivation.

IMPLEMENTING TECHCOM AS A SYSTEM FOR QUANTIFIED PLANNING INQUIRY

The Techcom model forms the basis for design of an interactive computerized planning information system. In applying the methodology, several alternative policy options (action plans) are postulated by the planners. Resulting values of social indicators at various future times must then be predicted. Procedures relying in large part on the utilization of available econometric input-output models have been incorporated in the model for this purpose. The basic approach consists of specifying alternative scenarios for future growth and change for various regional economies which would likely be affected by the introduction of the proposed action plans. It is important that these action plans be represented by mutually exclusive scenarios of economic and social development so that planners can contrast the flexibility, degree of irreversibility, consistency, and efficiency of various decisions across alternative scenarios.

Having specified the social indicator set and the consequent interaction system, one then has a policy tool for evaluating the effects of alternative actions on social welfare as defined by the goal-set.

Actions in this system are nothing more than first round perturbations of one or more of the social indicators. Further, action plans or alternatives can only be expressed as outcomes on social indicators. That is, if an action plan is to perturb the goal set in some meaningful way in lieu of purely qualitative assessment, the plan must be expressible as a set of outcomes (immediate, lagged or indirect) on social indicators. Thus, investment in nuclear energy becomes meaningful only when expressed in terms of outcomes such as firm power kilowatt hours produced, or tonnage of nuclear waste generated. Once

the initial impacts of social indicators take place, then primary and secondary repercussions on other social indicators occur via the various measured connectives between them.

The Technical Committee has included in its report a dynamic computer program which is capable of aggregating social indicator values into relative indices of superior subgoal achievement, and combining lower level subgoals into indices of superior subgoal achievement utilizing the connective relationships and weighting coefficients derived via Delphi interviews, public opinion surveys, empirical data or other means. The program is written in the Fortran language for batch compilation under SCOPE and use under KRONOS (two operating systems utilizing CDC6400 hardware commercially available on the CDC CYBERNET time sharing system).

Thus computerized Techcom system offers several unique advantages to public planners.

- The planner or evaluator can use a cathode ray tube computer terminal as a display device to compare the relative consequences of alternative actions on the goals and subgoals as perceived by various audiences.
- By interrogation he can retrieve detailed information about relative weights of specific interest groups or reference publics, or he can assign his own preference weights.
- He can retrieve information on the social indicators used and their relative values.

With these assessments, he can revise and amend his plans to improve the achievement of perceived goals and subgoals. In applying the methodology for planning purposes, all necessary considerations of policy imposed administratively, by statute, or by common agreement, can readily be taken into account by considering these as constraints on the system. The effects of the constraints can be visualized by considering alternative actions without constraints.

CONCLUSION

It is important to note that the Techcom methodology has yet to be fully tested. However, the underlying concept of the model, in contrast to the single criterion of benefit-cost efficiency, appears to provide a workable basis for comprehensive social evaluation of actions relating to public policy decisions. Further, the methodology has the potential of narrowing the gap which currently exists between the definition of national goals on the one hand and the implementation of action programs to achieve such goals on the other. As an interactive planning information system it should lead to more socially optimum plans at the field level; and, being comprehensive, it should substantially decrease the risk of error by omission, as

well as increase the reliability (credibility) of the results.

Since statements of social goals are derived through a public consensus approach, and subsequently used as a basis of deriving social indicators, the resulting social indicator set should be both comprehensive and socially relevant.

Techcom offers not only a significant advance in the development of technology assessment methodologies, but provides a mechanism for coordinating and synthesizing various currently diverse and unrelated policy capturing techniques (of which this paper has mentioned but a few) into a unified structure.

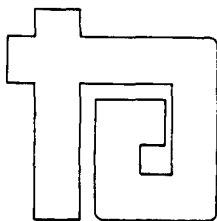
MONS 085087

International Society for Technology Assessment

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In many countries academics, industrialists, government officials and growing numbers of the public are aware that there are ways man can assess the consequences of existing and potential technological initiatives. There seems to be acceptance of the idea that by means of analysis, planning and wise goal setting and policy making, man can enjoy more of the benefits of his advancing technology and less of its negative and unexpected effects.

It is in this climate of an observable on-going social impact evaluation movement that ISTA enters its second year. Membership has climbed to approximately 500 persons from 20 nations and representing practitioners from many disciplines, government and private executives, legislators and interested members of the public. The Society's role is to serve as a forum for exchange of information on Technology Assessment among individuals (and organizations) from many nations, sectors of society and of differing professional disciplines.



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Multiple Technology Assessment

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ABSTRACT

Technology assessment (TA) is interpreted today to mean a single study of the potential impacts of a technological change. Most technologies being assessed can be implemented in a number of possible technical forms as well as in different geographic and cultural contexts. Such multi-faceted complexity suggests that the possibility of using multiple technology assessments (MTAs) should be explored to see if, in some situations, various of the possible multiple assessment strategies may provide more effective assessment. To provide grounds for comparison of various modes of TA, we list nine objectives of TA, divided into three categories: (1) validity, issues concerning the soundness of conclusions arrived at through TA; (2) utility, issues concerning the usefulness of TA findings; and (3) advancement of the state of the art of TA methodology. We differentiate between and examine five types of studies involved in TA: (1) macro-assessments, full-scale analyses by multidisciplinary teams costing on the order of \$300,000 or so; (2) mini-assessments, an order of magnitude smaller in scale; (3) micro-assessments, an order of magnitude smaller still; (4) monitoring, an ongoing information processing system; and (5) secondary evaluation, wherein a TA is re-assessed. These elements may be combined in various sequences to form MTAs. Six appealing examples of MTAs are selected for comparison with each other and with the standard "one-shot" assessment by considering each, in turn, against the set of TA objectives. Finally, we illustrate the MTA concept by discussion of a recent multi-national, multi-component effort dealing with the assessment of the likely effects of alternative work schedules. We conclude that MTAs appear potentially more valid, and more useful in a number of respects, as well as

more helpful in the development of TA methodology, than the "one-shot" mode of assessment. Hence, these alternative TA designs merit trial to ascertain their practicality and worth in actual practice.

INTRODUCTION

The archetypal technology assessment is today understood to be a single, ad hoc study performed by a multidisciplinary team, on a budget of the order of \$300,000, in a period of about one year. While actual studies undertaken to date vary greatly in terms of budget, time, available expertise, and sponsorship, they have rarely diverged from the notion of a single assessment effort. Paraphrasing two of Joseph Coates' definitions [4, 5], TA should anticipate, forecast, and evaluate the impacts of a technological intrusion — particularly the unintended, indirect, and delayed impacts — on all sectors of society. This is simply not feasible in a single study, no matter how well done. We argue that such an ideal can be better approximated by a combination of studies linked into a coherent research program — a multiple technology assessment.

To initiate critical consideration of the pros and cons of various types of MTAs as opposed to single assessments, we offer a set of nine objectives for TAs as a basis for comparison. We then examine, in turn, each of seven potential types of TA design as to how well they promise to fulfill these objectives.

TA OBJECTIVES

The following listing of objectives is offered as a first step toward critical appraisal of the TA process. Tech-

nology assessors will always face difficult trade-offs among such objectives as they attempt to perform their task under serious constraints of knowledge, time, and resources. Each assessment team, in conjunction with its sponsors and eventual users, will have to choose for itself its priority of objectives. And the TA community as a whole will need to learn better the implications of the available choices.

An example of such a trade-off which intimately affects efforts to analyze complex, many-faceted problems is the issue of appropriate depth versus breadth. Given budgetary and temporal guidelines, as well as the sponsor's preferences, the task group can try to cover all possibilities and contingencies as Dickson [9] did in the assessment of the videophone; or focus on one aspect only, which was the path chosen by Grad et al. [11] in their study of the automobile; or operate somewhere in between. Either focusing on breadth or focusing on depth causes information loss. Breadth treatment offers a coarse grain analysis without much detail. The danger in this approach is superficiality to the extent of being grossly wrong. On the other hand, a depth analysis loses scope and, by picking the wrong subject(s) for analysis, the perspective of the study may become irrelevant to the users. To decide such issues wisely, assessors must clearly visualize their objectives.

Our nine objectives for TA are divided into three categories: validity, utility, and the state of the TA art (see Table I). *Validity*, being well-grounded in fact, is represented by three objectives, a meager beginning on this crucial matter. In a related study area, evaluation research, with the more manageable task of assessing the effects of programs already implemented, some thirty threats to "internal validity" have been identified [7]. Any of these threats can invalidate the results of an assessment study. Technology assessors should realize that they are operating without sound scientific bases in terms of developed assessment designs, appropriate statistics, or sampling criteria pertinent to generalization of study findings. While serious scientists would correctly shrink from such adventuresomeness, TA nonetheless is justified in that decisions will have to be made with or without sound information, and TA promises information. The second category of five objectives reflect *utility*, the usefulness of the TA. Advancing the *state of the art* of TA methodology is proposed as the third category of objectives. We view this as essential to improved long-term fulfillment of the prior eight objectives and development of TA into a defensibly sound enterprise. We discuss the objectives one-by-one with some reference to prior TAs (see Table I).

Validity:

- 1 *Cause-effect understanding*. TA is clearly imbued with a causal orientation in that one is attempting

to determine the effects of a technological change. Of the several conditions requisite for causal inference [cf. 1], the one most suspect in our case is to demonstrate a thorough system understanding. How can we anticipate the effects of a particular technological change when we lack understanding of the other causal influences at play, interactions, and feedbacks encompassing "all sectors of society"? Indeed, no presently existing theory of social change is an adequate basis for treating the effects of the introduction of a technology on society [10]. Usually, effect analysis is partitioned into classes of effects amenable to a single disciplinary analysis — a difficult task itself — without investigating mutual causal relations between the various classes of effects [17]. For example, in the Jamaica Bay and Kennedy Airport Study [13], the possible effects of the primacy of environmental values (which the report seems to champion) on transportation needs and capabilities, is not thoroughly explored. The report never confronts squarely the value trade-offs involved.

- 2 *Balance*. Secondly, according to Daddario [8], technology assessment should provide a *balanced* (underscoring ours) appraisal to the policy maker. The reconciliation of competing interests within the context of a single report means that the authors of a report must strike the balance.

One can distinguish between two basic approaches to this issue: (1) scientific neutrality — perpetuation of the myth that there is such a thing as value-free study, especially in policy-relevant matters (for background on this point see the excellent article by Scriven [21]), or (2) adversarial — assumption that the truth will somehow out if we provide for opposing positions [cf. 12].

The first approach was taken in the "one shot" Jamaica Bay TA mentioned previously. It is our judgment that the balance was struck somewhere on the side of the environmental — as opposed to the transportation — interests. The question of whether the "right" balance was struck cannot be answered, for who is to decide? The policymaker would have to do his own TA to find his own balance. The desideratum of a balanced appraisal must deal with the question of: Balanced relative to whom? And the answer, of course, is the authors — or perhaps the sponsors — of the TA.

The second approach follows the suggestion of Mitroff and Turoff [19] (see also Churchman [3]) for dealing with management situations in which there is conflict. Our version of this approach allows the policymaker to face not a balanced appraisal, but a collection of deliberately unbalanced appraisals, each reflecting a defi-

Table 1. Multiple TA Designs and TA Objectives

OBJECTIVES	DESIGNS						
	One-shot	Multiple assessments at one point in time		Multiple assessments at different times			
	A. One-shot, full-scale assessment	B. Double assessment (macro-)	C. Macro- plus two mini-assessments (probably adversarial)	D. Micro-, then macro-assessment	E. (Macro-) assessment, then monitor	F. Macro-, then mini-assessment	G. (Macro-) assessment, then monitor with intermittent (mini-) assessments
<i>Validity:</i>							
1. Cause-effect understanding	0	0	0	0	+	+	+
2. Balance	-	0	+	-	0	0	0
3. Methodological soundness	0	0	0	0	+	+	+
<i>Utility:</i>							
4. Pertinence of the causal factors, issues, and impacts considered	-	0	+	0	+	+	+
5. Timeliness	0	0	0	-	+	-	0
6. Credibility	0	+	+	0	+	+	+
7. Communicability	0	0	0	0	0	-	0
8. Economy of assessment	0	-	-	0	-	-	-
<i>State of the Art:</i>							
9. Advancing TA methodology	-	+	0	-	+	+	+

"+" indicates a strong likelihood of fulfilling the objective;

"0" indicates a fair possibility of fulfilling the objective;

"-" indicates little likelihood of satisfying the objective.

nite interest focus. With the interest groups making their strongest cases for their particular perspectives, the policymaker can then strike his own balance. For Jamaica Bay, one might expect at least assessments from the environmental and transportation interests. Other TAs would offer other mixes of assessments.

- 3 *Methodological soundness.* This is a catch-all category given the current state of the TA art. At a minimum, one could expect that TAs evidence

some reliability (reproducibility of findings), do not violate established scientific tenets (e.g., survey techniques or statistics), and contain evidence of suitable peer review. (See Cook and Campbell [7] for a discussion of a multitude of further issues in gauging effects.)

Utility:

- 4 *Pertinence.* This refers to several dimensions - causal influences (independent variables) con-

sidered, issues evaluated (technological or policy options included), and impacts assessed. In essence, if the TA does not ask the right questions, it is of no value. An example of this objective is in the ability to generalize results from one TA setting to another. e.g., at different times, concerning somewhat different technological options, under different constraints and external influences, or in different locales. For instance, in the case of the TA on alternative work schedules, presently in preparation by Haldi and Associates (discussed in some detail later in the paper), there are differences in the laws, social structures and institutions, in the forms of the organization of work, and in the cultural traditions among the various other countries and the United States. These differences might make the problem of whether to adopt an alternative work schedule and, if so, which one, look different under analysis in different contexts. The results of the original U.S. TA, although designed in loose international coordination, would need some "massaging" for use by other nations. In this case, possibly one or more smaller studies might add perspective. Indeed, broadening the perspective to include other contexts offers the potential of enhancing understanding of the original context. Such might have been the case in the Jamaica Bay and Kennedy Airport Study if Chapter 5 - Public Policy: National Issues Raised by the Jamaica Bay Study - had contained more extensive analyses of the salient features of other airports to firm up the report's factual base for its discussion of national issues.

The problem of pertinence is well-expressed by Grad et al. [11, p. 4] as it relates to their TA on the automobile:

... any lengthy study - such as this one ... - operates on constantly changing terrain. In the course of the past two or three years there have been numerous technical advances ... that have cast new light on pollution control technology, causing, in turn, a need for reevaluation of policies considered either more or less favorably in the earlier stages of the study. Other developments ... have also called for changes in direction ...

One such development ... that was not fully predictable at the beginning of the study is the sudden awareness of the existence of an energy crisis. This development, though it may threaten to overshadow everything else in the field of environmental regulation, occurred so late in the course of the study that it finds only minor reflection in this report.

Any major study in isolation, unaccompanied by follow-ons or a monitoring program, is vulnerable to this problem.

- 5 *Timeliness.* In a policy context, it is imperative that a TA be available when the time is ripe. Many TAs were needed before they were begun. This is a major constraint on the depth of analysis possible in a given TA.
- 6 *Credibility.* Whatever the validity of a report, it is valueless unless the audience believes the report to be worthy of consideration. A fine example of a credible report is the oft-noted Jamaica Bay/Kennedy Airport Study whose conclusions were implemented the day after public release.
- 7 *Communicability.* Unless the findings are presented in a usable format, the TA may receive scant attention. This threat is particularly acute in the case of more quantitative approaches that use more esoteric techniques, particularly those that combine a plethora of impacts under a weighted utility function (also those that present a multitude of impacts without a viable means to aggregate toward conclusions!).
- 8 *Economy of assessment.* After consideration of the preceding, we duly note that cost is a consideration. In the extreme, one must ask if a costly assessment is worth doing in the first place. Do the potential benefits of a study outweigh its costs? What are the risks involved in not doing the TA?

State of the Art:

- 9 *Advancement of TA methodology.* Unlike some other emergent areas of study, TA has not had the luxury of an academic birth. As a policy tool, it has been born close to the firing line. Despite such a pragmatic role, it is incumbent on the TA group to develop a means to assure that assessments present valid conclusions. One approach to further this end is the undertaking of secondary evaluations designed to critique both conclusions and methods.

More generally, several of the suggested MTA designs offer a potential for comparison of methodological effectiveness lacking in the "one-shot" study.

MULTIPLE TA DESIGNS

If the MTAs should be considered as a potential improvement over the "one-shot" study, what are their possible components and how can they be assembled? In this section five types of components and their possible temporal relationships are discussed: "macro", "mini", and "micro" studies; monitoring programs; and secondary evaluations. Then selected combinations are considered in the light of the nine TA objectives.

The most common and well-known type of TA is the "macro" or full-scale TA (the "one-shot" of Table

1), in which a team of investigators analyzes many facets of the effects of a technological system. Such an effort might typically run between one and two years and have a cost range of \$300,000 or more (V. Coates [6], and G. Patrick Johnson, private communication). By every measure, the full-scale TA is a large-scale research project. The Jamaica Bay Study, the STOL TA (LaPorte et al. [15, 16]), and the Assessment of the Automobile, cited above, fall into this category. Their results cover a wide variety of technological consequences, including some fairly detailed analyses, as well as overview impressions. The diversity of the scope and contents of such TAs is truly amazing.

Another type of TA is smaller in scale, say by an order of magnitude, than the full-scale TA. Such an effort could not usually aim at comprehensiveness. However, as a pilot study, as a supplementary study, as a study of a single effect or problem area, or as an assessment of another study from a different cultural context, it has definite potential value. In some cases, a full-scale study breaks down into an aggregate of smaller, relatively isolated substudies. The second report of the STOL TA (LaPorte et al. [16]) broke down into an integrative essay and three separate, essentially unrelated, studies dealing with social change, public attitudes toward technology, and regulation of technology. Each mini-assessment is generally useful only as a part of a total view; it lacks the capability of presenting anything like the complexity of the effects of a technology in reasonable depth.

Even more limited in scope than the mini-assessment is the micro-assessment. For discussion purposes, this can be considered an order of magnitude smaller than the mini-assessment. As such, it cannot be much more than the assessment analog of a thought experiment. Yet the micro-assessment can serve, for example, by way of a dry run, to focus and anticipate problems with larger-scale assessments. It also has potential for attacking specific conceptual problems within the larger context of an assessment. The micro-assessment is brainstorming rather than hard study, quick and dirty rather than careful and thorough. It should usually be tied closely to a larger assessment effort.

Not usually considered in the context of technology assessment is the monitoring program by which information from the environment is selected and processed to provide a continuing update on ambient conditions. Technology assessment, as Grad et al. [11] discovered, is operating in a constantly changing environment. Not only do technical performance parameters and political and economic conditions change, but the values of a society and its members are constantly changing. The groundwork to help TA sponsors to determine which assessments should be undertaken appears as the result of a (usually informal) monitoring process. Besides pro-

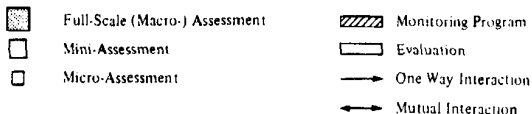
viding information useful in determining what TA should be done and when, monitoring can allow for changes in an assessment already under way. While such major events as the "energy crisis" certainly affect the TA on the automobile, a cumulation of much smaller events, including marketing and regulatory decisions, might also affect Dickson's TA on the videophone [9].

The final component to be considered here for MTAs is an evaluation of the TAs themselves, secondary evaluation. Self-study and evaluation has not been a strong point of technology assessments. Indeed, none of the assessment reports cited earlier contained introspective components. A state of the art review of 13 selected TAs by Jones [14] offered only a relatively superficial critique, confining itself largely to exhibiting a comparison of the studies along specific dimensions, such as managerial approach and data collection procedures. Since there is no fixed, agreed upon methodology for doing TAs, evaluation can not be a "checklist" procedure. But evaluation should receive more explicit consideration precisely because of the massive uncertainties in TAs. It is to be expected that a competent TA team is constantly aware of the need to correct procedural and substantive errors as they arise, but this informal, internal review is not a long-term substitute for more formal and systematic evaluation. Secondary evaluation or evaluation of TAs themselves is listed here because of its potential usefulness rather than its current application.

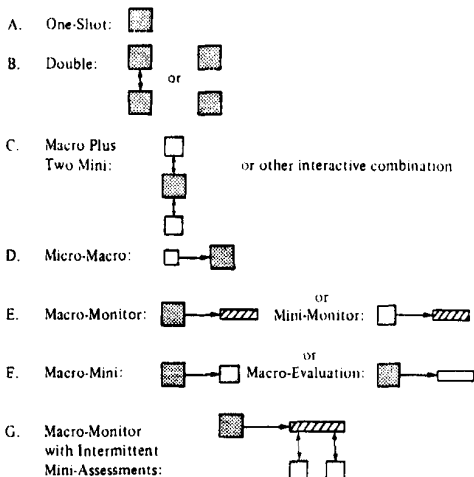
Table II illustrates a schematic representation of the components of MTAs and the representation of the combinations selected in Table I. The components can fit together in time in a variety of ways. An MTA may be made up of sequences of components. For example, a monitoring program in a particular area of technology may reveal the need for a major TA effort. A micro-study scopes out the dimensions of a full-scale undertaking. An evaluation of the full-scale effort reveals a deficiency which is correctable by a mini-assessment. The monitoring program continues. This sequence of activities illustrates the possibility of viewing TA as a *process rather than an event*, as indeed are technological change and its human consequences.

Turning now to the designs assembled in Table I, we consider seven, in turn, as key samples of the endless array of possible combinations of full-scale, mini-, or micro-assessments in conjunction with monitoring and secondary evaluation of TAs. We caution the reader to interpret both the following comments and the tabular entries with great caution - too many variants are conceivable and lack of experience with all but the "one-shot" design preclude definitive statements. The evaluations were done by the authors on their personal experience and judgment in order to indicate the points at which various MTAs appeared a

Table II.



With positive time flow from left to right horizontally the designs of Table I may be diagrammed as follows:



Other MTA designs can be diagrammed similarly.

priori stronger or weaker than "one-shot" assessments.

- A *One-shot Assessments*. The standard TA is considered particularly weak in terms of balance, pertinence, and contribution to TA methodological development. In each case, the flaw is the absence of any basis for comparative analysis.
- B *Double Assessment*. This alternative compares favorably to the one-shot in providing a basis for comparison, hence strengthening the three weaknesses noted. In addition, credibility may be enhanced; but all these gains are at the expense of doubled assessment costs. Two very different variants are worth considering: (1) independent, "scientifically neutral" assessments, or (2) adversarial assessments wherein most opposite view-

points are afforded a means for development of bases for their positions.

- C *Macro- (full-scale) Plus Two Mini-Assessments*. This implies that the full-scale TA, most likely "scientifically neutral", would share its generated data base as it became available with two adversarial groups oriented toward elaboration of opposing viewpoints. An alternate version would support two "scientifically neutral" mini-assessments designed to elaborate different technological alternatives or different contextual assumptions. The advantages of such a design are along the same lines as noted for double assessments, with even greater potential for balance and pertinence.
- D *Micro- then Macro-Assessment*. This adds a

small-scale pre-assessment effort to better define the critical parameters for the full-scale TA to follow, and involves perhaps a small loss in timeliness.

- E *Assessment (Macro- or Mini-), then Monitor.* This is the prototype for the "process" designs. It offers the strong advantage over the preceding designs in that it is ongoing. Monitoring can be undertaken in a variety of styles: formal or informal; focused or scanning; intermittent or continuous. As indicated in Table I, this appears to offer great potential on all counts, excepting economy, but the level of the effort does not have to be very large. Timeliness is of course a function of the need for information.
- F *Macro-Assessment, then Mini-Assessment(s) or Macro- then Evaluation.* This design offers good potentials via a number of alternatives. For instance, one could evaluate the TA by means of a secondary analysis - this would be particularly rich in terms of advancing TA methodology. Or one or more small-scale assessments could elaborate on particular issues raised by the initial assessment, or by changed circumstances, or by strident opposition. Informal assessments by concerned parties could also be considered as variants of this design. In all cases, the result should be considerably richer than the "one-shot"; however, one could anticipate less expeditious decision processing, greater confusion if divergent opinions are apparently supported, and higher costs.
- G *(Macro-) Assessment, then Monitor, with Intermittent (Mini-) Assessments.* Without belaboring the notion, this is a reasonably attractive mode of extension of the multiple TA concept toward an ongoing effort. Advantages appear attractive, similar to Design E.

Since the MTA concept has not been widely accepted, we turn to consider activities which embody some of the salient features of MTAs.

AN MTA EXAMPLE

We now consider a technology assessment of Alternative Work Schedules (AWS) supported by the NSF as part of a loose international coordination among the OECD member nations. These efforts were handled by the OECD Directorate of Science, Technology and Industry under its work groups on Humanized Working Conditions in the Social Assessment of Technology research area. The NSF effort, lasting 18 months, funded at about \$207,400, was performed by Haldi Associates Inc. of New York, with John D. Owen serving as principal investigator.

The Principal Investigator and members of the Oversight Committee met with European experts to

discuss their countries' experiences to date with AWS forms. In its analysis, the team made use of the techniques of historical analysis and trend evaluation, econometric analysis, inter-disciplinary brainstorming and matrix analysis. Work schedules were analyzed from the aspects of both the number of hours worked and the timing of those hours, as well as from the focus of the degree of choice of employees and employers. Scenarios were reduced to three: (1) status quo (with overtime premium pay requirements of the present Fair Labor Standards Act continuing); (2) "Flexi-time" (with no premium pay for hours worked over 8 in a single day); and (3) compressed work-weeks (e.g., 4-day, 40-hour or 4-day, 36-hour week). Because the project's final report has not yet been issued, it is premature to discuss its conclusions.

During the Haldi study, two micro efforts at the assessment of AWS were undertaken by two teams of six undergraduates each at the Georgia Institute of Technology. The details of these efforts are analyzed elsewhere [20]. It suffices for present purposes to mention that one group undertook an evaluation of "flexiweek", a novel AWS consisting of alternating 4- and 6-day work weeks of 8-hour days with businesses remaining open 6 days per week, while the other studied worker satisfaction under four different work schedules using an operationalized version of Maslow's [18] hierarchy of needs.

In May 1975, the Haldi group's methodology and results to date were reported to an OECD work group, at the group's exploratory meeting. The OECD will probably hold further sessions tying together ongoing projects and publishing a wrap-up containing final reports of the various national studies. Project results and methodologies would thus be shared. The OECD Observer, No. 81, May-June, 1976 presents some comparative information regarding flexitime in France, Germany, Sweden, the United Kingdom, and the United States.

Projects related to the Haldi effort are taking place in other OECD member nations. In Great Britain, the Work Research Unit of The Department of Employment [2] set up a Steering Group on Job Satisfaction. This group set up a series of projects to explore ways in which the content and organization of work could be changed to meet individual needs for job satisfaction. The Swedish Work Environment Fund [22] has devoted considerable effort to the study of shift work and its medical, social, and productivity effects. Additional research in this area has been suggested.

Apparently, OECD supports no coordinated data-gathering studies or evaluations of the work. It is, of course, too early to form any meaningful judgments of the validity and utility of the output of this program.

OBSERVATIONS AND CONCLUSIONS

As is apparent, our "MTA Example" of the last section really wasn't an example of an MTA. Instead, it represented a loose attempt to coordinate diverse efforts to assess a broad and important topic — alternative work schedules. That we chose such an example is a reflection of the current state-of-the-TA-art. The complexity of the assessment problem is recognized and a plurality of studies is undertaken. However, overall (as opposed to limited) design planning and coordination is not yet being used.

Brief mention should be made of two other groups of assessments. One example of a true MTA design consists of a full-scale assessment of earthquake amelioration possibilities under Ed Dickson of the Stanford Research Institute, and a coextensive mini-assessment by Martin Jones, both supported by the NSF. The second assessment reputedly did not significantly influence conclusions and partly on this basis we have not included the concurrent "macro" plus "mini" as an interesting MTA design.

The second group of TAs is currently under way with support from the Office of Technology Assessment on various aspects of materials resources. This effort shows promise of excellent coordination as a single advisory committee serves to oversee five full-scale assessments at this time with a potential for several more. However, this design is also not included in our seven favorites because it simply divides the topic into essentially non-overlapping sub-topics, whereas our MTA designs provide for various forms of replication.

Two problems exist. Since TA is not a discipline, but a collection of ad hoc, problem-oriented studies, there is no cumulative body of knowledge being developed. At the same time the management and coordination of TAs is fragmented, with each fragment possessing a short time horizon.

Studies in social change due to technology and in TA methodology may make some progress in solving the first problem. However, we feel that improvements in this area will be increments rather than breakthroughs. It may prove necessary to provide continuity through systematic monitoring of important areas of technology and their effects on man. This, coupled with long-term commitment to study various classes of impacts, may provide continuity to what is, after all, the assessment of a process. What the mechanisms of coordination, control, monitoring, and evaluation should be we leave to the further deliberations of TA practitioners, users and supporters. If the need for understanding the human effects of technologies is as great as we believe it to be, the replacement of the present hodgepodge of isolated efforts of uneven quality with assessment programs possessing continuity and form seems a logical next step.

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A Case Study: Polychlorinated Biphenyls

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ABSTRACT

The Government "decisions" on polychlorinated biphenyls (PCBs) constituted an unusual regulatory exercise compared to much of the experience of the past few years.¹ PCBs had been developed in the late 1920s to serve in instances where high physical and chemical stability were advantageous. In part, precisely because of these peculiar properties, they became recognized as particular environmental hazards. The processes of analysis and study by the Government for decision were fuller and more deliberate than is often the case. A number of scientific reviews were joined in the process. Benefits as well as hazards were explicitly considered. Regulatory type action was not taken until suitable information was marshalled and recent scientific evidence was given the benefit of interpretation. Finally, the process of deliberation was an unusually open one with the results of analysis fully displayed.

¹Written for the study on Decision Making for Regulating Chemicals in the Environment, Environmental Studies Board, National Research Council, National Academy of Sciences, and undertaken at the request of the U.S. Environmental Protection Agency, Contract No. 68-01-2262, this paper was completed in December 1974.

²In February 1975, the National Academy of Sciences organized a working conference to explore the process of Government decision-making to regulate chemicals in the environment. To assist this conference, a series of case studies of past regulatory decisions was solicited from persons who had reasonably detailed knowledge of them. What follows is the case study of polychlorinated biphenyls as one of the series used in the NAS study. The majority of the Government pronouncements and decisions in this instance derived from a series of studies and analytic exercises convened by the Office of the President's Science Adviser. (This study is also to appear as a part of a book by the author on regulation and human health to be published by Lexington Books, Inc.)

INTRODUCTION - NATURE OF THE DECISION

The process of Federal Government deliberation and decision on polychlorinated biphenyls (PCBs) was relatively circumscribed and straightforward. The Government actually possessed little in the way of legal, regulatory authority. Hence, the "decisions" leaned heavily on persuasion and on para-regulatory moves. Nevertheless, the Government's decisions in this case did lead to the intended and recommended actions (reduction and restriction in certain uses of PCBs) and a tightening of the procedures governing the manufacture, importation and continued use of these chemicals.

Most important, perhaps, was the fact that the decisions and actions assumed by the Government (and by parts of the private sector) were taken deliberately and on the basis of unusually good analysis and information. The PCB decisions, in brief, were unusually well informed decisions when compared to others of this type, and the analyses used to arrive at the decisions were probably fuller and of a higher quality than is the case with most regulatory actions.

The several agencies of the Federal Government concerned with the PCB question contributed to the deliberations and to the analyses. At the same time, an outside group of scientific experts was engaged by the Office of Science and Technology to consider PCBs from a broad perspective as a case study of a hazardous substance existing in the environment in trace quantities. The Government's major deliberative body for its decisions was an interagency, PCB Task Force - run jointly by the OST and the CEQ. The case study of the outside advisers to the OST was timely and useful to the Government's own analyses.

THE ENVIRONMENT - OFTEN DISTANT FROM APPARENT SOURCES

PCBs were among the materials found, but when analysed they were often confused with other substances. PCBs were first distinguished from the "unknown interfering compounds" found in nature in 1966 by Jensen² and the next year by Widmark.³ On the basis of this latter report, the Food and Drug Administration was moved to develop analytic methods to distinguish between PCBs and chlorinated organic pesticides encountered in monitoring for regulation.

In February 1969, Dr. Robert Risebrough gathered attention by warning, in an article in the *San Francisco Chronicle*, of the dangers of PCBs in the ecosystem. Over the next 6-7 months, the FDA increased its surveillance of foodstuffs for evidence of PCB residues. Notable positive findings were in fish. Monitoring of foodstuffs, raw agricultural products, fish, and feeds for PCBs was augmented throughout 1970. PCBs were found in fish and in marine animals in high concentrations close to plants which manufactured the chemical.

ACCIDENTAL SPILLS OR LEAKAGES OF LARGE QUANTITIES OF POLYCHLORINATED BIPHENYLS WITH CONSEQUENT CONTAMINATION OF FOODSTUFFS AND ANIMAL FEEDS.

In 1968, PCBs, used as a heat-exchange fluid in a pasteurizer, leaked into rice oil being manufactured for home cooking use in a plant in Japan. More than 1,000 persons were affected by the contaminated rice oil, many of whom exhibited persistent skin lesions as well as systemic disease (Yusho disease). In July 1971, leakage of heat exchange fluid caused contamination of pasteurized fish meal which was used as a feed ration for chickens and catfish.

In addition to these two major areas of concern, PCBs began to be reported with increasing frequency in poultry and in eggs, and in packaging material for food.

PCBs appeared with increasing frequency in 1970 and 1971 in the professional scientific literature dealing with wildlife and the environment.^{4,5} In September 1970, the National Swedish Environment Protection Board held a conference on PCBs.⁶ One of

the sessions of this conference highlighted the "environmental problem". This conference, perhaps for the first time, brought together the extent of understanding on the manufacture, use, and biological effects of, the extent of environmental contamination by, and the analytic methods for, PCBs.⁷

In August 1971, an Environmental Quality Workshop was convened in Durham, New Hampshire, by the National Academy of Sciences, to consider Marine Environmental Quality and Ocean Pollutants.⁸ PCB contamination was highlighted.

In addition, provoked by both the accidental spills and by the widespread finding of trace quantities of PCBs in the environment, there emerged in the lay press a series of stories and articles dealing with PCB contamination. Most of them occurred in late 1971 and reflected especially the contamination of foodstuffs.^{9,10}

The FDA, aware that PCBs were to be found as a contaminant in the environment, and alert to the occasionally reported cases of accidental spillages, elected to engage in watchful surveillance of food. It did this in part in cooperation with the Department of Agriculture. As a result of the findings of PCBs specifically in fish and milk, the FDA established, between December 1969 and February 1970, "Action Levels" for PCBs in milk, poultry and fish. Action levels are temporary thresholds for regulatory decision pending the establishment of a more permanent regulatory policy and procedure. In August 1970, the FDA established a similar action level for eggs. During 1970 and 1971, the FDA used these guideline values in various seizures of foods found contaminated with PCBs.

The number of reported contaminations of foods, recreational fish, packaging materials and animal feeds increased toward the latter half of 1971. Accompanying the announcements in the public press (and, undoubtedly, reflective of them), there also occurred toward the end of 1971 a series of inquiries from Congressmen and other elected officials over PCB contamination of food and the environment. On

tection Board, Research Secretariat, Wenner-Gren Center, Stockholm, Sweden, 29 September 1970.

⁵ Marine environmental quality. A special study held under the auspices of the National Scientific Committee on Oceanography of the National Academy of Sciences Ocean Affairs Board, Durham, New Hampshire, 9-13 August 1971.

⁶ Monsanto limits food plants' use of chemical PCB. The Washington Post, 30 September 1971.

⁷ Some dried foods found tainted by perilous chemical. The Washington Post, 28 September 1971.

⁸ Tainted turkeys. The Washington Post, 24 September 1971.

⁹ Turkeys, salmon tainted by PCBs. The Evening Star, 23 September 1971.

¹⁰ A contaminant is found in cardboard. The New York Times, 28 September 1971.

¹¹ If you think DDT's a problem, meet PCB. The New York Times, 30 September 1971.

¹² FDA studying chance of contamination in containers for food. The Wall Street Journal, 28 September 1971.

² Jensen, S.: A new chemical hazard. *New Scientist*, 32: 612 (1966).

³ Widmark, G.: Possible interference by chlorinated biphenyls. *J. Assoc. Offic. Anal. Chem.*, 50: 1069 (1967).

⁴ Peakall, D.B., and J.C. Lincoer: Polychlorinated biphenyls. Another long-life widespread chemical in the environment. *BioScience*, 20: 958-964 (1970).

⁵ Michirio, J.: PCBs: Leaks of toxic substance raises issues of effects, regulation. *Science*, 172: 899-902 (1971).

⁶ PCB Conference. National Swedish Environment Pro-

16 August 1971, Senator McGovern addressed a letter to the Commissioner of the FDA, reflecting this concern. In September, Governor Miliken of Michigan sent a telegram to Elliott Richardson, Secretary of HEW, in which he announced a restriction of commercial salmon fishing because of the finding of PCBs in fish.

By August 1971, the FDA (and to some extent, the USDA) found itself rapidly propelled into a position where it would be "required" by public pressure and advocacy to take a stronger and more forthright position against PCBs. The scientific issues were still not clear and there were glaring gaps in information. What really were the biological effects of the complex known as PCBs? How did the various PCBs vary in human toxicity and which members of the PCB family were found as contaminants? Was observed toxicity due to PCBs proper or to contaminants produced during their manufacture? How widespread was the contamination, and how good was the monitoring system in picking up accidental spills? Furthermore, it was clear that the twin issues of widespread environmental contamination, by trace quantities of PCBs, and the selective, higher level contamination of foods and feed, had to be joined at some point in Government decision-making.

On 5 August, 1971, the FDA, on its own initiative, called a meeting of spokesmen from each of several Government agencies and Federal research laboratories to review the state of scientific understanding of PCBs. The text for the meeting was the reported series of accidental spills and leakages.¹⁵ Shortly following that meeting, the Department of Agriculture and the Commissioner of the FDA asked the Office of the President's Science Adviser to provide assistance and act as a focus for the Government's actions and decisions concerning PCBs. This request was made because: (1) the issue cut across several Federal agencies and also involved outside scientists, (2) the issue was rapidly becoming uncomfortable for the FDA to handle alone, and (3) the Office of Science and Technology already had under way a scientific review of polychlorinated biphenyls and had quietly begun to gather information several months back.

In April 1970, spokesmen for the Monsanto Company agreed to meet with the staff of the President's Science Adviser in the OST to discuss a number of issues concerning PCBs, including a series of animal toxicology studies which Monsanto had undertaken. During this meeting, Monsanto was asked for information concerning the amounts of PCB it manufactured and distributed. The company, being the sole producer in the U.S., was reluctant to make public this information, although it reported that it might

be able to provide the data on a confidential, non-public, basis to the Government.

In October 1970, a review was begun, in the Office of Science and Technology, of the general subject of hazardous substances existing in the environment in trace quantities. This review, known ultimately as the Panel on Hazardous Trace Substances, had as its major goal the identification of the needs for information by the Government in making judgments about trace hazardous substances.

The Panel was composed principally of non-government experts in the fields of ecology, chemistry, biology, environmental and occupational medicine and geology. Three case studies were begun from which it was hoped to draw generalizable experience. The particular subjects for the case studies were chosen because they were thought to be of importance, because regulatory or other governmental action had not yet been taken but could be expected at some time in the reasonably near future, and because it was thought that there existed sufficient information from which to draw conclusions. The choices were cadmium, arsenic and PCBs.

Thus, as the Government began to develop its own position on PCBs in 1971, the OST-initiated study was already under way. What followed, in part, was for the Government to borrow the experience developed by the OST Panel and even for the two exercises to be joined to some extent. Notwithstanding, a separate and identifiable PCB report was published by the members of the Panel on Hazardous Trace Substances.¹⁶

On 1 September 1971, the FDA held a meeting with the USDA, the EPA, the Council on Environmental Quality, and the Office of Science and Technology, to explore options for further action concerning PCBs. The FDA and the USDA requested that the Office of Science and Technology take a lead role in handling this matter. OST acceded to this request and agreed to collaborate with the CEQ in the task. This became known as the Interdepartmental Task Force on PCBs. The Task Force was announced on 5 September in a joint FDA-USDA press conference.¹⁷

On 15 September 1971, the OST Panel on Hazardous Trace Substances and the governmental Task Force met jointly with representatives of the Monsanto Company. The principal agenda item of this meeting was a request for information concerning the amounts of PCBs produced, patterns of distribution and usage, and estimates of losses into the environment.¹⁸ Again, the manufacturers expressed their

¹⁴ Polychlorinated biphenyls - environmental impact. A review by the panel on hazardous trace substances. March 1972. Environmental Research, 5: 249-362 (1972).

¹⁵ Press release on interdepartmental PCB task force. Food and Drug Administration, Department of Health, Education, & Welfare, 5 September 1971.

¹⁶ Letter from Edward J. Burger, Jr., M.D., of the OST to Mr. John Mason, The Monsanto Company, 15 October, 1971.

¹⁷ Transcript of proceedings of the interagency meeting on polychlorinated biphenyls (PCBs). Food and Drug Administration, Department of Health, Education, and Welfare, Washington, D.C., 5 August 1971.

willingness to supply information of this sort to the Government, but with the understanding that the data would not be released publicly except in a full and detailed fashion. In addition, the Monsanto Company expressed some concern over the seemingly disconnected character of the Government's activities up to that time and the difficulties involved in finding responsible spokesmen for each of the agencies involved. Monsanto made a strong plea (in the form of a condition for their supplying information) that they be permitted to deal with a single spokesman for the Government.

The office of Science and Technology, on the advice of the Counsellor to the President, did reach agreement with Monsanto on the terms of receiving the information.¹⁹ These were shortly rendered moot by a request from the Environmental Defense Fund for the same information. This information ultimately served as important background for the Government's decisions and was leaned on heavily by both the OST Panel and the Task Force.

The OST Panel combined the production figures and the data on distribution and use with knowledge of the physical properties of PCBs to develop a composite picture of the rates and routes of environmental transport and disposition. The data were reflected in a series of coefficients for a model of transport of PCBs. While this was necessarily a crude description, it served as a very useful instrument for placing PCBs in perspective. It replaced what otherwise would have been a totally qualitative — even intuitive — exercise. It pointed up important gaps in knowledge. Finally, some verification was afforded by the results of physical measurement and monitoring. This attempt at environmental modelling was a major contribution by the Panel to decision-making.

The OST Panel report was also appropriately critical in its review of biological effects and analytic methods for PCBs. It considered what was known of the mechanisms of observed biological effects, and relationships between variations in chemical structure and biological activity, and it attempted to compare the effects of controlled laboratory experiments with observations made on animal populations in nature.

The Interdepartmental Task Force reflected much of this information in its report. It explored additional territory as well — reflective of the fact that it was a Government report which focused on a number of specific, pragmatic, governmental or public problems. Thus, as well as serving as a review of the scientific aspects of PCBs, the Task Force explicitly reviewed a number of broad aspects of the PCB question. Most important, perhaps, was the exploration of the benefits or utility of PCBs and of the industrial

and commercial dependencies built up over the years. This explicit review of the benefits of PCBs, which is often not done for regulatory decisions, was of vital importance for decision-making on PCBs. The National Bureau of Standards engaged in a review and analysis of the benefits and even the "essentiality" of each of the several uses of PCBs. In this, the NBS received advice from the National Industrial Pollution Control Council, especially concerning the electrical uses of PCBs. In each of the cases examined, the question of a possible and satisfactory replacement for PCBs was raised. This review became the basis for the ultimate decision to preserve electrical uses of PCBs (for which there were true dependencies and no satisfactory substitutes) and to restrict other uses.²⁰

The Government Task Force report included a systematic summary of monitoring experience for PCBs in food. It had been this matter of PCBs in food as much as any other which had brought PCBs to public notice. Hence, it was thought highly desirable to systematically lay out the apparent extent of food contamination and to consider what the patterns of contamination would suggest for public policy and Government action.

The Task Force Report explicitly reviewed all of the pertinent Federal regulatory laws for their applicability to PCBs. This was, therefore, an exploration of the power of the Government to control and limit the manufacture, distribution, use and disposal of PCBs. This review pointed out something that was already known — that existing regulatory authorities were capable of responding to specific incidents of contamination of foodstuffs once they were recognized. However, it acknowledged that the Government's legal armamentarium was generally "inadequate to prevent more PCBs from entering the environment".²¹

In addition to the above, the Interdepartmental Task Force review considered the chemical and physical properties of PCBs, the occurrence, transfer and cycling of PCBs in the environment, and the known biological effects — especially on man.

During the time that the Government review of PCBs was being pursued, the level of public concern over these chemicals continued to rise considerably. For this reason, the Commissioner of the FDA felt compelled to hold a press conference to "... try to help establish a perspective on PCBs..." roughly a month after the Task Force had begun its work.²² This was an appropriately reasoned statement which attempted to allay fears and discourage demands for a sudden, outright ban on PCBs (even if

¹⁹ Memorandum from John Dean, Counsellor to the President, to Edward J. Burger, Office of Science and Technology, concerning the Freedom of Information Act, 4 October 1971.

²⁰ Polychlorinated biphenyls and the environment, Interdepartmental Task Force on PCBs, Washington, D.C., May 1972, National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, No. COM-72-10419.

²¹ Statement by Charles C. Edwards, M.D., PCB press briefing, Food and Drug Administration, 29 September 1971.

the Government had been capable of invoking one). The statement deferred to the ongoing process of review and deliberation as the basis for considered decision and action.

There was, finally, a third review of PCBs undertaken within the Federal walls. One of the national institutes of health, the National Institute of Environmental Health Sciences, had sometime before elected to conduct a series of "scientific" reviews of materials which were of impending regulatory concern and for which no systematic accounting of scientific information had been done. The philosophy in this case was to bring together, in a conference, spokesmen for the principal research projects — published or under way — in order to take the measure of the available scientific understanding. At the same time, members of the press — especially scientific writers — were invited to attend these sessions, in order to enjoy the products of this review process. The aim was to educate both the scientists and the public.

In December 1971, the National Institute of Environmental Health Sciences held the first of this series of conferences in North Carolina, and it was on PCBs.²² (Since then, the NIH has held similar reviews on lead, automotive emissions, and other substances of current public and governmental concern.) Many of the same spokesmen who were engaged in the other reviews made presentations at the "open" conference. One of the major accomplishments of this meeting was to impart an understanding to the press and science writers of the character of the scientific evidence and the scientists' own interpretation of experimental findings. The net (and immediate) effect of that exercise was to take the newsworthiness out of the PCB issue and to remove it from the category of the sensational. Very little was actually reported in the press of that meeting. More important, relatively little more was reported on PCBs in any form in the lay press.

The principal "control" actions for PCBs were the result of persuasion by the Federal Government rather than by direct regulatory exercise. The Government possessed no real regulatory authority to control the manufacture, distribution or use of PCBs. However, the persuasive influence of the several Government inquiries — especially the PCB Interdepartmental Task Force — was not doubted. Thus, the major action was taken "voluntarily" by the Monsanto Company, the sole U.S. manufacturer.

Beginning in 1970, the Monsanto Company had begun to reduce the sales of PCBs — especially for non-electrical uses. Domestic sales for PCBs for non-

electrical uses had risen from 12,000 tons in 1968 to 16,000 tons in 1970. By 1971, this figure was reduced to approximately 4,000 tons.²³ In addition, the Monsanto Company quietly assumed for itself the role of distributor as well as manufacturer in order to exercise some control over end-use of PCBs. In this way, the manufacturer was able to "discontinue sales of PCBs for use in paints, plasticizers, sealants, adhesives and other 'open-system' uses".

Thus, during 1971 and 1972, the Monsanto Company also restricted (or attempted to restrict) sales of PCBs to installations in which food or animal feed was processed.

The principal recommendation of the PCB Task Force was the discontinuance of all uses of PCBs except in electrical capacitors and transformers. These latter were judged to be essential uses and represented "closed systems".²⁴ To the extent that it could exercise this type of restriction on distribution, the Monsanto Company again undertook "voluntarily" to control end-use through its control of the manufacture and sale of PCBs.

OBJECTIVES

The Interdepartmental Task Force report on PCBs was issued publicly in May 1972 and was accompanied by a statement of governmental "thinking" and governmental "action". Perhaps the major conclusion reached in the report, which became an objective in Government decisions, was that of *limited* restriction on PCBs. PCBs were seen as having certain essential uses in electrical transformers and capacitors and it was judged in the country's best interest not to be totally denied the use of PCBs. This was a direct reflection of the analysis performed by the National Bureau of Standards of the utility and essentiality of PCBs, which pointed to the possibility of an increase in fires and explosions from encased or enclosed transformers if PCBs could no longer be used — representing the possibility of trading one hazard for another hazard. In addition, it derived from the attempts to map out the patterns of environmental dispersal of PCBs which had been lost from human use. Electrical applications were seen as "closed" applications and were not thought to contribute to environmental distribution.

Other uses of PCBs were reviewed as either not essential, potentially or actually contributory to the environmental "load", or were found to have suitable substitutes. This, then, pointed to an elimination of

²² National Institute of Environmental Health Sciences meeting on polychlorinated biphenyls (PCBs), Rougemont, North Carolina, 20-21 December 1971. Proceedings published in *Environmental Health Perspectives*, Experimental Issue No. 1, April 1972. National Institute of Environmental Health Sciences, Research Triangle Park, North Carolina.

²³ Monsanto Industrial Chemicals Company, press release: Monsanto releases PCB production figures to Department of Commerce, 30 November 1971.

²⁴ Press release accompanying the release of the PCB Interdepartmental task force report on PCBs, Washington, D.C., 12 May 1972.

essentially all other uses — heat exchange fluids, hydraulic fluids, and the miscellaneous category of "plasticizer" uses. The objective of limited restriction became the basis for governmental persuasion of the Monsanto Company to restrict its distribution and sales of PCBs — in fact, the principal governmental action.

Highlighting of the fact that true regulatory control by the Government was limited, became the text for a plea for passage of a then-pending bill in Congress to close this gap. A second objective, then, became the enactment of the Toxic Substances Control Act which would permit the Government to exercise useful control of industrial chemicals at their source.

The regulatory tools which the Government did possess in this case permitted enforcement action after PCBs were found in foods for human consumption and in animal feeds. Here, the FDA and the USDA re-stated their thresholds for action (which had been evolving over the previous four years), and announced the strengthening of their monitoring and analytic efforts. The other avenue of governmental control was that over industrial effluents and ambient water quality. Here, the Environmental Protection Agency stepped up its effort to assess the foreign chemical content of waters downstream from plants manufacturing PCBs and the Justice Department was close behind with enforcement teeth.

INFORMATION

The PCB "decisions" were perhaps among the best informed of governmental actions of this type in recent years. There was, it turned out, a certain body of scientific and technical knowledge about PCBs and a modest documentation of past experience. In addition, this information was better assembled and analyzed than was usually the case. Perhaps time was an important factor since time was permitted for deliberate and reasonably careful study and reflection before decisions were announced. Thirdly, there was more opportunity for public airing and scientific interpretation before decision-making than is usually the case. A Swedish scientific meeting on PCBs had been held in 1970.⁶ The Office of Science and Technology had begun its review and analysis of PCBs by December 1970, and the results of its analysis were made available as they emerged. The Government's own scientists reviewed and interpreted the base of technical knowledge over roughly six months beginning in September 1971. In December 1971, a third forum of scientists was convened by the NIH to review much of the same material. Thus, the process of interpretation and maturation of data by scientific peers — while characteristic of the traditional scientific process but unusual in regulatory decision-making — was played out in this case.

The processes of review in this case explicitly sought information for a broadly-based decision. Thus, there was a dedicated attempt, for example, to determine the benefits or utility of PCBs and of the costs that could be expected if their uses were restricted or denied. This information was later found to have been highly influential and important in formulating the Government's position.

One other element of information which proved to be important was the analysis of environmental distribution and dispersal. The analysis itself was something of an experiment. It was reasoned early on by the participants in the OST review that it should be possible, starting with some elementary information on total amounts of PCBs produced, and patterns of distribution in commerce and disposal, and armed with a certain elementary understanding of physical and chemical properties, to build a model predicting PCB distribution in the environment. Thus, in fact, was done, and the coefficients used in the model were partially tested or "validated" against the physical measurements of PCBs in the environment which had been reported in the literature. This exercise and the information from it became the basis, for example, of the judgment that PCBs used in electrical capacitors disposed of in the earth by burying in landfills would not be expected to migrate very far through the soil and would not represent a significant source of environmental pollution.

IMPLEMENTATION

The principal "decisions" deriving from this exercise were to restrict PCBs to "closed-system" electrical uses. There soon emerged a few additional issues which reflected either loose ends or areas which deserve some additional study.

The principal reason for denying the use of PCBs as heat-exchange fluids was to avoid accidental spills and leakages of PCBs into foodstuffs (where heat was used to "pasteurize" the food material). However, there were often PCB heat exchanger applications. One of these, for example, involved the use of heat on off-shore oil rigs to maintain low viscosity of the oil. PCBs had been chosen here because of the characteristics of high thermal stability and low probability of fire and explosion, and many of the heat exchange devices had been designed specifically around the use of PCBs. Denial of the use of PCBs in this case raised the spectre of an increase in the number of fires in off-shore oil rigs or the continued use of PCBs from imported sources.

This general question of worldwide (as opposed to U.S.) production and use of PCBs, became a matter of immediate concern. There was an early visit of a spokesman from the Swedish Government to the Office of Science and Technology. The Tantal Com-

nussion and the Customs Bureau were pressed to search for signs of imported PCBs.²⁵ Perhaps most useful was the fact that the OECD was persuaded to take up the question of the industrial production and commercial use of PCBs in the industrialized parts of the world. PCBs, in fact, became the major example of intergovernmental "consultation" in a mechanism which the OECD had established for this purpose. The U.S. position and the information behind it became major elements in the OECD position paper²⁶ and in the deliberations at the OECD in November 1972.

Trace amounts of PCBs in packaging materials became a matter of particular concern. In part, this was due to uncertainty over their origin. There was some evidence that trace quantities of PCBs were magnified in the process of recycling paper. To the extent that this was true, the Government and national policies aimed at recycling were seen to be in possible jeopardy. One of the principal motives for exploring this particular issue, apart from the economics of paper and cardboard production, was the contamination of food wrapped with PCB-containing paper. There followed, therefore, a series of investigations by the Food and Drug Administration into the process and rate of migration of PCBs from packaging materials into foodstuffs which the packages contained. In December 1972, the FDA produced an Environmental Import Statement (perhaps the only one of its kind from that agency) on its proposed rule-making for PCBs.²⁷ Among other things, this document summarized the FDA investigations and positions regarding PCBs and packaging.

CONCLUSIONS, OBSERVATIONS, AND RECOMMENDATIONS

The Government "decisions" on PCBs constituted an unusual regulatory exercise compared to much of the experience of the past few years. In the first place, the Government's position was generally well prepared. Related to that was the fact that time was taken for deliberate study and deliberate action, even in the face of public outcries for immediate action. Thirdly, the "decisions" were taken without much tangible legal authority for governmental control.

They represented, instead, persuasion and voluntary action. It is worthwhile, perhaps, to examine some of the factors which contributed to any successes that can be claimed.

- 1 The PCB decisions represented, perhaps, a somewhat more manageable challenge than many. Only a single U.S. manufacturer was involved. Further, the majority of commercial and industrial uses and the major users were known.
- 2 There was some information which proved useful in decision-making. Quantitative figures showing production were provided — albeit only after a delay — which were essential in determining the scale of the problem and its change with time. Similarly, the corresponding figures for commercial distribution were essential in ascertaining the patterns of human use and dispersion. To complement these data, there were at least some results of physical measurement and monitoring of PCBs in the environment or indices of dispersal.

In terms of hazards, there was a legacy of at least some documentation of previous human exposure and some laboratory data. However, many questions remained. Perhaps, most important, was the luxury of critical review (in fact, several critical reviews) of this information. Further, these reviews engaged some very good scientific talent — both inside and outside the Government and in a way which permitted the decision-makers to be very well informed of their advice.

In terms of benefits, a specific analysis was commissioned of the utility and essentiality of PCBs. (It is interesting to note that while this was done well, the National Bureau of Standards entered into this exercise very reluctantly, seeing in it the perils of the battery additive episode of some years before.)

Finally, there was performed the unusual but highly useful attempt at modeling the patterns of rates and routes of distribution of PCBs in the environment. This was done for the most part as an experiment to determine whether such an exercise could be performed. It did, in fact, provide some useful and immediate insight.

- 3 There was a single spokesman for the Government. The agencies involved early determined that the PCB question cut across several departments. This, by itself, was probably not persuasive and the joint request from the FDA and the USDA to the OST to "take on" the PCB question arose also from a desire on their part to push on to someone else a tough or "hot" decision. It should be noted, also, that the OST had already begun a review of PCBs.

The fact that there was a single spokesman

²⁵ Letter from Alvin Alm, Council on Environmental Quality, to Mr. Vernon Acree, Commissioner, Bureau of Customs, 22 June 1972.

²⁶ Organization for Economic Cooperation and Development, Environmental Directorate, Sector Group on Unintended Occurrence of Chemicals in the Environment, Polychlorinated biphenyls — proposals for concerted action, 13 October 1972.

²⁷ Food and Drug Administration, Final environmental impact statement. Rule making on polychlorinated biphenyls. Department of Health, Education, and Welfare, 18 December 1972.

proved important in arriving at an orderly decision. The Monsanto Company insisted on dealing only with a single spokesman after months of unconnected and frustrating interchanges with a variety of Government agents. The fact that there was a single spokesman also undoubtedly made it easier to amass and analyze in an orderly fashion the variety of information from several sources. The fact that it was an Executive Office spokesman was probably important in soliciting certain other studies in parallel (such as the National Bureau of Standards' study of benefits) and the review of the Government-wide legal option for regulatory action.

- 4 Although already mentioned, the scientific information (especially that related to biological effects) underwent the benefit of several reviews. This had two salutary effects. It assured scientific interpretation by peers and it developed a constituency among scientists for the decisions ultimately taken.
- 5 The decisions were deliberately broadly-based. While this may appear elementary, this facet is generally not characteristic of regulatory decisions concerned with human health. Both benefits and hazards were explicitly explored. Economic consequences were considered. Each of several avenues of possible action was ex-

amined in turn. Again, a single spokesman for the Government and one placed above the operating agencies was probably a necessary feature in this broad examination.

- 6 The decision process was a relatively open one. The fact that there was an Interdepartmental Task Force was public knowledge from the outset. The Task Force published its full report. Similarly, the reports of the OST Panel on Hazardous Trace Substances and the report of the NIH meeting on PCBs were published. Further, science writers and other members of the press were specifically invited to participate in the NIH meeting. (Note that the question of freedom of information was a matter of some concern during the deliberations of the Interagency Task Force in the Office of Science and Technology.¹⁴)
- 7 Time was permitted for deliberate decision-making. At one point, in fact, the Commissioner of the Food and Drug Administration held a press conference in which he specifically announced that he would not proceed with an outright ban on PCBs and deferred to the study process that was then underway.¹⁵ This, of course, contradicts the classical argument which insists that Governments *must* make regulatory decisions immediately without the luxury of time for good decisions.

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Technology, The Past and the Future

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ABSTRACT

This paper presents an overview of forecasting and social indicators and discusses some of the difficulties which are encountered in the methodology. An attempt is made to consider these factors in a political context.

Ascertaining the future has been a human concern since ancient times. Greeks would travel to Delphi where the priestess of the Oracle would forecast for them (usually ambiguously), and Romans would study the entrails of birds and animals. In the East, the I Ching was developed. Astrology has been practised in many cultures and retains its vitality even in post-industrial times. The scientific method itself is a form of forecasting; when Mendeleev constructed the periodic chart, one of its functions was to predict the existence of undiscovered chemical elements. In a non-technical area, Justice Holmes once defined the law as a prediction of what courts will, in fact, do.

People engage in futurology in order to understand the present and its contradictions; in order to understand future possibilities and the alternatives open for choice; in order to set up goals and objectives, to construct utopias; and in order to investigate the implications of social change because, since change is not neutral, its burdens fall unevenly. Predictability is important because it is intimately tied to notions of security, stability, and the ability to plan. In other words, most of us have a gut reaction that if we can know the future, we can control the future.

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* Parts of this paper derive from work done by a colleague, Michael Teel.

Beginning around the turn of the century, speculation on the future commonly involved speculation about technology. Thomas Edison made forecasts about the applications of electricity in popular magazines from 1910 to 1914 and Charles Steinmetz of General Electric wrote an article for *Ladies' Home Journal* in 1911 discussing home uses of electricity. After the First World War, U.S. General Billy Mitchell predicted the importance of aviation for military purposes and was such a vigorous proponent of his conclusions that he was court-martialled. In 1920, *Scientific American* published 65 predictions for the year 1995: the predicted events in general occurred much sooner than expected, and of course some important breakthroughs were not foreseen at all.

The current increased interest in forecasting, and the attempt to develop methodologies of some rigor, can be generally associated with the high technological level of contemporary society. More particularly, this development has been strongly influenced by the military (and to a lesser extent by the associated space interests). The impetus here has been to anticipate enemy innovations, to suggest areas for technological investment and to improve ongoing research and development, and to foster analytic techniques which would be used directly for tactical and strategic planning. In other words, modern forecasting is clearly goal-oriented and linked to the notion of control.

Forecasts may be described by general characteristics. For example, we may distinguish between technological or non-technological predictions. Another distinction is between exploratory and normative forecasts. In an *exploratory* forecast, we start with today's knowledge base and look towards the future; in other words, with a materialist perspective we look at what might be probable scientific developments, innovations, and inventions as well as the characteristics or capabilities of new technologies. An

example would be extrapolation. A *normative* forecast, on the other hand, is based more on future goals, needs, desires, and values; in other words, from a non-materialist orientation one would work backwards to the present in order to facilitate change and assure that the desired goals are served. Scenario writing is an example of this technique (obviously, normative forecasting raises important issues as to whose goals and whose norms are used in the construction of the desired future state).

Another classification of predictive techniques divides them into explicit and implicit. *Explicit* methodologies are those which are consciously based on various environments or events which structure technological change; in other words, a methodology which might be looking at developments of a particular technology but emphasizes the effects which economic, political, sociological, and marketing factors, as well as other technologies, have on the subject technology. In contrast, an *implicit* methodology is one which does not focus on the external environments (for example most extrapolations are of this type).

Increased pressures for systemization of forecasts arise from a suspicion of intuitive processes, a desire to render information more explicit, functional attributes of prediction which tend to favor hierarchical organizations and the exercise of power by those in key roles, a desire to speed up change and — as mentioned — to control it.

PREDICTIVE TECHNIQUES

Some writers have identified over 100 proposed forecasting methodologies.¹ All of these techniques should be judged by the criteria of what they can tell us about the future magnitude of the variable being studied and what degree of certainty or confidence we can place in them.

Trend extrapolation is perhaps the most familiar predictive tool. With it we read the future by studying the past. It comes in five varieties, but each of them share two basic assumptions: that the forces which have created the past pattern are likely to continue, and that the forces which have created the past pattern are likely to extend that pattern. In other words, trend extrapolation is an evolutionary mode of analysis; it is unable to forecast radical changes. In addition, because of its heavy reliance on past data, the accuracy of this base information is of critical importance. The first subtechnique here is that of "persistence". Very simply stated, this method is based on there being no change in the future. For

example, records indicate that about 70% of the time the weather tomorrow will be just like it is today, thus, one can predict tomorrow's weather with considerable accuracy by looking out the window (modern meteorology, it should be noted, has raised the level of accuracy to approximately 85-90%). The next method is perhaps the most common "trajectory" (or "projection" or sometimes just "trend"). This is our old friend "extending the curve". The assumption here is that while there is change, the change is stable. Although projections may be perfectly fine in the short-run, they can lead to ridiculous long-term claims if taken literally. There is the story that in the early days of the telephone system, one of the Bell analysts made the startling discovery that, based on their experience at the time, by an ascertainable future year the demand for telephone operators would exceed the total female population of the United States; sexism is not the only error in this prediction, because the technique could not foresee the introduction of superseding technologies: mechanical and then electronic operating equipment. A variant of trend analysis, the use of envelope curves, may be helpful in dealing with this latter problem. A macrovariable (such as "vehicle speed") may be plotted against time and separate curves created in a series in which each individual curve represents a development of a single device or technique which, when its improvement begins to run up against natural barriers and its development slows down, is replaced by a new technique represented by a new curve within the overall envelope.

The third form of trend extrapolation is called "cyclical". Here it is posited that the underlying pattern is stable and recurring. This technique is helpful for the prediction of certain natural events such as the return of comets, sunspotting, and insect infestations. It also plays a role in astrological calculations. A fourth technique is "associative" or trend correlation. In this method, one uses data from one event or variable in order to predict about another. The assumption here is that there is a stable relationship between the two, and this might be, for example, a cause-and-effect relationship. Usually the two variables are on similar levels of complexity, but many fortune-telling devices — such as reading tea leaves or cards — use very different event sets. Finally, we may classify certain extrapolation techniques as "analogue". Here there are also two sets of events but one is explicitly simple or familiar and the other complex and/or unknown; the technique is based on first making a prediction for the familiar event set and then transferring over the reasoning to the complex one. Such a technique underlies the modern notion of modeling.

Models and gaming have assumed such importance and frequency in contemporary forecasting that they can legitimately be described as a major category on their own. The construction of a model or game is

¹ See Jantsch, E.: *Technological forecasting in perspective* (Organization for Economic Co-operation and Development, Paris 1967).

always beset by two opposing desires — to create a simple enough model so as to be able to manipulate it conveniently and yet not to abstract it so much that it loses meaningful relationship to the real world. What frequently happens is that the factors or variables in the model (each of which has error possibilities) are manipulated to such an extent that the potential for error in the outcome is quite large.

The Delphi technique is a "scientific" resurrection of the old visit to the Oracle. This is an intuitive process relying on a group of wise people who are sent sequential interrogations or questionnaires interspersed with information and opinion and with feedback derived from earlier rounds as iterations. Usually the people answer these questions anonymously, and the desire is to minimize the influences of personality and status. A question on a Delphi study might be of the form: when will technology *x* be developed? After all the answers have been received, usually the analyst eliminates the extremes; for example, a common practice is to report just the mid-50% of responses. If the responses collect about more than one mode, we can assume that there are different underlying assumptions which can be explored in turn. The limitations in Delphi studies involve the selection of the experts, and the design of the questions.

Scenario writing is a process in which statements are made about sequences of factors which might lead from one situation (the present) to another. The sequential steps are related by probabilities, often of a conditional nature. Some scenarios focus on the description of the end state or social future, others are more concerned with the transitional processes. The idea is to develop knowledge about likely events, interactions, and future branching points at which decisions will be made by forcing the analyst to deal with details and dynamics otherwise easily overlooked. This technique has usually been employed in economic, political, and social spheres; in other words, to describe the environment for technological change. Utopian literature falls within this category, as does a more analytical work such as Kahn and Weiner's *The Year 2000* (although these authors use scenarios, they say these are not predictions at all).²

The identification of all possible means to a given end is sometimes given the fancy name of *morphological analysis*. Here a checklist of possibilities is created by identifying the problem or end state accurately, identifying all of the characteristic parameters, and dividing all the parameters into their states or cases. One example in the literature concerns possible jet engines.³ The alternatives are:

Parameter and States

No. of States

1 Intrinsic or extrinsic chemically active mass	2
2 Internal or external thrust generation	2
3 Intrinsic, extrinsic, or zero thrust augmentation	3
4 Internal or external thrust augmentation	2
5 Positive or negative jet	2
6 Possible thermal cycles (adiabatic, isothermal, etc.)	4
7 Medium (vacuum, air, water, earth)	4
8 Motion (translatory, rotatory, isolatory, none)	4
9 State of propellant (gas, liquid, solid)	3
10 Continuous or intermittent operation	2
11 Self-igniting or non-self-igniting propellant	2

The total number of combinations described by these parameters and their various states is $36,864$. Of these, $25,344$ appear to be possible. One of the uses of the morphological analysis such as the above is that it may lead to new inventions by suggesting possibilities for further exploration; what is probable, and where does a new item fit in regard to the existing state of the art? A morphological analysis may also reflect the era in which it was performed. The above example was constructed in 1951 and therefore could be augmented by more recent knowledge about nuclear state variables; however, a first exercise of this type done in 1943 contained only 576 possibilities.

A form of morphological analysis which stresses the known ways of achieving a certain capability is called the *contingency tree*. These may be categorized as either "directed" or "undirected". The former type of tree consists of networks which lead to a stated objective. The idea is to identify those conditions which are necessary to achieve the objective (functional prerequisites) and those which are sufficient (alternative means of achieving sub-goals). Each subobjective can be further broken down. As an example, we can list the major technological developments which were necessary to achieve a Polaris system⁴: nuclear reactors for marine propulsion, accurate self-contained inertial navigation and guidance systems, solid-fuel rocket boosters, compact nuclear thermal warheads, and ablating re-entry nose cones. Undirected contingency trees are exploratory forecasts which do not aim towards a specific goal. The purpose is to explore the various consequences which might follow from a particular hypothetical technological development. This technique highlights technical interrelationships between the subject technology and those beyond it.

Another form of morphological analysis is the *relevance tree*. These are networks of relationships organized into one of two complementary types,

² The Ford Foundation's Energy Policy Project made considerable use of three scenarios (historical growth, technological fix, zero-energy growth) in its report, *A time to choose* (Ballinger, Cambridge 1974).

³ In Ayres, R.U.: *Technological forecasting and long-range planning*, p. 73 (McGraw-Hill, New York 1969).

⁴ *Ibid.* p. 90.

"horizontal" or "vertical". A horizontal relevance tree is designed to lead to the definition of specific objectives, to be a guide to areas of threat or opportunity. Its purpose, in other words, is identification and guidance rather than solving a problem. When the specific objectives are identified these may be arranged in a vertical tree which is nothing more than an hierarchically linked pattern of objectives useful for normative forecasting.

CRITIQUES OF FORECASTING

In large part, the attention given to forecasting assumes that societal problems are due to surprise rather than to indifference: it is not at all clear that if we could truly anticipate a troublesome future we would have the social willingness to be able to alleviate it.

Many predictions have a limited utility because the analyst either engaged in oversimplification or lacked the necessary imagination or nerve. At the other extreme, some forecasts exhibit overcompensation and excessive fantasy. It is often difficult, but necessary, to transcend the specific technological, political, and social configurations of one's own circumstances (which was not done in the above example of the telephone system). Incorrect calculations are an obvious, but recurring, problem. The choice of the time span over which to predict is also critical, since uncertainties and accidents will be more likely in a longer period. A common error in prediction, also, is a failure to anticipate the effect of converging developments: the subject of the forecast will be influenced by changes in its future environment.

This leads to another common drawback with predictive techniques — the assumptions of stability which underlie many methodologies. Many functions are not continuous over time, many developments are not evolutionary. Discontinuities, revolutionary changes — in either technologies or social structures — do occur. It is a naïve form of technological determinism which ignores changes in competitive system relationships and the supplanting of one structure by another. It should be noted that some interesting work has been done which focuses on this specific experience: "substitution analysis" is an attempt to document the way in which one technology supplants an earlier, competing one (for example, the replacement of natural fibers in clothing by synthetics).

We should also not fail to ignore the relationship between predictive techniques and normative concerns. Our attitude towards forecasting usually is tied to an ideological position or political philosophy, even if it is not acknowledged. Obviously, the ancient problems of free will are involved here: Can we create the future? Are individuals and societies autonomous? Forecasting, as it has primarily evolved in this

society, has increased centralization and the power of organizational hierarchies. By emphasizing the interactions of organizations and groups (rather than individual diversity), forecasting has attempted to make large organizations more effective. As a result, forecasters and kindred analysts are placed in elite roles.

SOCIAL INDICATORS

Closely aligned with the concept of forecasting is the recent development of social indicators. Forecasting is concerned with predicting the future, but indicators may be thought of as telling us where we are now, especially in relationship to where we have been and perhaps in the light of where we would like to be. A social indicator may be defined as

... a statistic of direct normative interest which facilitates concise, comprehensive, and balanced judgments about the condition of major aspects of the society. It is in all cases a direct measure of welfare and is subject to the interpretation that, if it changes in the "right" direction, while other things remain equal, things have gotten better, or people are "better off".³

In other words, social indicators are not merely statistics or raw information, but the organization of that information and measurement within the framework of a trend. They are not absolute but relative. They are also normative, because one of their functions is to tell us whether or not things have improved. Proponents of social indicators claim that the technique will help decision-makers in rational planning and societal management. It should also enable society to set priorities and to evaluate programs by measuring the degree of attainment of stated goals; in this light, it is better for an indicator to reflect social outputs rather than inputs. The development of social indicators is strongly tied to improved and rationalized data gathering.

In many ways, the development of social indicators was predicated on the earlier work done in regard to economic indicators. Over the past 30 years or so, we have all grown familiar with economic statistics presented along a trend or spectrum where their position indicates a more or less desirable state of affairs: unemployment statistics, cost-of-living index, Dow Jones stock market average, and the like. What was there in this earlier experience in economics which led other social scientists to try to develop similar tools? Beginning with the Depression and World War II, the U.S. was much more willing to embark on explicit economic planning. Despite the

³ U.S. Department of Health, Education, and Welfare. *Toward a social report*, p. 97 (Government Printing Office, Washington, 1969). The seven areas investigated in this document are health, mobility, environment, poverty, crime, education, and alienation.

laissez-faire capitalist myth, we have experienced price and wage controls, regional economic development programs, conscious alteration in fiscal policies, and similar, governmental involvement in the economy for the purpose of certain economic objectives. Social scientists in other fields may have felt like second-class academics as post-industrial society arrived. Economists, as the "hardest" of the social scientists, were moving close to the centers of power as consultants and advisers, and plunging into quantification and other apparently rigorous methodologies (although some of this, at least, appears to be a false scientism). The economists developed indicators, they devised elaborate accounting procedures (most notably the Gross National Product), and they began to exercise an important influence over governmental decision-making, with the development of benefit-cost analysis and PPBS (Program Planning and Budgeting Systems).⁶

Social Indicators 1973, a recent government publication, prepared by the Office of Management and Budget with the assistance of the Department of Commerce, examined eight major social areas in which improved social statistics and analysis were seen as necessary to reflect broad social concern: health, public safety, education, employment, income, housing, leisure and recreation, and population.⁷ The study claimed that for each indicator there was a widely held basic social objective or definition of a satisfactory condition: "good health and long life, freedom from crime and the fear of crime, sufficient education to take part in society and make the most of one's abilities, the opportunity to work at a job that is satisfying and rewarding, income sufficient to cover the necessities of life with opportunities for improving one's income, housing that is comfortable within a congenial environment, and time and opportunity for discretionary activities."⁸ The authors claimed that for each of these social areas one or more indicators, statistical measures of important aspects of the concerns, have been identified.

Ideally, an indicator would show, in a timely fashion, the status of the population in relation to a particular concern. It could be disaggregated to show which groups of the population were affected, and it could be linked statistically with other indicators to relate change in one condition to change in another. Thus, an indi-

cator would reveal not only the status of the population in relation to a perceived social objective, but it would also furnish some idea of what forces were influencing that status. At the present time, not enough is known about the cause and effect of social conditions to develop such ideal indicators. Rather, the indicators presented in this publication represent simply a first step toward the development of a more extensive indicator system.⁹

The indicators chosen were based on two main criteria frequently overlooked in past work: that they measure individual and family - rather than institutional or governmental - well-being, and that they measure outputs of the social system rather than inputs.

As an example, the accompanying figure is a tiny fragment from this 258-page report which is crammed full of graphs, charts, and tables. Of course, it lacks the sense of breathless excitement conveyed by the original four-color illustration (red, light blue, magenta and black). The accompanying text reads

EMPLOYMENT OPPORTUNITIES.

The unemployment rate is the proportion of persons in the civilian labor force who do not have jobs but are actively looking for work. The civilian labor force is made up of all noninstitutionalized civilians 16 years old and older who are employed or unemployed. (The total labor force includes members of the Armed Forces as well.) The severity of unemployment may be judged in terms of the duration of unemployment (the number of weeks) and by the number of spells of unemployment in a year.

The unemployment rate is based upon a monthly survey in which household members are asked a series of questions, one of which seeks to find out if a person who does not have a job looked for work at some time during the preceding 4 weeks. Those looking for work are considered in the labor force but unemployed. Those not looking for work (even if they say they would like work) are not considered in the labor force and are not counted as unemployed. Thus, those who have become discouraged with the lack of opportunity to find work and have stopped looking are not included in unemployment statistics. Information on this group, the so-called "hidden unemployed" is given in [another chart].

The information is disaggregated along many different parameters, but what does it tell us? Is society getting "better"? Note on the graph that unemployment dropped in the late 60s. This was the period of the Viet Nam buildup (and members of the Armed Forces are included in the ranks of the employed): is increased militarism "good" for society because it provides jobs? This period also saw the beginning of a major inflationary trend (also related to Viet Nam,

⁶ A good survey of the history, problems, and frame of mind of the proponents of indicators is in Reinhold, R., "Changes in social attitudes monitored in broad surveys of the 'quality of life'." *New York Times*, p. 1, 20 August 1973. See, also, Sheldon, E.B. and Parker, R.: *Social indicators*. Science, pp. 693-699 (16 May 1975); and Wilcox et al.: *Social indicators and societal monitoring: An annotated bibliography* (Elsevier Scientific Publishing Co., Amsterdam 1972).

⁷ Executive Office of the President, Office of Management and Budget, *Social indicators 1973* (Government Printing Office, Washington 1973).

⁸ *Ibid.*, page xiii.

⁹ *Ibid.*

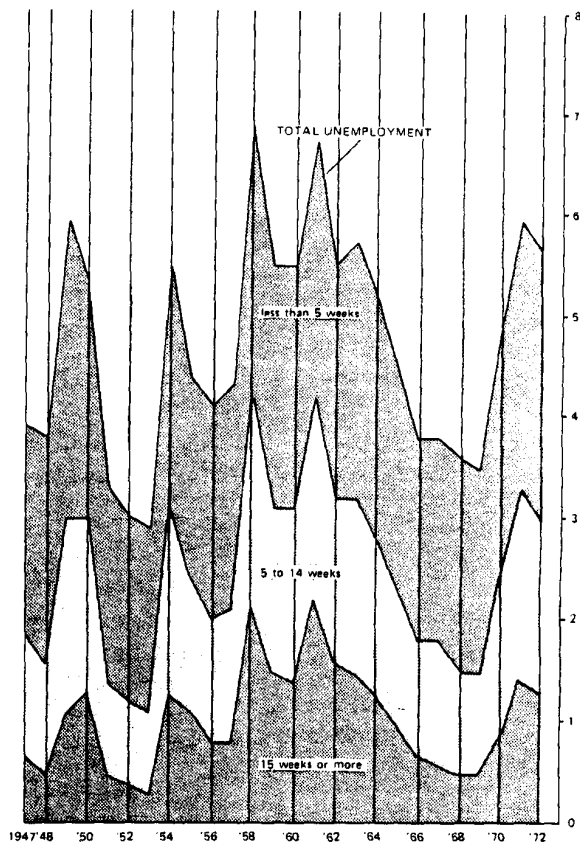


Figure 1. Unemployment Rates, 1947-1972, by Duration *

*Source: Social Indicators 1973, page 112.

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because Johnson tried to finance the war without a tax increase which would have added to its political unpopularity: inflation tends to reduce unemployment because of increased expenditures, so is it "good" for the country? People who have given up looking for work because they are too discouraged (1.1 million in April 1975) are not even included in the unemployment rate, the social statistic which is used in Congress and elsewhere during policy debates.

Is the social indicator movement another example of technological determinism, another mechanism by which a burgeoning technocracy attempts to monitor and control social forces? This is an important threshold issue. Some of the proponents of these new statistics argue that they represent a radical change and a liberalizing humanism. Maybe these individuals, like Lady Macbeth, protest too much; the social indicators movement may be a mere aping of prior developments in the field of economics and a part of the quest for power. It may be another "technological fix" for social problems. It is still too early to tell.

The more successful indicator efforts are in relatively "hard" areas and a number have been developed for the environment.¹⁹ One chapter of an early annual report of the U.S. Council on Environmental Quality was devoted to the subject.²⁰

Some of the difficulties with constructing and using social indicators are methodological in nature. Should the indicator represent an input to, or an output of, the social system (for example, money expended per pupil in elementary school or average reading level attained)? Since in most areas we do not have data extending over long time frames, there are difficulties in ascertaining the base line for the indicators. Defining the indicator variable itself is not easy either. What units should be used? In this regard, economics has a much simpler task — money is most frequently the unit selected. Once we move away from dollars and cents to other variables, however, we introduce a great number of problems: lack of comparability between different quantities, so that we cannot express trade-offs the way the economic market place does with the concept of selling price (how many units of sulphur dioxide pollution are equivalent to a unit of airborne particulates?), nor effectively aggregate and weigh variables (if "pollution" is a problem, how do we measure it in terms of summing up contaminated air, dirty water, noise, pesticides, radiological exposure, diminution of biotic diversity, altered possibilities for scenic and esthetic experience?). Individual preferences cannot always be easily aggregated.²¹ What is the desirable scale for the vari-

able — local, regional, national, or global? A further problem not to be overlooked concerns the actual measuring of the variable of interest. To give an example, there are several techniques for attempting to measure the amount of sulphur dioxide in the ambient air, and the interpretation of the numbers arrived at may be dependent on such things as the location of the monitoring station. Extrapolations and inferences add other problems: the "poverty line" is derived from estimates of expenditures for one requirement, food, for a limited emergency period (therefore, not accounting for long-term nutrition), multiplied by a factor derived from other governmental statistics. Upon the result are based government policies intimately affecting the lives of about 50 million Americans.

There are more general, and even political, problems as well. What areas of social life should we concentrate on, and how should we define the goals? What is "good" and what is "better"? Are social indicators really non-ideological?²² If we look at the area of crime statistics, reported every year by the Federal Bureau of Investigation, we should notice that certain criminal activity is included because it happens to fall within Federal jurisdiction (auto theft), but other illegal behavior (such as price fixing or the use of chemical warfare agents) are not part of the statistics. (These statistics are also suspect because of the ease with which the raw data may be manipulated by the local police departments supplying it, and the changes in reporting procedures and emphasis which have occurred over time.) Unlike economics, for social indicators there is no generally accepted social theory purporting to explain the system's structure and performance; in particular, we often do not understand cause and effect relationships in a social system and the best we can work with are merely correlations. And information can alter or distort political perceptions and preferences. Indicators share a questionable assumption with forecasting techniques, that social problems are due to a lack of information rather than a lack of will; also, they are similarly premised on stability and continuity in underlying trends, yet they deal with change which may at times be more abrupt.

Increased information techniques always lead to questions about the costs incurred in making decisions. They can also exercise an anti-democratic pressure if they result in a lessening of citizen participation because public issues are tied to a "scientific" jargon. Here is the fundamental paradox presented by indicators (as well as prediction methodologies): techniques which appear to increase rationality and social understanding may operate to overwhelm citizen comprehension, thus increasing social alienation.

¹⁹ See Thomas, W. A. (ed.): *Indicators of environmental quality* (Plenum Press, New York 1972).

²⁰ U.S. Council on Environmental Quality, *Environmental quality: The third annual report* (Government Printing Office, Washington 1972).

²¹ On the "paradox of aggregation", see Arrow, K.J.: *A dif-*

ficulty in the concept of social welfare. *J. Polit. Econ.*, pp. 328-346 (August 1950).

²² For an early warning, see Kopkind, A.: *The future planners*, New Republic, pp. 19-23 (25 February 1967).

Technology Assessment as a Political Process

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ABSTRACT

Technology assessment is usually considered to have the dual function of developing information as to the full consequences of technological innovation, and of shaping decisions as to the most appropriate utilization of technology. Very often, attention is concentrated on the first of these functions, to the exclusion of the second. If it is undertaken for the purpose of influencing the implementation of technology, technology assessment inescapably becomes a political activity. As such, it is subject to a wide and varying range of pressures and challenges. In this article, particular attention is given to the pressures and challenges to which the assessment of nuclear power has been subjected. From this case study, conclusions are drawn as to the role of technology assessment within a democratic political system, and the critical importance of the structural and procedural aspects of such assessments if they are to accomplish their intended objectives.

INTRODUCTION

Technology assessment is, at the same time, both a very recent and a well-established activity. As a field of intellectual inquiry and investigation, technology assessment does not date back more than a few years. There is, of course, a much longer record of a few individuals and isolated groups seeking to identify and evaluate the full social, political, environmental, and other side-effects of particular technologies and technological systems. Much of this effort, however, has been more sporadic than routine. Quite clearly, the interest now evident in the routine and systematic assessment of the side-effects of technological innovation has developed, for the most part, only in the last ten to fifteen years. And the emergence of technology assessment as a distinct intellectual discipline

has taken place only in the past five or ten years.

If looked upon as a form of political activity, or as an aspect of the political process, however, technology assessment indeed has a long history. Government has long had the unique responsibility of protecting the interests of those who may be, or who have been, injured by the actions of others. One very important purpose of law and adjudication has been to provide the means by which such injuries may be compensated for. Thus liability laws, when applied to matters involving technology, assign responsibility for any unintended but detrimental consequences of particular technological projects. Individuals undertaking such projects, are accordingly given strong incentives to identify and limit the most serious of these consequences. Further, in some areas, such as pharmaceutical regulation, governments have taken a much more active role in limiting the side-effects of some technologies. And, on the positive side, it has not been at all unusual for a government to actively support those technological innovations which hold the promise of alleviating a particular social problem, or of providing a needed public service.

A situation such as this suggests that the practical experience gained in this latter form of assessment would be invaluable to those seeking more certain and effective means of achieving the full objectives of technology assessment. In spite of this, however, it would appear that only limited attention has been given to this experience. It is the purpose of this paper to focus attention on one such assessment—that of commercial nuclear power technology, which has been carried out by the United States government over the last thirty years. As will become evident below, this on-going assessment has several significant aspects. Of interest here will be the unprecedented nature of this assessment, the procedural and substantive guidelines followed in the assessment, and the pressures and stresses to which these guidelines have been subjected.

THE ASSESSMENT OF NUCLEAR ENERGY

As an example of technology assessment, U.S. government policies for the development and implementation of nuclear power reactors are quite unique and important. One very critical aspect of technology assessment is that explicit attention be given to identifying and evaluating the probable consequences of a technology well before it is implemented. While this may be a desirable goal, it certainly has not been realized with many technologies. An important exception to this, however, is nuclear energy. Its full assessment was mandated in law well before there was even any certainty that it had any commercially practical uses. The uniqueness of this situation has prompted the comment that the Atomic Energy Act of 1946, which mandated this assessment:

... is a radical piece of legislation - in some respects as radical and unprecedented as the scientific discovery that occasioned it. It is, in sober fact, an act without precedent in the legislative history of this or any other country. Never before have men in any state, standing on the threshold of a new technological era, attempted to provide in advance for rational control of the forces to be unleashed.¹

The major impetus for controlling this technology, of course, was due to its obvious international and military implications. Beyond this, however, was also a growing concern for the non-military risks and dangers posed by nuclear energy. Rather early in the development of this technology it was recognized that its use would create some very serious hazards for the public. Indeed, the government was quick to conclude that, as a means of generating substantial amounts of electricity, nuclear energy was "... by long odds the most dangerous manufacturing process in which man has ever engaged."² And it was clearly recognized that some means had to be found for controlling, if not eliminating, these dangers.

The Atomic Energy Act established the legal and organizational features of the assessment of nuclear energy. For one, it created the Atomic Energy Commission (AEC) and gave this agency nearly complete power to control the development and implementation of this technology. Among its powers, the AEC was authorized:

- 1 To license the manufacture of any equipment or device utilizing nuclear energy.³

- 2 To take ownership of any material found to be capable of releasing energy through nuclear fission.⁴
- 3 To restrict and control the use, possession, and dissemination of information, patents, and inventions found to be essential to the utilization of nuclear energy.⁵

This Act further required the AEC to exercise its powers in such a way as to protect both national security and public health and safety. Lastly, this law authorized the Commission to adopt and enforce such rules and regulations it "... may deem necessary or desirable to protect health or to minimize danger from explosions and other hazards to life or property."⁶

From the perspective of subsequent interest in technology assessment, the Atomic Energy Act is indeed important. At several places in this law, the Congress explicitly stated its intentions regarding the full assessment of nuclear energy. At one point, the law states:

The effect of the use of atomic energy for civilian purposes upon the social, economic, and political structures of today cannot now be determined. ... Accordingly, it is hereby declared to be the policy of the United States that ... the development and utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace.

This certainly was a clear statement of congressional intention that the development of nuclear energy not proceed in such a way as to jeopardize significant values held within the United States.

The Atomic Energy Act, of course, went far beyond stating intentions and goals. Of significance in this regard is the requirement of this law that:

Whenever in its opinion any industrial, commercial, or other non-military use of fissionable material or atomic energy has sufficiently developed to be of practical value, the Commission shall prepare a report to the President stating all the facts with respect to such use, the Commission's estimate of the social, political, economic, and international effects of such use and the Commission's recommendations for necessary or desirable supplemental legislation.⁷

Certainly few pieces of legislation enacted in this country, or in other countries, have been quite as

¹ Newman, J. R. and Miller, B. S.: The control of atomic energy, p. 3 (McGraw-Hill Book Co., Inc., New York 1948).

² Atomic Energy Commission, Eighth semiannual report, p. 3 (Government Printing Office, Washington 1950).

³ The Atomic Energy Act of 1946: (Public Law 585, 79th Congress), 60 Stat. 755-751, Section 7(a).

⁴ *Ibid.*, Section 5.

⁵ *Ibid.*, Sections 10(a) and 11.

⁶ *Ibid.*, Section 12(a).

⁷ *Ibid.*, Section 1(a).

⁸ *Ibid.*, Section 7(b).

explicit in mandating the full assessment of a technology, and doing so prior to the implementation of the technology.

THE SIGNIFICANCE OF THIS ASSESSMENT

The assessment of nuclear energy is significant for reasons other than that it was mandated and begun before the technology achieved commercial implementation. Beyond this, it is significant in that those seeking to proceed with this implementation were assigned the burden of proving that doing so would pose no undue risks or dangers to the public: that a strong role was assigned to a group of independent experts in evaluating the nature and extent of these risks; and that the public was assured the opportunity of participating in this assessment process. As will become evident below, this assessment has achieved quite varying results in each of these areas.

In seeking a permit to construct a nuclear power reactor, the applicant was required to submit reports to the Atomic Energy Commission detailing the nature of the proposed reactor, the variety of safety factors designed into the reactor, and the risks and dangers that would be posed should the reactor be built and operated as designed. For its part, the AEC would issue such a permit only if it was satisfied that the reactor would not be "... inimical to the common defense and security, or to the health and safety of the public."⁹ In turn, the Commission translated this mandate into the requirement that the applicant, among other things, "... provide, to the Commission's satisfaction, reasonable assurance that the proposed reactor can be constructed and operated at the selected site without undue risk to public health and safety."¹⁰ Certainly not much clarity was added in the AEC's translation of this legal requirement into its own administrative standards. In actual practice, however, these standards have been quite demanding of the applicant. For example, the various reports required of the applicant can consume between several man-months and ten or more man-years in preparation.¹¹

In addition to being reviewed and accepted by the AEC's regulatory staff, the reactor application and supporting reports must be reviewed by the independent Advisory Committee on Reactor Safeguards (ACRS). This Committee, which is composed of a variety of non-AEC scientists and engineers, traces its history to the early years of power reactor develop-

ment. While its initial role was mainly an advisory one, this was changed in 1957.¹² In that year the independence of the ACRS was strengthened, and it was required to report publicly on its evaluation of each reactor license application. The effect of these changes was to assure that, as far as is possible, the ACRS reports would be complete and impartial evaluations of proposed reactors.

The final aspect of this assessment to be examined here is that of public participation. The Atomic Energy Act as amended in 1954, was quite explicit in making this requirement "when ... granting, suspending, revoking, or amending ... any license or construction permit ... the Commission shall grant a hearing upon the request of any person whose interest may be affected by the proceeding, and shall admit any such person as a party to such proceeding."¹³ And even later changes in this law further opened this opportunity for public participation. On all applications to construct a power reactor, a public hearing was made mandatory.¹⁴ The thinking behind this change is rather important - it was that "full, free, and frank discussion in public of the hazards involved in any particular reactor would seem to be the most certain way of assuring that the reactor would indeed be safe and that the public would be apprised of this fact."¹⁵

THE POLITICS OF ASSESSMENT

The evolution of this assessment of nuclear energy over the last several years has been quite significant and often dramatic. What once seemed to be a rather well structured means of assessing and controlling the side-effects of this technology turned out to be other than it seemed. In the latter years of its existence as an independent agency, the Atomic Energy Commission lost much of its credibility as well as its control over this assessment process. And, instead of providing a means by which those interested in and affected by a particular proposed reactor could participate in determining whether and how to proceed with this proposal, all semblance of cooperation had been lost. In fact, this carefully constructed assessment process came to resemble a battle-ground on which the contending parties maneuvered to achieve their objectives by whatever means could be devised.

As will become evident below, this disintegration was largely due to flaws which soon became apparent in the participatory features of this assessment. To understand this, it is necessary to appreciate the re-

⁹ The Atomic Energy Act of 1954: (Public Law 83-703, 68 Stat. 919), Section 104(d).

¹⁰ Atomic Energy Commission: Twenty-first semiannual report, p. 121 (Government Printing Office, Washington 1957).

¹¹ Luvie, W. W. Creating power plants: The costs of controlling technology. *Technology Review*, p. 25 (January 1972).

¹² Atomic Energy Commission, *op cit.*, p. 120.

¹³ The Atomic Energy Act of 1954, Section 189(a).

¹⁴ Public Law 87-615 (76 Stat. 409) (1962).

¹⁵ Extracts from committee reports on 1957 amendments to Atomic Energy Act, Joint Committee on Atomic Energy, U.S. Congress, AEC licensing procedure, p. 1687 (Government Printing Office, Washington 1971).

sults — or lack of results — achieved in the public hearings held on reactor proposals. Here the conclusions of the Administrative Conference of the United States are quite significant. After a lengthy review of this assessment process, it concluded that the public hearings had little if any impact on the licensing decision. Indeed, the Conference's conclusion was that "There has never been an instance in which reactor design has been altered by the public hearings."¹⁶ And the Conference offered the even stronger conclusion that "The hearing in contested cases is largely devoted to an affirmation of a result already achieved as a result of prior negotiation and settlement."¹⁷ Since the public was seldom involved to any substantial degree in these negotiations, this meant that the critical decisions had already been made by the time it was allowed to participate in this assessment.

This outcome of the hearing process does not seem to be significantly at variance with the intentions of the Atomic Energy Commission. Indeed, the AEC often stated that certainly one of the functions, if not the most significant function, of license hearings was that of public relations. Rather than participating in shaping the substantive decisions, the public was to be shown the reasonableness of decisions that had already been made. Indicative of this are the conclusions of a committee appointed by the AEC to review its assessment process. The committee concluded that the hearings were proving to be of value for the following reasons:

- 1 The public gains a firsthand impression of the applicant's character and competence and his whole approach to the safety and siting of nuclear facilities.
- 2 The public is shown that the AEC has been diligent in protecting the public's interest. Especially, the hearing can make it unmistakably clear that the staff and the ACRS have only the public's interest in mind as they conduct these reviews, inquiries and inspections.
- 3 The public receives a convincing demonstration that the regulatory process includes a thorough and competent review of the applicant's proposal.¹⁸

In light of subsequent events, this may well have been more wishful thinking than well-formed conclusions. These conclusions, however, do seem to indicate more of a concern with creating the image of assured safety, than the substantive of participation in determining the degree of this safety.

There were other indications that the Commission intended the public hearings to have a limited purpose. This is most clear in the limitations it placed on the issues to be considered in these hearings. Among other reasons, nuclear energy has become a matter of controversy because of the radiation created in the process of nuclear fission; the adverse impact that reactor operations can have on nearby bodies of water; and the need for strong protection of the reactor facility against the threat of sabotage and other destructive forces. These matters, again, do not exhaust the dangers which have been associated with nuclear energy. They do, however, indicate some of the most significant of these dangers.

For those who became concerned with these dangers, the reactor assessment process did not prove to be a useful means of voicing and giving effect to these concerns. This is because the AEC systematically disallowed these issues from being considered and resolved in this process. The Commission, in fact, became more than a little insistent on its position that its authority extended only to health and safety issues involving nuclear energy, and that its "regulatory interest is further restricted to public health and safety questions relating to special (that is, radiation-related) characteristics of nuclear materials and atomic energy."¹⁹ And further, with regard to these radiation issues, the Commission refused to allow any consideration of, or challenge to, its radiation emission standards in the assessment process.²⁰ Thus it became routine that the AEC denied participation in this process to anyone seeking to raise one or another of these issues.²¹

THE DEVELOPMENT OF COUNTER-ASSESSMENTS

Being excluded from significant participation in this assessment process did not stop those most concerned with the implementation of nuclear energy from seeking to have an effect upon this implementation. Rather, a range of counter-strategies was developed and pursued by these individuals. Some continued to participate in this process, but not for the purpose of accepting some pre-ordained conclusion. This participation, instead, was pursued for the purpose of bringing direct and indirect pressure upon the license applicant and the Commission. Thus, one advocate of this strategy suggests:

If the licensed project will damage the environment, it must be opposed irrespective of the

¹⁶ Administrative Conference of the United States: Licensing of nuclear power plants by the AEC, in Joint Committee on Atomic Energy, *op. cit.*, pp. 550-51.

¹⁷ *Ibid.*, p. 558.

¹⁸ Seaborg, G. T.: Statement, Joint Committee on Atomic Energy: Licensing and regulation of nuclear reactors, p. 10 (Government Printing Office, Washington 1967).

¹⁹ Atomic Energy Commission: Jurisdiction of the AEC and other federal and state agencies with respect to nuclear power facilities, Washington, D.C., p. 2.

²⁰ *Loc. cit.*

²¹ 10 Code of Federal Regulations 2, Appendix A, as of 1 Jan. 1970.

prospects of defeat or victory. The administrative arena must be used as an educational forum to alert the public to the project's adverse effect on environmental quality. The environmental stakes must be vividly dramatized as a prelude to organizing political action to block the project or correct its deficiencies. Viewed in this perspective, a losing environmental cause is worth fighting for because it adds to the ecological enlightenment of the public.²²

Very often those pursuing this strategy did not have to strive for such moral or principled victories. One reason for this involves the tremendous investment utilities have in the design and construction of nuclear reactors. It has not been unusual for this to go beyond \$500 million for one reactor. With an investment this large, utilities are necessarily anxious to have their project licensed so as to bring closer the day they will begin to realize a return on their money. And those seeking to more strictly regulate the utilization of nuclear energy have been able to take advantage of this anxiousness. As one disgusted proponent of nuclear energy has observed:

Requests for nearly unlimited discovery — thousands of documents, hundreds of interrogatories, extensive pretrial dispositions — objections to evidence, prolonged cross examination, demands for adjournment, exceptions to rulings and intermediate appeals-techniques like this can be used to hold up a project, . . . and to force utilities to make nearly any concession just to get the plant authorized.²³

These tactics often have been used so successfully that utilities have agreed to upgrade reactor radiation treatment systems, waste water treatment systems, and cooling systems.²⁴ And these have been concessions that the AEC had refused to make or require.

Even these relatively significant achievements failed to satisfy some of those concerned with the many side-effects of nuclear energy. Thus some have extended their strategies to include activity outside of the formally established assessment process. In several instances, environmental and other groups have sought to have individual states assume assessment and regulatory authority over nuclear energy.²⁵ The

hope, of course, is that the states will be more severe with nuclear energy than the AEC has been. Other groups have sought to use the judicial process for this purpose. In one suit, the plaintiffs alleged that they were denied their due process right to an impartial hearing on the licensing of a reactor, because of the AEC's dual responsibility for promoting and regulating this technology.²⁶ The purpose of this suit, of course, was to limit, if not abolish, the Commission's tight grip on the full assessment of this technology. In an even more wide-ranging series of suits, the licensing of each and every existing and proposed reactor was challenged as illegal.²⁷ The purpose here was to have the courts enjoin the further issuance of any licenses until the AEC could demonstrate convincingly that each reactor would pose no undue risk to public health and safety.

IS THIS ANY WAY TO ASSESS TECHNOLOGY?

From the above discussion, it is quite apparent that the assessment of nuclear energy has encountered serious and persistent problems. The underlying cause of these problems is clear — the assessment process proved incapable of resolving the many conflicting positions and opinions which developed regarding the range and acceptability of benefits, costs and risks associated with nuclear energy. Those who held serious doubts about the acceptability of these costs and risks were often far from satisfied with the outcome of the formal assessment process. And rather than accepting the Atomic Energy Commission's assurances as to the reasonableness of these costs and risks, these people sought alternative means of influencing the implementation of this technology. Thus this assessment became entangled in very serious conflict, with the parties to this conflict pursuing a variety of strategies to achieve their objectives.

Perhaps the most significant lesson to be drawn from the experience gained in this assessment is that decisions made in structuring an assessment are extremely critical, and must be made with careful deliberation. And probably the most critical of these decisions is that relating to the purposes for which the assessment is to be conducted. In the broadest sense, assessments may be conducted for either or both of two purposes. One such purpose would be informational in nature. Thus it may be intended to

²² Like, I.: Multi-media confrontation — The environmentalists' strategy for a 'no-win' agency proceeding. Joint Committee on Atomic Energy, AEC licensing procedures, pp. 1404-5.

²³ Atomic Industrial Forum, Inc.: A new approach to reactor licensing. Joint Committee on Atomic Energy, op. cit., p. 1448.

²⁴ Gendlin, E.: The Palisades protest: A pattern of citizen intervention. Science and Public Affairs 27: 53-56 (Nov. 1971). "FOE won't try to block Turkey point license, but Siegel might." Nucleonics Week, 12: 4 (2 Dec. 1971). Commonwealth Edison signs with intervenors, avoids Dresden-3 fight. Nucleonics Week 12: 2 (18 Feb. 1971).

²⁵ For example, see Gillette, R.: Reactor emissions: AEC guidelines move toward critics position. Science 172: 1215 (18 June 1971). Illinois blocks Dresden-3, challenged AEC

radiation pre-emption. Nucleonics Week 12: 3 (11 Mar. 1971). An escape clause on control of radioactive effluents. Nucleonics Week 11: 4-6 (30 July 1970). The Vermont Board of Health has proposed standards stiffer than AEC's. Nucleonics Week 11: 2 (8 Oct. 1970). Quad cites his new regulatory holdup. Nucleonics Week 12: 4 (23 Sept. 1971).

²⁶ Conservationists challenge atomic energy act constitutionality. Nucleonics Week 12: 1 (14 Oct. 1971).

²⁷ The Arizona Republic, 15 July 1973, p. 4, para. K.

develop information that is as complete and as impartial as possible concerning the consequences of implementing a particular technology, and to predict the future course and direction of technological innovation. This is reflected in the suggestion of Vary Coates:

Technology assessment implies identification of the social impacts or secondary consequences — both detrimental and beneficial — of a new technology or an existing technology; it also includes prediction of technological developments early enough to allow weighing of the relative social desirability of alternative lines of development.²⁸

Beyond this, technology assessment may have the more ambitious purpose of having a significant impact upon near-term decisions relating to the implementation of particular technologies. Here it would be intended that technological decisions be made only within a context which allows due consideration of the varying consequences of the alternative choices which are available. This, accordingly, is a more action-oriented type of assessment. Reflecting the concern for this is the sentence immediately following the above quotation from Coates:

Technology assessment looks to both the prevention of secondary consequences harmful to the physical environment or to the quality of life, and the alleviation of existing environmental and social problems through exploitation of technological application.²⁹

There is obviously more of a concern here with the effect of assessment than is apparent with the first purpose cited.

To state these as two separate purposes of assessment is not intended to suggest that they are in any way incompatible. Under the appropriate circumstances, it would be possible to accomplish both of these purposes in the same assessment. To do so, however, would certainly require very deliberate decisions, followed by careful planning of the assessment structure and process itself. To do otherwise, would be to invite confusion, with neither purpose likely to be accomplished. And this confusion and ineffectiveness would seem at times to have characterized the assessment of nuclear energy.

If an assessment is intended to develop relevant information as to the full consequences of existing or future technologies, this will most nearly resemble, in the best sense of the phrase, an academic exercise. To accomplish this, one would want to get the most qualified experts available, and to assure them what-

ever means may be necessary to develop the desired information. Further, such an assessment would probably be most successful if it were isolated. In other words, one would probably not want these experts subjected to the distractions and interference of outside pressure and demands. And finally, such an assessment could be quite successful even with a narrow focus. In other words, the range of desired information could effectively be limited to a single technology, or even a few aspects of a single technology. The scope of the assessment thus could be limited or expanded depending upon the issues of interest.

If the purpose of an assessment is to shape and influence technological decisions, a process such as that just described would clearly be inadequate. An assessment with this larger purpose would more approximate a political than an academic exercise. The reason for this is that the decisions at issue would relate to the range and distribution of technological benefits and costs. A range of choices would almost certainly be available in all but the most exceptional circumstances. And, depending upon the choice which is made, some would be better off and some worse off than if another choice were made. Certainly this would indicate that the choice would inevitably be a political one.

Assessments which are thus political in nature, if they are to be successful, must be more open and comprehensive than assessments which are more informational in nature. The reasons for this can perhaps best be understood by examining the flaws in the assessment of nuclear energy. Thus, without question, was intended to be, in the above terms, a political assessment. Indeed it was given the legal mandate of assuring that the risks posed by utilizing nuclear energy were not "... inimical to the common defense and security, or to the health and safety of the public."³⁰ The assessment thus had two tasks — to identify the risks posed by a particular power reactor, and to determine whether any of these were inimical to the above values. Once an assessment sets out to accomplish this latter task, it would seem inevitable that no one individual or group of individuals can claim to be expert in making such decisions. Rather, once the relevant information had been developed, a democratic political system would seem to insist that all mature citizens have some minimal competence to participate in shaping and influencing these decisions.

In the case of nuclear energy, the Atomic Energy Commission obviously was not in complete sympathy with this conclusion. If anything, the severe restrictions it imposed on those aspects of the assessment which would have made participation meaningful, indicate its reluctance to share decision-making in this area. This certainly is reflected in its efforts to keep the assessment of nuclear energy as narrow and con-

²⁸ Coates, V. T.: *Examples of technology assessments for the Federal Government*, Committee on Science and Astronautics, U.S. Congress, Technology Assessment: p. 283 (Government Printing Office, Washington 1970).

²⁹ *Loc. cit.*

³⁰ The Atomic Energy Act of 1954, Section 104(d)

lined as possible. Thus it sought to restrict this assessment to one energy source – that of fissionable fuels; to one technology for converting this into usable energy – that of nuclear power reactors; and to one type of pollutant resulting from this conversion process – that of radiation. This may be a meaningful framework within which to conduct an assessment for the purpose of developing desired information. It certainly is not, however, a meaningful framework for an assessment the purpose of which is to make decisions regarding the development and implementation of technology to achieve a specific social goal. In other words, a decision-making process becomes increasingly inadequate as it excludes possible alternatives and their consequences from consideration. And certainly the assessment of nuclear energy did not allow the consideration of more than one alternative – namely, that of not constructing the proposed reactor.

Recent changes in this assessment have had the effect of more nearly assuring consideration of the range of available alternatives. One of the most significant of these changes was the enactment, in 1970, of the National Environmental Policy Act. The effect of this law has been to require federal agencies to assess fully the environmental consequences of activities they sponsor or regulate. More specifically, the agency must prepare a public statement in which it assesses the following aspects of these activities:

- 1 The environmental impact of the proposed action.
- 2 Any adverse environmental effects which cannot be avoided should the proposal be implemented.
- 3 Alternatives to the proposed action.
- 4 The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.
- 5 Any irreversible and irremediable commitments of resources which would be involved in the proposed action should it be implemented.¹¹

Under this law, as interpreted and enforced, it became impossible for the AEC to maintain its narrow, singularly-focused assessment of nuclear energy. And this broader, comparative assessment more nearly assures that full consideration will be given to the range of alternatives by which the desired objective may be realized. The result of this is that the ultimate choices which must be made, are more likely to be made in a more meaningful and realistic context.

A further, and more recent, change in this assessment has been the abolition of the Atomic Energy Commission, with the creation of the Energy Research and Development Administration, and the Nuclear Regulatory Commission. The effect of this

was to abolish what had been the dual responsibilities of the AEC both to promote and to regulate the implementation of nuclear energy. It is now the responsibility of the Energy Administration to assess the full range of alternative energy technologies, and to promote the development of those which show the greatest promise of satisfying this country's long-term energy needs. And it has become the responsibility of the Nuclear Regulatory Commission to regulate the implementation of nuclear energy in such a way that it complies with the requirements of the Atomic Energy Act and the National Environmental Policy Act.

With these changes, it now becomes possible to achieve a truly comparative, problem-oriented assessment of nuclear energy. Of further benefit is the fact that these changes are beginning to have the effect of extending assessment to the other energy technologies. In a very meaningful way, these changes indicate the healthy integration of technology assessment into the political decision-making process. No longer is assessment merely intended to serve some abstract purpose. Rather, at least in the areas discussed here, this assessment is structured so as to have a substantial impact on decision-making.

The final thing to be commented upon here is that, as technology assessment is extended to other areas of activity, the politics of public choice must be taken into consideration in structuring future assessments. In the assessment of nuclear energy, the most persistent conflict involved its scope or boundaries – that is, the scope of issues and choices which were to be considered as part of the assessment process. The AEC sought to restrict this scope, while some members of the public sought to expand the scope to include a wide range of issues and choices. As was suggested several years ago by political scientist E. E. Schattschneider, the most critical political decisions are those determining the boundaries within which conflict occurs.¹² The reason for this is that different boundaries will produce different outcomes or decisions. As long as nuclear energy was assessed without regard to the social benefits and costs of alternative energy technologies, the outcome was quite likely to be favorable to its implementation. Now, however, since it must be assessed in comparison with these alternatives, the outcome is no longer pre-ordained in its favor. Again, this lesson must not be lost on other assessments. If the assessment process is structured so as to allow meaningful comparisons and choices, conflicting opinions and positions, while not done away with, will be channeled in a way that more nearly encourages their satisfactory resolution. Otherwise, this conflict will not be resolved, but rather will grow and spread to the point where resolution will indeed become difficult if not impossible.

¹¹ The National Environmental Policy Act of 1969, Public Law 91-190, 83 Stat. 932-56, Section 102.

¹² Schattschneider, E. E., *The semi-sovereign people* (Holt, Rinehart and Winston, New York 1960).

Acquiring Baseline Data on Potential Uses of New Communication Technologies

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ABSTRACT

Widespread deployment of portable telephones, made possible by a new cellular telecommunication system, could create major social change — altering social relationships, organizational processes, and lifestyles. To anticipate the possible nature and scope of such changes, a technology assessment of potential social impacts of new mobile communication technologies is being undertaken at Cornell University. To collect baseline data, a methodological approach combining fieldwork and survey research is employed. Using in-place mobile communication systems — paging systems and dispatch services — as proxies for the new cellular system, preliminary findings drawn from 24 public and commercial organizations are presented. Employing fieldwork and survey research in organizations where antecedent technologies are used is suggested as an efficient way, in many instances, to develop baseline data on newly emerging technologies.

INTRODUCTION

The emergence of a Post-Industrial Society based in large part on the generation of new knowledge, the development of new technologies, and the diffusion of innovations has profound consequences for social life in the United States.¹ Inherent in the concept of

the Post-Industrial Society are several important trends: increased private disposable income and public transfers, development of new and more temporary organizational forms and work patterns, greater emphasis on productivity as well as greater leisure time, increased importance of professional and technical workers in the economy, development of new and alternative lifestyles, increased politicization of public planning and corporate business decisions, and the continuing development of national communication networks. The maturation of these trends will have a major influence on the types of new technologies that are developed and the manner in which they are absorbed into the economic and social system.²

Technologies do not develop in isolation.³ The forms that new technologies take, as well as their impacts on society, are integrally related to the dynamics of social and organizational structures. The

¹ Gross, B.: *Friendly fascism: A model for America* (Social Policy I, 34-54 (1970); Brezinski, Z.: *Between two ages* (Viking, New York 1973); Kahn, H. and Weiner, A.: *The next thirty-three years: A framework for speculation*, in Bell, D. (ed.) *Toward the year 2000*, pp. 73-101 (Beacon Press, Boston); Hinshaw, M.L.: *Wiring the metropolis: Two scenarios*, in Gerner, G., et al. (eds.) *Communications technology and social policy*, pp. 307-318 (Wiley, New York); Best, J. (ed.): *The future of work* (Prentice-Hall, Englewood Cliffs 1973); Bennis, W., and Slater, P.: *The temporary society* (Harper and Row, New York 1968); McDermott, J.: *Technology: Opiate of the intellectuals*, in Teich, A.H. (ed.) *Technology and man's future*, pp. 151-177 (St. Martins, New York 1973).

² See Bell, D.: *The coming of the post-industrial society* (Basic Books, New York 1973).

familiar concept of "cultural lag" (behind technology) has a counterpart in "technological lag", or the development of technologies that respond to and facilitate the expression of new social forms and cultural styles.⁴ This is well illustrated by the increased mobility of American society, which is related to the above-noted trends, and the appearance of new mobile communication technologies.

The term "mobile communications" labels a type of communication activity that, by its very nature, is linked to the state of mobility. In the most general sense, mobile communication technologies are movable apparatus, including hand-carried and vehicular-mounted equipment, that permit communication among persons in mobile units such as cars, trucks, trains, and recreational vehicles; among pedestrians; and between persons who are moving and persons at fixed locations. Present users of this technology can be further divided into categories such as commercial (e.g., taxi companies, delivery services), public (e.g., police and fire departments, ambulance services), and private (e.g., boat owners, and citizens-band and walkie-talkie enthusiasts).

Most vehicles, and certainly most people, are not presently equipped with mobile communication devices. Nevertheless, the potential for utilization of these devices exists in every instance of mobility, and if any significant proportion of this potential were to be realized (i.e., if mobile communications became a "mass event") the character of society could be significantly altered.

This paper addresses the problem of anticipating, in a systematic and disciplined manner, patterns of use of technologies currently in the development stage. The methodological approach undertaken here — fieldwork and survey research — appears promising to apply to areas other than communication technologies, although not to all technological analysis. An important constraint in such efforts is obtaining the necessary information at a reasonable cost, in terms of both financial and human resources. This precludes undertaking the large-scale social experiments necessary for full confidence in the results. This is a problem of increasing importance as more and more effort is devoted to technology assessment, in which attempts are made to evaluate, for policy-making purposes, some of the higher order costs and benefits of deploying new technologies.

There is considerable advantage in conducting a technology assessment of an innovation in its early stage of diffusion because there is more potential to guide its future course in directions beneficial to users and "the public interest".

A technology assessment appears to possess special utility when the technological innova-

tion under consideration has begun to take a concrete form but has not yet been deployed or reached a critical concentration. Since it may take several years to go from pilot demonstration to wide-spread deployment there is ample time for deliberate policy decisions to affect the nature, regulation and deployment of the technology.⁵

The Cornell group's technology assessment, of which the work reported here is a part, is concerned specifically with mobile communication technologies.⁶ It is a "technology initiated" assessment in that the starting point is the development of a particular technology, and the research objective is to study a wide range of possible socio-economic, political, and technological impacts.⁷ The principal technology under investigation is the "cellular system" which makes possible the introduction of portable telephones. An area is divided into small "cells", each covered by low power transmitter receivers, which can be connected to a central station by means of a land line or high-frequency directed electromagnetic link. As the mobile unit — either hand-held, vehicular mounted, or both — moves from cell to cell, a monitoring system relays this information back to a central computer and switching structure so that communication can be maintained.

While the cellular system is the central focus of the study, examination of the research-development-diffusion networks of existing mobile communication technologies is of crucial concern since they provide both competition and support for the cellular system. Moreover, they serve as proxies for it. By obtaining baseline data on the capabilities of existing technologies, on producers' marketing strategies for them and actual diffusion patterns, and on some of their impacts, we are able to obtain clues as to some po-

⁴ Dickson, E., and Bowers, R.: The video telephone. A new era in telecommunications (A preliminary technology assessment), p. 5 (Praeger Publishers, New York 1973).

⁵ The Program on Science, Technology, and Society, directed by Raymond Bowers, is undertaking a three-year project which began in 1974 on "A Technology Assessment in the Area of Mobile Communications" sponsored by the National Science Foundation and the Cogar Foundation. The objectives of the research are to analyze: (1) the likely course of development of the technology, as well as supporting and competing technologies; (2) potential uses; (3) economic, political and legal issues associated with regulation, particularly competition in the industry; (4) issues of spectrum allocation; (5) impact on medical practice, safety services, and crime prevention; (6) potential for new work patterns; (7) potential legal problems including privacy, liability, individual freedom; (8) energy and transportation issues; and (9) some of the international issues, emphasizing the special case of electronics competition with Japan.

⁶ This approach contrasts with "problem initiated" assessments where the starting point is some social problem or need, such as the improvement of health services or education. With this approach, the research explores a wide variety of technological means for alleviating the problem. (Herman, E.: Society and the assessment of technology, p. 63 (Office of Economic Cooperation and Development, 1973).)

⁷ Ogburn, W. F.: On culture and social change (University of Chicago Press, Chicago 1964).

tential impacts of the cellular system. In Herman's terms:

the process of generating relevant data is of the utmost importance and constitutes undoubtedly the most responsible part of the assessment. In a sense, technology assessment may be viewed as a many-sided, multidisciplinary and continuous process of inference. Schemes of future events, courses of possible evolution and situations or states of society must be derived from some existing data base, either statistical or conceptual, be it in the form of givens of past experience or in that of logical constructs of desirable images of the future.⁸

Accordingly, the objective of this component investigation is to generate a data base on the uses and impacts of several currently in-place mobile communication technologies - radio dispatch services, paging systems, conventional mobile car telephones, and citizens-band units - based on the collection of primary data from commercial, public service, and private organizations. This data should shed some light on the following questions: Why do organizations and private citizens presently use mobile communication devices? What are the advantages and disadvantages of these mobile technologies? What factors would increase or decrease the attractiveness of the new cellular system for present users of competitive mobile technologies, as well as for persons not using these technologies? What is the magnitude of the potential demand for advanced mobile communications? What are some of the more important likely organizational impacts of such use, e.g., on work activity patterns, on speed and effectiveness of service to clients and customers, and on organizational structure?

This paper will be divided into two parts. The first will consist of a brief introduction to some of the telecommunication literature, with a special focus on the methodologies used by researchers to collect empirical information about uses and impacts of communication technologies. While much important work has been published, it is clear that there are major gaps in this area. In addition, there are few generally accepted theories and techniques which can guide an analysis of either existing or newly emerging technologies. Thus, the second part of the paper will briefly describe the approach being employed to collect baseline data and undertake anticipatory analysis as part of a comprehensive technology assessment of mobile communications. It is not our intention to present final results, as the research is still in progress and many of the conclusions must be regarded as tentative. Consequently, we are presenting only sufficient material on dispatch services and paging sys-

tems to illustrate the conceptual framework and research design being employed.

AN OVERVIEW OF TELECOMMUNICATION RESEARCH

Telecommunication studies range from those based on existing and/or potential impacts resulting from the deployment of a technology, to those examining the contribution of a technology to the solution of a particular social problem. Included in the latter category are studies which seek short- and long-range solutions to current technological problems, such as congestion of the electromagnetic spectrum.

Technology-Initiated Studies

The telephone, although a more stationary form of communication technology, has capabilities parallel to those of a two-way mobile radio. Long since a "mass event", the telephone would seem the ideal technology to examine in order to determine methodological guidelines for assessing less widely deployed communication technologies. However, it has received scanty attention in the social science literature.

In an attempt to fill this research gap, Aronson, in an article entitled "The sociology of the telephone", examines those areas of American life most obviously and pervasively affected by the telephone: the economy, mass communications, and community and social relationships.⁹ While perhaps setting the stage for more in-depth studies on the impacts of the telephone, Aronson's qualitative work does not lead to a methodological prescription for technology assessment.

The video telephone, a communication device adding visual capabilities to the telephone, is highly developed technically but not widely diffused. However, "the technology is sufficiently mature that the technological limitations constraining usage, and hence impact, are discernible with a good degree of accuracy."¹⁰

In their technology assessment, Dickson and Bowers, rather than investigating current users, uses, and impacts of the video telephone, consider a "super" video telephone of the future, the continuing development of related and competing technologies, and a social environment conducive to its widespread usage as a foundation for making informed speculations about both its technological capabilities and its potential social impacts.

Cable television has also received attention in the telecommunication literature. This is a communi-

⁸ *Ibid.*, p. 200.

⁹ Aronson, S.H.: The sociology of the telephone. *Int. J. Compar. Sociol.* XII: 153-167 (1971).

¹⁰ Dickson and Bowers, *op. cit.*, p. 6.

cation system whose use, except in a few cases, is restricted to amplifying and distributing television signals where there is poor broadcast reception, thereby improving the signal quality. Thus, like the video telephone, cable television is a highly developed technology that is not presently employed to the full extent of its capabilities.

Robert Yin's study, "Cable Television: Applications for Municipal Services", is designed to help officials decide how to use the municipal channel mandated in 1972 by the FCC for 100 new urban cable systems, and to stimulate awareness of potential future uses and issues. The report deals not only with the potential uses and impacts of a one-way channel, but also with the applications made possible by a two-way cable. His sources of baseline data include existing studies, plans for urban cable systems, and the operating experiences of WNYC-TV, the only municipal station currently operating in the United States. The case study of WNYC-TV includes the station's history, resources, programs, and audience penetration. Based on its strengths and shortcomings, Yin is able to make certain projections: ways in which future pitfalls can be avoided, for example, or recommendations for desirable practices.

The format of this report, like that used by Dickson and Bowers, may prove useful to investigators of other communication technologies. Further, many cable television and video telephone applications may be more effectively achieved through the use of other technologies; e.g., two-way mobile radio may be adequate when only voice communication is required.¹¹ In other words, a discussion of the potential uses of a communication system must consider not only the feasibility of such uses, but also the relative advantages of a given medium over others.

Finally, one study (a survey of several major companies by the managing editor of *Communications*, a trade journal) investigates the impacts of two-way radios on company operations, such as service delivery, and the problems accompanying their use, such as spectrum congestion. Although information was obtained relative to further desired technical capabilities, this study was not designed as a technology assessment nor did it seek to determine whether alternative systems, such as the cellular system, would be viable.¹²

Problem-Initiated Studies

Problem-initiated studies suggest ways in which a particular technology or technologies may contribute to relieving social problems. Yin and Lewis, again study-

ing cable television, use this approach to investigate its potential for delivering public services. The agenda of experiments suggested in their report is derived from case studies of the special problems of service delivery in two locales, one an urban center and the other a suburban community on the outskirts of a large city. The report

combines two case studies that consider the problems of public service delivery as seen and experienced by local government officials, service providers, and users of those services.

In this report we use the concreteness of the case study approach to draw out and illustrate some of the difficulties and the opportunities of applying new technologies to public services.¹³

Thus, the researchers determine a specific service need and suggest a technological solution which they recognize to be only one of several possible alternatives. They further realize that "even if the innovation is successful, it is the burden of research to determine why success has been achieved before an application can be transferred to another locale."¹⁴ These are important considerations in looking at the potential deployment of the cellular system.

Using much the same approach as Yin and Lewis, members of Peter Goldmark's New Rural Society Project tackle the problem of urban congestion and seek, in part, a telecommunication solution to overcome some of the barriers now preventing companies from moving into less crowded areas. Here again, research based on existing communication technologies (in fact, several communication technologies in varying combinations) attempts to solve a particular problem. And once again, the technologies under study are fairly sophisticated from a technical standpoint, but not commonly used for those purposes envisaged by the author.

As part of an overall strategy to understand the process of organizational communications, Goldmark's team is attempting, through carefully controlled laboratory experiments, "to determine those electronic communications systems which would substitute most satisfactorily for face-to-face meetings between two individuals."¹⁵ Little research has been conducted in this area. As Reid notes, "the human aspects of person-person telecommunications have been curiously ignored. . . . It is necessary to make the negative point that in all [the] huge body of experimental social psychology research, the question

¹¹ Yin, R.K.: Cable television: Applications for municipal services, p. 33 (R-1140-NSF, Rand, May 1973).

¹² Jiskrom, J.R.: Business users applaud radio's benefits - cite service and frequency problems. *Communications* 9: 26-32 (1974).

¹³ Lucas, W.A., and Yin, R.K.: Serving local needs with telecommunications, p. ix (R-1345-MF, Rand, November 1973).

¹⁴ *Ibid.*, p. 3.

¹⁵ Goldmark, P.C.: The new rural society, in *Papers in communication arts* #5, p. 14 (Cornell University, Ithaca 1973).

of communication by any media other than face-to-face has been virtually ignored."¹⁶

Several different problem-initiated research studies have been conducted in the area of radio dispatch systems. This technology is deployed and used on an extensive scale: by the early 1960's, spectrum channels allocated to users had become highly congested and the issue had become of central interest to Congress and the FCC.

Rather than looking at specific applications or diffusion patterns of this technology in order to find a solution, attempts to alleviate spectrum congestion have generally been made from an economic or technical perspective. One study by Crandell and Ward involves a market analysis to "measure the economic value of reduction in congestion; and technical alternatives such as channel-splitting and cellular systems, to augment efficiency in spectrum allocation."¹⁷ But, as the researchers note, "measuring the direct costs of congestion from models of user behavior is very difficult and exceedingly expensive due to the diversity of land mobile use."¹⁸ McCray, who deals with the issue as a case study in communication planning, finds that short-term orientation on the part of the FCC has led, for one thing, to the lack of "credible market studies for future mobile telephone demand."¹⁹

Another technique to determine the pattern and amount of usage of the available spectrum involves setting up monitoring stations.²⁰ While valuable for determining better utilization of spectrum, this technique provides little information about who is using the technology, for what purposes, and with what impacts; nor does it lend itself to projections regarding demands which will be placed by future technologies and their users on the spectrum.

Methods for Collecting Baseline Data

As there is neither a standard methodology for analyzing the impacts or uses of communication technologies presently in use or in the development stage, nor much available data on the users, uses, or impacts of in-place mobile communication technologies, this research is primarily of an exploratory nature. Using

observation and interviewing, we have been able to generate preliminary data on the deployment and uses of two mobile systems, paging systems and dispatch services, as well as develop some possible hypotheses about the deployment and potential uses of the cellular system. However, for generalizable findings to be established, it is necessary to utilize survey research and rigorous sampling procedures.

In *Unobtrusive Measures*, Webb et al. suggest that any technique suffers from inherent weaknesses that can be corrected only by cross-checking with other techniques.²¹ In particular, a combination of case studies and survey research can be particularly useful. Case studies allow the assessor to examine subtle aspects of social processes and individual attitudes as well as explore the possible relationships between variables, but survey research allows us to distinguish between those characteristics of relationships which are unique to a particular case and those which are generalizable across cases. Both techniques of fieldwork and survey research must, however, confront the problem of respondent bias, interviewer effect, and other interaction contingencies which can produce spurious results. There are, however, several advantages of using case studies and survey research together in the data gathering effort in technology assessment.²²

In the design stage of survey research, case studies can be used to determine which organization or collectivity will maximize the advantages of comparative research, and thus can be used to confirm the selection of cases (or related technologies) for inclusion in the survey. Case studies can also serve to sharpen the focus of the investigation by directing attention to particular relationships or problems which appear to be most important. By examining the attributes of a complex system through qualitative fieldwork prior to survey, the precision of the survey instrument can be improved.

Likewise, in terms of data collection, case studies provide information on the receptivity, frame of reference, and span of attention of respondents. According to Sieber, "Improvements in the questionnaire stemming from qualitative pretest information enhance rapport between interviewer and respondent, reduce nonreturns of mailed questionnaires or refusals to be interviewed, and generally ease the data-collection efforts of the research staff."²³

At the analysis stage, case studies can aid in the development of a theoretical structure to guide the

¹⁶ Reid, A.: New directions in telecommunications research. In A report prepared for the Sloan Commission on Cable Communications, p. 39 (June 1971).

¹⁷ Crandell, R., and Ward, J.: The land mobile study (substantive findings), in First annual report, p. 20 (MIT Research Program on Communications Policy, Cambridge, Massachusetts, December 1974).

¹⁸ *Ibid.*, p. 11.

¹⁹ McCray, L.: Administrative planning and its political context: The case of FCC policy for land mobile radio in the 900 MHz band, in First annual report, p. 14 (MIT Research Program on Communications Policy, Cambridge, Massachusetts, December 1974).

²⁰ Dayharsh, T.L., et al.: A study of land mobile spectrum utilization, Parts A & B (Stanford Research Institute, Menlo Park, California, July 1969).

²¹ Webb K., Campbell, D. T., Schwartz, R. D., and Sechrest, L.: *Unobtrusive measures* (Rand McNally, Chicago, 1966).

²² The discussion of the use of fieldwork and survey research is based on Sieber, S. D.: The integration of fieldwork and survey methods, *Amer. J. Sociol.* 78(3): 1335-1357 (1973).

²³ *Ibid.*, p. 1343.

survey analysis. An intensive on-site study of a social situation can produce substantially new research perspectives as well as call to mind relevant theoretical frameworks. Case studies can be used to validate survey results or at least increase plausibility by recourse to observations and informant interviews. Finally, fieldwork can also serve as a tool in interpreting statistical relationships; specifically, interview materials can be used in refining the correlation between variables by suggesting relevant intervening variables.

The following section presents a portion of the information and analysis derived from the fieldwork effort as an illustration of utilizing this type of analysis in technology assessment.

EXPLORING COMPETITIVE TECHNOLOGIES

Paging Systems and Dispatch Services Compared to the Cellular System²⁴

Currently used mobile communication technologies such as paging systems and dispatch services offer strong competition to the cellular system now under development.²⁵ For example, *paging systems* facilitate many communication functions yet can be rented for as little as \$20/month/unit. Because of the advanced state of integrated circuit technology, pagers can be compact, lightweight, and portable.

Many paging systems are directly linked to telephone lines with computer interfaces permitting direct-dial paging. A caller needs to know only the special access number and the page identification number for the page — in the form of either a 10 second voice message, a single tone, or a combination of tones or lighted lamps — to be directly transmitted via the telephone lines. In the case of non-voice paging, depending on what the signal has been deter-

mined to signify, the pageholder may respond by calling the office, home, etc. from a regular telephone.

Not surprisingly, many of the largest corporate pager users have expressed a strong desire to see the development of more efficient, high-capacity, digital display paging systems for deployment in their service departments.²⁶ One-way voice messages or printed paper tape output are now technically feasible and are within FCC rules. Research is also currently underway to reduce transmission time for voice messages to a fraction of what it is now, that is, from one page every 10–12 seconds to one page every 2–3 seconds. This represents a 75% reduction in transmission time and a corresponding 75% increase in system capacity.

Typical users of pagers are persons whose work activity necessitates their being almost constantly on the move and at the same time readily available to receive information. Doctors, lawyers, contractors, police and other emergency personnel, real estate salespersons, servicepersons, and many others fall into this category. One hospital administrator suggested that "anyone who is frequently being looked for, but is not usually by the same phone or a known phone number" has need of a paging unit. Certainly this type of description can fit persons in almost every walk of life, from priest to prostitute.

Dispatch services are two-way radio systems operating on VHF and UHF frequencies. All dispatch services in the organizations studied consisted of several mobile units and one or more base units operated by dispatchers. In general, it was found that most mobile radio systems except the smallest had the capacity for mobile-to-mobile transmission, though messages were generally transmitted through the dispatcher except in the case of an emergency. Direct communication between mobile units as well as between mobile and base units is constrained because their output power, antenna height, and receiver sensitivity are relatively low and because of the system overload incurred by scarce spectrum space. These constraints have in part been alleviated by the introduction of fixed repeated systems which effectively extend the area of coverage of the central system.

In dispatch services, the fixed and mobile units may use the same frequency. If more than one frequency is allocated, access in the simplest systems involves informal methods, such as a manual search for the channel affording optimum communication. A simple dispatch system requires a relatively small capital investment. However, there is a certain lack of privacy in communica-

²⁴ An interview instrument was administered to 70 employees in 24 commercial and public service organizations, of various sizes and representing different functions, known to be users of mobile communication systems. The organizations using paging systems included a large medical school, a metropolitan teaching hospital, an elevator manufacturer, a home fuel service firm, an ambulance service, a dairy, a national chemical corporation, a medium-sized city police department, a neighborhood health center, a local television station, a county law department, and the mayor's office of a medium-sized U.S. city.

Organizations investigated about their use of dispatch service included: two large electric utility companies, a plumbing company, a building materials manufacturer, a construction firm, a parks and recreation department, an international oil company, a local fuel service delivery company, a large metropolitan government communication department, a telecommunications research and development firm specializing in health care delivery, a city public works department and a large city police department.

²⁵ Some of the following descriptions of mobile communication technologies are based on the STS group's interim report on telecommunications (Bowers, R., mimeo, 44 pp., Feb. 1975).

²⁶ An organization using more than ten mobile communication units constitutes what shall be referred to as a large organization.

cation, and congestion in single-channel systems or the difficulty of channel-switching in multi-channel systems makes use by a large number of people impractical. An element of privacy can be incorporated but this involves increased cost. Receivers and transmitters can be coded so that only a specific receiver will "ring" when called by the dispatcher, indicating that a "listen" switch should be activated to receive the message. Privacy is partial, however; the message can be heard on any unit that happens to be activated to "listen" on that channel.

The new cellular system offers potential solutions to problems associated with both dispatch services and paging systems as well as increased communication capabilities. In this system, a large service area is broken up into cells, with each cell operating in a manner similar to that of the multi-channel trunked system (MCTS). With MCTS, a central computer controls access to the several channels and all users must request permission to transmit. Permission may be requested by voice through a dispatcher or automatically by pushing a button on the mobile unit. Trunking allows each caller to use one of many channels available, rather than having to wait for a designated channel to become free.

The cells in a cellular system may be from 1 to 20 odd miles in diameter, with the transmitters in adjacent cells operating on different sets of frequencies. The major purpose of this system is to increase mobile communication capacity within a given spectrum allocation. Short-range transmitters and small cell size permit re-use of allocated frequencies; cells separated by a sufficient distance can use the same frequencies. Moreover, small cell sizes are compatible with the limited range and unfavorable propagation characteristics of the frequencies now being made available for mobile communications.

In addition to the basic components of MCTS, a cellular system requires facilities for locating mobile units with a precision of one cell and for automatically switching receiver/transmitter frequencies and transmitter stations as the mobile unit moves from cell to cell. The component technologies necessary for a wideband cellular system include large-capacity computers and associated software for signal switching, microwave or laser transmitters and receivers for links to cells or increased wired system capacity for these links; and high-reliability mobile transceivers. These technologies are rapidly being improved at this time.

The major advantage of the cellular system is its very large potential capacity; it could ultimately accommodate millions of users. The capacity is not only proportional to the number of channels assigned, but also inversely proportional to cell size. As cell size is reduced, the number of cells in a given service area is expanded, thus increasing frequency

re-use. Additional advantages are relatively secure privacy and virtually unlimited effective range.

The cellular system is the only way that truly widespread mobile communications can be achieved in the foreseeable future. Spectrum available in the lower frequency ranges is limited and it seems unlikely that mobile units operating at higher frequencies (above 900 MHz) can be built at reasonable costs.

Utilization and Diffusion of Mobile Communication Systems in Organizations

Organizations initially acquired dispatch services and paging systems to assign and reassign personnel in the field, to locate and deploy equipment, to handle emergencies, and to decrease response time to dispersed consumers and clients.²²

Dispatch services, in all cases, were utilized by field-oriented, service delivery organizations, or divisions of organizations. Two-way mobile radios were diffused throughout the smaller, basically single-function organizations with the head of the firm using the system most frequently. This person, usually highly mobile, could be contacted when supervision and/or supplies were needed, or when a decision-making situation or emergency arose which his/her employees felt they could not handle, or preferred not to handle, without receiving higher level approval. At the same time, the head of the firm could contact his/her employees wherever they were to monitor or redirect their efforts.

In the larger organizations, dispatch services were used primarily by field operatives: e.g., park police, delivery persons, servicepersons, and utility field crews. Higher level personnel have little if any information that has to be immediately or directly communicated to them, alleviating the need for upward diffusion of the mobile system to these levels. In addition, field operatives can contact middle-level technical and administrative personnel at headquarters when they have a question or problem. Further, the communication needs of higher level personnel differ from those in the field-service sectors in that they are more proprietary, more stationary, less routine, and of longer duration. For this reason, too, a specifically mobile system is less useful to them.²³

²² It should be noted that in every organization studied, it was at the organization's own initiative that the system was installed; they did not acquire it as a result of marketing efforts by producers. Each organization sought out a producer or distributor to install the mobile communication system and then actively participated in its design to insure that it fulfilled the organization's needs. This indicates that there was a mobile communication "gap" that the owners/managers believed would be filled by installing a mobile communication system.

²³ Similarly, the characteristics of the users of paging systems varied with the size of the organization under study. In smaller organizations, the users were typically the owners

A definite diffusion pattern took place within the larger organizations. The first field units to have a dispatch system installed were the ones that handled emergencies; next were those units which handled fairly routine jobs like field construction and installation, followed by those units charged with specific functions, like field inspections, where operations rather closely followed a predetermined work schedule. In general, the more non-routine a field operative's task, the more likely he/she was to have access to a mobile system in its first stages of introduction.

For example, in the case of one of the large electric utility companies, the transmission lines service division was the first to receive dispatch service. This division handles extremely dangerous and non-routine assignments where speed and efficiency are of utmost importance in insuring continuity of service. The electric service division, which handles customer complaints, was then equipped with a mobile system. While their task is also dangerous and non-routine, the consequences of a slower response time are not usually as adverse as disruption of transmission line service. The gas service division, with the more routine functions, received the system next.

This three stage diffusion process also took place in the parks department. The park police, who handled emergencies, were the first to have radios installed, second came staff supervisors who traveled from park to park inspecting facilities and dealing with park attendant problems, and third came the maintenance persons whose activities tended to be more programmed and routine.

In large organizations, the dispatch system was never expanded beyond the sectors involved with field service to the public. Likewise, in most organizations with paging systems, there has been little diffusion of the system beyond field departments or divisions; an adequate number of pagers were rented to meet the perceived mobile communication needs of the divisions and there diffusion of the system typically ended.¹⁹

And/or managers of the companies, while in the larger organizations, the users were at the supervisory and field worker levels. Reflecting managerial utilization, there was a certain degree of status associated with being assigned a pager in the smaller organizations. In larger organizations, the technology was perceived much more as a communication "tool", much like a telephone. Hence, many of the individual paging units in the organizations studied were not considered to be the "property" of a single employee, but instead, were shared by a number of users. Thus, individuals may or may not have pagers on a given day depending, to a large extent, on their and their co-workers' workload.

¹⁹ The exceptions to this generalization in our sample of organizations were the medical school, the teaching hospital, and the chemical manufacturing firm where, after the first department acquired paging units, other departments began to demand that they too receive pagers. This may partly be explained by the status associated with the pagers, that is, as a symbol of departmental importance, but it is equally likely

Social and Organizational Impacts

Although few organizations have undertaken a formal evaluation, a preliminary assessment of some of the social and economic impacts of installing a mobile communication system can be made.

Economic Impacts

There was general consensus among executives and administrators that their organizations were both saving money and providing better service to clients or customers as a result of installing a mobile communication system. They made reference to decreases in transportation costs in terms of travel time and mileage for field workers. One large city public works department undertook a study which showed that their dispatch system produced savings of \$3.55/employee, and an elevator manufacturer estimated that their paging system saved \$390/day serviceperson in telephone calls.

Despite the alleged increases in efficiency resulting from improved communication capability, organizations neither developed new services nor increased their service areas. Those using pagers did not expand their service areas because the range of their systems fully covered their potential area of operations. Moreover, many of the organizations using dispatch services, such as the parks department and the utility firms, have legally prescribed service areas. For organizations not having delimited service areas, the mobile communication system permitted a more intensive servicing of the existing area since the demand for the service had generally been greater than the organization's ability to supply it efficiently before the system was installed. In short, because the range of their system was adequate or because they had to operate within legally delimited service areas, organizations used the efficiencies deriving from mobile communication systems to expand the number of customers they could service within an area, to deliver more services, or to deliver the same service more expeditiously.

Coordination and Control

Improvements in service appeared to result from the organization's ability to assign and reassign men and material in a more efficient way with a mobile system. For example, a number of supervisors spoke of

that there was a real perceived need for the pagers on the part of the other departments. The pattern of diffusion in these three organizations was, however, quite similar to that noted in the study of two-way radio users. The system was first introduced in those departments which handled frequent emergencies. It was next acquired by those which handled occasional emergencies, but whose mission priorities entailed more routine work. Finally, the system spread to departments where jobs were quite routine; in these units, pagers are more of a convenience or status symbol than a vital communication necessity.

dispatch services as providing them with direct links to their men, enabling them to utilize field personnel as their "eyes, ears, and hands". Smaller firms also used the mobile system to centralize technical advice by keeping specialists at the home base, thus increasing their productivity. This type of situation was not found in the larger organizations where field operatives, for the most part, were highly skilled craftsmen and journeymen who had little or no need to ask for technical advice—only for parts, equipment, and locational information.

The predominant type of headquarters-to-field transmissions (approximately 75%) were locational. Even field-to-headquarters transmissions for assistance and technical advice, though more frequent in the smaller organizations studied, did not occur as often as locational transmissions when the uses in small and large organizations were considered together. Locational transmissions, in addition, tended to be institutionalized, especially in the larger organizations. In many cases, field personnel were responsible for calling in when they arrived at a job site, when they completed the assignment, and at specific time intervals. Such locational transmissions allowed field personnel to complete a larger number of jobs during the day; from the organizations' perspective, there was less "wasted time" in deploying and coordinating personnel.

For example, personnel in the electric service division used their mobile radio to obtain information instead of returning to headquarters or attempting to find a regular telephone. Working through the dispatcher, the supervisor informed them where the power line was located, its path, whose homes were being fed electricity, which other personnel were working on the line, etc. Similarly, as a result of introducing pagers, emergency crews of the elevator manufacturing concern were able to maintain direct contact with headquarters. The firm was also able to respond more quickly to emergency calls for elevator repairs because crews in the field could be contacted directly for reassignment.

The case of television news crews provides an interesting example of the effects of mobile systems. At one time, all communication between the newsroom and camera crews in the field took place via two-way, car-installed radios. Many "spot" news stories were therefore missed because a news crew covering a story could not be contacted for reassignment. Since the additional introduction of pagers, better and more complete coverage of news events could be provided.

Job Structure and Worker Satisfaction:

The overall response of workers to having to use a mobile communication system was favorable. None of them felt that they were working more, though several commented that their productivity had in-

creased as a result of using pagers. That respondents were favorably disposed to using the system may be explained by three factors.³⁰ First, few workers had to use the system during non-working hours; being paged was considered as part of their job. Second, because pager users all held some position of responsibility (e.g., doctor(s) or felt that their work was important (e.g., elevator repairmen, linemen, television cameramen), they believed that the mobile system helped them to respond to assignments, emergency and routine, more effectively. Third, the system reduced errors and unnecessary trips thus increasing workers' confidence in their ability to handle decisions and problem situations because they had more rapid contact with their supervisors. Indeed, workers and supervisors/managers agreed that dispatch services provided both greater control over and greater support of field personnel.³¹ In fact, respondents found it difficult to separate these two activities, many actually stating that support and control go hand in hand.

It is further the case that, while workers could accomplish tasks more efficiently due to substantially reduced response time, the actual structure of their jobs was not markedly changed. In fact, the alterations that did occur were in job structure were viewed as being in a positive direction—towards increased freedom and flexibility. Many of the users were able to maintain less rigid schedules since they could be contacted if they were needed. Additionally, several of the organizations allowed employees to conduct personal errands during slack working hours since they could be in constant communication via the paging system.

Possibilities for Adoption of the Cellular System

Higher level personnel responsible for the acquisition of the mobile communication system in their organization generally expressed a great deal of satisfaction with it. They indicated that dispatch services and paging systems provided a convenient and adequate communication link for employees who were mobile.

While their perception may have been colored by a recession-induced outlook, they considered few of the innovative features of the cellular system, such as privacy, two-way capacity, virtually unlimited num-

³⁰ A few of the doctors, who are sometimes paged as often as 80 to 130 times a day, did express some negative feelings about the number of pages they received, but they were quick to add that they could not get along without the system.

³¹ Perhaps as important, especially for non-professionals such as plumbers, the system provided them with a way to transfer some responsibility for field-related technical and deployment decisions back to the supervisors. This transference of responsibility seemed to provide supervisors with the feeling that they had greater control over the subordinate's activities and subordinates with greater feelings of support.

ber of users, and extended range, as either desirable or necessary.³² The two-way capacity of the cellular system was viewed as unnecessary by pager users since they usually have ready access to fixed telephones if they work in an office. Further, page acknowledgment capacity is increasingly being used. Of course, dispatch service has two-way capacity, although time limits are imposed on conversations.

Higher level personnel in only two organizations were interested in the privacy feature of the new system. One police official indicated that in public emergency situations or stake-outs, privacy would be desirable but that, in general, it would be relatively unimportant. The manager of the national chemical corporation also expressed some interest in the privacy aspect of the system when a situation involved danger to the public and there was concern about possible panic. In some instances, privacy was definitely not desired.³³ In fact, a number of dispatch users stated that the "openness" of the system was valuable since each field operative could hear his co-worker's radio transmissions and sometimes be of assistance. Likewise, except for dispatch users facing spectrum limitations, the cellular system's unlimited user capacity seemed to hold little interest for higher level personnel since they thought of their current system as being virtually limitless; however, the improved quality of transmission would be an attractive feature for some dispatch users because they experienced occasional interference and frequency overload.

Several features of the cellular system were actually objectionable to many respondents. For example, paging system users were concerned about the size of the portable units in the cellular system. Employees could carry pagers on their belts or in their pockets anything larger than this might be an effort to carry. Further, a person can either respond immediately or at some later time when he/she is paged. The new system would require that the response be given immediately. This could cause etiquette problems for executives in a meeting or in other constraining situations. As one person put it, "You'd be looking for a closet wherever you were so that you could answer your phone." Another objectionable feature of the

proposed system can be termed "use imperative"; that is, several executives felt that if you had the system, you would feel obligated to use it in order to justify its expense.

In short, higher level personnel did not view the cellular system as an attractive replacement for their present mobile systems. Only the unlimited number of users and, to a lesser extent, the privacy of communication characteristics were viewed as positive considerations.

TENTATIVE CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

Even at this exploratory, fieldwork stage of the investigation, important clues concerning the potential uses and impacts of *emerging* mobile communication technologies have been uncovered by studying types of users and patterns of use of *existing* mobile communication systems.

It can be tentatively asserted, for example, that organizations presently using dispatch services and paging systems in their field operations are not a likely source of demand for the cellular system. A new market will therefore have to be developed. Such a demand for the cellular system may appear in white-collar service organizations at higher levels in the managerial and professional hierarchy than where mobile systems are presently being used. Higher level personnel may have privacy/proprietary and status needs which would be well served by the cellular system. A second potential clientele is made up of self-employed or independent professionals (doctors, lawyers, real estate salespersons, engineers, architects) — both those presently using paging systems or the conventional mobile car telephone, as well as those who do not now have a mobile communication system. A third potential user group consists of organizations engaged in police, emergency, and other disaster-related activities. Despite the assertion that the openness of communications in existing mobile systems is considered an advantage, the need for private or secure communications is nevertheless of at least equal importance in this area and may well be persuasive in adopting the cellular system *in conjunction* with current mobile systems.³⁴ Finally, the mushrooming market for citizens-band radio suggests an enormous potential demand on the part of average citizens for mobile communication capacity in personal and recreational (as well as quasi-business) uses.

³² Cost factors seemed to strongly affect respondents' bias against the cellular system; with the exception of respondents in one large national corporation, none of the owners or managers expressed appreciable interest in the cellular system unless the cost could be brought down to approximately the current cost of pagers or radio systems. In fact, a number of respondents commented that they would be uninterested in deploying new communication equipment unless it could be clearly shown that it would save a substantial amount of money.

³³ It was noted that during some civil disturbances, it is desirable to have some police broadcasts overheard since the knowledge that police are on the way will frequently cause a "mob" to begin to disperse. Additionally, it was indicated that officers are able to "watch-out" for one another if their radio contacts are heard by a number of other officers.

³⁴ The New York Telephone Company's lower Manhattan switching building fire in early 1975 provides an example of the importance of a high capacity mobile telephone system as at least a back-up to the existing fixed line network. In this instance, conventional mobile telephones were provided to police, fire, ambulance and other emergency organizations in order to maintain at least some communication capacity during this "disaster".

1

It is in this instance of "the technology as a toy" that there is the potential for massive penetration of the cellular system.

Future research will continue to focus on existing forms of mobile communications (radio dispatch service, paging systems, the conventional mobile car telephone, and citizens-band radios) but in a more rigorous and in-depth manner. Survey questionnaires will be mailed to a sample of users and matched non-

users of these technologies in order to derive a significant and reliable data base about usage patterns and social impacts of these technologies. Through analytic induction, some statements about possible impacts of the cellular system will be derived. This information will be utilized by the other researchers in the component investigations as well as by the technology assessment group as a whole in developing impact chains and policy recommendations.

Coates' Corner

THE YOSSARIAN

This column is pleased to announce the establishment of a new annual award, the Yossarian, for that act of creative or performing art, in or out of bureaucratic organizations, which displays most effectively the vital innerdynamics of large organizations.

The Yossarian will be awarded annually in mid-July. It will consist of a large eagle, carved from a block of ice. The recipient will receive the award by surface mail. Nominations must be in hand by July 13th.

A current contender for the 1976 Yossarian is a recent Hollywood film, "One Flew Over the Cuckoo's Nest". This can be seen as a tale of the difficulty management faces in the operation of a lunatic asylum.

Nominations for the 1976 award may be preliminarily submitted (in triplicate) to this column in a self-addressed, stamped envelope, marked return to sender.

LONG-RANGE TRENDS - A STARTER SET

One of the major difficulties associated with any technology assessment is the matter of state-of-society assumptions and possible discontinuities, shifts and changes in and among them. The implications of continuity and change in those trends for the physical, biological and social technologies and the related public policy, is a central matter in future planning. Without wishing to suggest here in detail how one might begin to utilize long-range trends, I offer some sixty long-range trends as a starter towards beginning to understand and systematically consider the implications of trends with regard to any technology. Any specific large-scale problem in technology should be analysed and evaluated against this trends background.

General Long-Term Societal Trends

- 1 Economic prosperity and affluence
- 2 Expanding education throughout society
- 3 Rise of knowledge industries and a knowledge-dependent society
- 4 Relative decline in common knowledge of the physical world
- 5 Urbanization/Metropolitanization
- 6 Rise of the middle class society

- 7 Cultural homogenization - the growth of a national society
- 8 Growth of permanent military establishment
- 9 Mobility
 - a personal
 - b physical
 - c occupational
 - d job
- 10 International affairs and national security as a major societal factor

Technology Trends

- 11 The centrality and increasing dominance of technology in the economy and society
- 12 Integration of the national economy
- 13 Integration of the national with the international economy
- 14 The growth of research and development as a factor in economy
- 15 High technological turnover rate
- 16 The development of mass media in telecommunications and printing
- 17 An awareness of the finitude of resources

Trends in Labor Force and Work

- 18 Specialization
- 19 Growth of the service sector
- 20 Relative decline of primary and secondary employment
- 21 Growth of information industries, movement toward an information society
- 22 Expansion of credentialism
- 23 Women, blacks, and other minority groups entering into the labor force
- 24 Early retirement
- 25 Unionism
- 26 Growth of pensions and pension funds
- 27 Movement toward second careers and multiple change in career
- 28 Decline of the work ethic

Trends in Values and Concerns

- 29 General shift in societal values
- 30 Diversity as a growing, explicit value
- 31 Decline of traditional authority
- 32 The growth of anti-authoritarian movements
- 33 Increasing aspirations and expectations of success
- 34 Growth of tourism, vacationing and travel
- 35 General expectations of high level of medical care

- 36 General expectations of high level of social service
- 37 The growth of consumerism
- 38 Growth of physical culture and personal health movements
- 39 Civil rights, civil liberties expansion for Blacks, Chicanos, gays, and other minorities
- 40 Growth of women's liberation movement

Family Trends

- 41 Decline in birth rates
- 42 Shifts in rates of family formation, marriage, divorce and living styles
- 43 The growth of leisure
- 44 The growth of the do-it-yourself movement
- 45 Improved nutrition with the consequent declines in the age of menarche
- 46 Protracted adolescence
- 47 Decline in the number and significance of rites of passage, birth, death, marriage, etc.
- 48 Isolation of children from the world of adult concern
- 49 The acculturation of children by other children
- 50 The growth of a large aged population
- 51 The replacement of the extended family by the nuclear family and other living arrangements

Institutional Trends

- 52 The institutionalization of problems. This is the tendency to spawn new institutions and new institutional mechanisms for dealing with what were in the past personal, private, or non-governmental responsibilities
- 53 Bureaucratization of public and private institutions
- 54 Growth of big government
- 55 Growth of big business
- 56 Growth of multi-national corporations
- 57 Growth of future studies and forecasting and the institutionalization of foresight mechanisms and long-range planning
- 58 Growth of public participation in public institution and private institution decision-making
- 59 The growing demands for accountability and the expenditure of public resources
- 60 Growth of demands for social responsibility

If one were studying a particular technology, there would presumably be subsidiary trends peculiar to the technology or the institution or the public or private frame in which it is imbedded. For example, there would be special long-range trends in the chemical industry, in the manufacturing and selling of automobiles, in health care delivery, and in local government. It would be a good start to use this list to see how many directly transfer to a particular area. Trends to bureaucracy, credentialism, participation

and telecommunications, for example, permeate all sectors. Backing away from these trends, which I call middle level long-range trends, one might also want to keep in mind the more general long-term multi-phase trends identified by Herman Kahn and others.

The author welcomes comments and suggestions for other specific long-term trends that might be added or utilized in the expansion or extension of this list.

WORLD PRIORITIES: CANDIDATES FOR PROBLEM FOCUSED TECHNOLOGY ASSESSMENTS

Boris Pregel, Harold Lasswell, and John McHale edited Volume 26 of the *Annals of the New York Academy of Sciences* (227 pp., September 1975), on the general subject of "Environment and Society in Transition: World Priorities". The report is an excellent introduction to many of the problems affecting the world. It is written from authoritative and credible perspectives by people of the calibre of the editors. By the nature of the case it has much to recommend it as a mine for problem-originated technology assessment topics. In the limited space available, without doing justice to any of the authors, consider the topics covered. "A Survey of the World Priorities", by John McHale, follows his now traditionally fine systematic exposition of complex issues. It gives an excellent sense of collective thinking on world priorities. Other articles deal with the quality of life, alternative futures, energy, world monetary order, policy selection, economic growth, education, science and technical information, food population, violence, and other subjects.

THE SECOND AMERICAN REVOLUTION: A VIEW FROM MOUNT OLYMPUS

In 1973, John D. Rockefeller 3rd published a book, "The Second American Revolution - Some Personal Observations". It is an interesting digest and summary of much of what has been said by others about the generally unsatisfactory state of the Republic. However, this book enjoys singular interest, comprising as it does the deliberations of a man of significant corporate and industrial responsibility in the United States. Some indication of the scope of "The Second American Revolution" is given by the titles of the first seven chapters, which deal with currents of change, Blacks, youth, values, conflicts, new values, and the crucial role of the moderates.

The second section of the book, on critical areas, covers in nine chapters such topics as the self-renewal of organizations, humanistic capitalism, corporate re-

sponsibility, the role of government, the giving society, a learning society, a planning society, and the politics of humanism. The book ends with a personal view expressing optimism and the author's interpretation of the concepts "private initiative" and "quality of life". The style is gracious, conversational, tentative and unpretentious. The book is available from the publishers, Harper and Row, for \$1.50.

ILICH VS. ENERGY

In the mass of data, information and propaganda being disseminated on the worldwide energy situation, it is unusual to find someone with a truly fresh perspective on the matter. In this regard, Ivan Illich's book, "Energy and Equity" (Harper & Row, New York 1975) is provocative and radical in getting to the roots of the issue. It is the energy equivalent of his famous "Deschooling Society".

A sampler of Illich's thinking: he points out that there are two common approaches to dealing with the energy situation. One is to address the supply side of the problem, looking for new methods, means, and resources to meet growing energy demands. The second approach is to look for means of conservation, reducing both waste and demand. Illich points out that very little effort has been made to deal with the issue from an organizational perspective, such as put-

ting those responsible for energy programs in a position of being conservative with energy. Taking this concept and applying it to the American situation, it would be an interesting problem to turn to the Energy Research and Development Administration or the Federal Energy Administration and make it a condition for employment in the organization that one engage actively in an energy accounting and conservation program. For example, one could imagine a yearly energy balance and running inventory of energy consumption struck for each employee and his family. This could add a new reality to the energy issues in the lives of those responsible for dealing with them. Consider the results if one were to provide some kind of incentive or reward for each 10% or 3% decrement in annual consumption that could ensue. Bringing the realities of a problem home to the bureaucrats is one of the central problems facing every major national and world issue. Illich has some keen thoughts on this question.

O'NEILL'S LAW

As you all know, the great anonymous Murphy proclaimed the fundamental law of human activity that "if anything can go wrong, it will". We have learned recently via Kenneth Boulding of the more powerful O'Neill's Law: "Murphy was an optimist".

Information for Authors

All manuscripts (with the exception of review papers) are submitted with the understanding that they are not under consideration for publication elsewhere or that they have not been published previously. If a paper has been prepared for presentation at a meeting, this information should be noted on the manuscript. Accepted manuscripts become the property of the journal.

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- 1 Coates, V.T.: Technology assessment in the political context: A summary of an AAAS session. *J. Int. Soc. Tech. Assess.* 1(2): 45-49 (1975).

- 2 Arnstein, R., and Christakis, A.N. (eds.): *Perspectives on technology assessment*: pp. 45-49 (Science and Technology Publishers, Jerusalem 1975).

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Edited by MARVIN J. CETRON

In many countries academics, industrialists, government officials and growing numbers of the public are aware that there are ways man can assess the social, economic and environment consequences of existing and potential technological initiatives. There seems to be acceptance of the idea that by means of analysis, planning and wise goal setting and policy making, man can enjoy more of the benefits of his advancing technology and less of its negative and unexpected effects. The name given this movement, or "social invention" as it has been termed, is Technology Assessment.

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