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TECHNOLOGY AS SOCIAL ORGANIZATION:

Contributions to the Improvement of Social Impact Analysis for Technology Assessments

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CONTENTS

Introduction		1
Part I.	Technology as Social Organization: The Basis for More Credible Technology Assessment	6
	Technology in an Expanded View	9
	. Technology as Stimulus to Change	14
	Technical Systems as Social Stimuli	18
	. Sources of Impact	19
	. Functional Elements	25
	Bases for More Credible Estimating Operational Impacts: Enhanced Characterization of the Technology	26
	. Resources and Social Properties	27
	Linking the Development of Technologies with the Public and Governmental Reactions to Them	38
	Conditions of Social Strain	40
	The Dynamics of the Receiving Regions	48
Part II.	Implications for Office of Technology Assessment Processes	55
	Reflections on the "Review" Technology Assessment Reports	55
	Technology, Organization and Social Change: A Promise Unfulfilled	75
	Conclusion	80
Notes		82
Bibliographic Appendices		85

Introduction

Over the past decade, efforts in the U.S. to anticipate the effects of technological development upon the physical and biological environment and upon economic and social change have accelerated enormously and have gained a remarkably high level of political legitimacy. As work has gone apace on environmental impact analysis and on technology assessment, there has been a parallel growth in emphasis on the more general field of policy analysis. These areas have in common at least: an intention to inform decision-makers and attentive publics more fully concerning the future consequences of present policy choices; and an implicit uneasiness with merely pragmatic learning in those policy areas where the negative consequences of significant error or inadequately anticipated future impacts appear to be increasing in magnitude. In a sense, trial and error, common sense learning in such policy matters does not win great confidence as the predominant basis for improving policy formation and complex political decision-making.

Yet the call for accurately anticipating future effects of policy implementation requires for its accomplishment a keen conceptual understanding of the effects of technology on social experience. In effect, we have taken up the challenge of providing a predictive theory of technology and social and environmental change. This paper addresses that requirement in the context of the objectives of the OTA Task Force on TA Methodology and Management. My effort is perhaps more narrowly confined than other papers, first, to the "methodological" aspects of TA, understood somewhat differently than is the custom in OTA, and second, within those aspects, to the "Technology Description and Technology Forecast" segments outline in the Task Force's first draft reports.[1] Some attention is paid to the "Social Description and Forecast" segments as well, though in spirit and in substance, very differently from what is outlined there.

Two points are necessary to clarify my perspective: the first concerns the role of analysis in technology assesment, and the second the inherent limitations of analysis as developed within the view of "methodology" taken in most of the technology assessment literature. First, the analysis undergirding technology assessment, whatever policy oriented steps are advised for its use, should be rooted firmly in descriptions of the technical phenomenon such that reasonably straightforward connections can be made between the proposed deployment of the technology and the likely changes people might experience in the communities and regions, and the governmental agencies and industrial organizations involved. This injunction should be followed in terms of the technology spreading widely and growing to industrial maturity especially when the economic sector associated with it departs markedly from a condition approximating the classic market system.

But at our present level of understanding, this objective difficult to achieve fully. Therefore, the most likely and most effective use of technology assessment is as an aid in avoiding programs that would make thing worse--essentially an exercise in damage limitation. Supposing that we are able systematically to secure social goods is unwarranted. Expectation to do so through technological development result in short-term over estimation of what technology assessment can accomplisy. Thus, taking our limited understanding into account, the avoidance of social strain should be a more immediate objective for technology assessment with much more humble aspiration for assuring the public good in any direct sense.

Second, the term, "methodology," as it usually used in technology assessment--within OTA and certainly outside it--refers to a process of arranging information about the likely impacts on society of particular technologies or aspects of them and then communicating it to significant elites, especially Congress. This arrangement of information often includes the use of a battery of "impact techniques" such as cost or risk-benefit analysis, forecasting of various sorts, and other devices summarized usefully in the Task Force's first draft report.[2] But there is little or nothing to suggest, that this perspective encourages analysts to account for two aspects of research and analysis that have in the social sciences become part and parcel of "methodology." The first is an emphasis, often quite technical, on the quality of data, its reliability and accuracy as a basis for statistical interpretation, on the one hand, and, on the other, a concern for the uncertainty bounds underlying quantitative measures. It is in this sense that "methodology" or "method" is used most often in the social sciences rather than, as in the engineering disciplines, "methods" of applying general well-formulated, tested and law-like relationships developed from basic research in the physical sciences to specific problems. Social phenomenon, both less well studied and more complex than physical phenomenon, have been more resistant to fundamental characterization.

But the second aspect missing in the "methodology of TA" is more crucial. There is an insistance among students of social phenomenon that there be a coherent description of the phenomenon which self-consciously explicates the causal relationships assumed by the analyst to tlink the sources of changes to the specific changes themselves; and to do so in a manner allowing them to be renered empirically. Since there are few law-like relationships in the social sciences that are assumed to be valid on their face, there is no body of "lore" that is "common property" of the analytical community. Such being the case, each analyst, requiring some sort of conceptual ordering scheme, must make it explicit. Technology Assessment, in my view, has mainly to do with anticipating changes in the social experiences of people associated with the deployment of a new or improved technology. Therefore, such a "leap over" measurement and conceptual questions is unjustified and is, I believe, the primary source of error in and the limited utility of technology assessment as it is practiced today... at least as an analytical enterprise as contrasted to a persuasive, essentially political one.

What follows in this paper is a challenge to the OTA staff and others working and supporting technology assessment activities to take an expanded view of technology, complementing the engineering, industrial view with a perspective of technology-as-social-organization. In Part I this view is outlined and some of the conceptual and data collecting/analysis implications of it are examined. In Part II I comment on the technology assessments conducted by OTA and assigned to us for review in light of this expanded perspective and explore briefly the situation likely to be encountered by those analysts who accept the challenge.

Part I. Technology as Social Organization: The Basis For More Credible Technology Assessment

The perspective of technology advanced here attempts to provide a more fruitful and improved conceptual basis upon which the analysis undergirding technology assessment could be done. It speaks directly to the need for a better understanding of the social and political impacts of new or improved technologies, especially when public funds and legitimacy are sought to forward their development. When such technologies draw legislative or public interest, there is often considerable debate based mostly on speculations about likely social changes or about the desirability of developing a new technology in one way or another. Often cost/benefit or risk/benefit analyses are presented to show variously that the new development will deliver more benefits than harm to the society, or that the negative effects perceived by different groups will overwhelm the benefits they expect. Thus far nearly all the attempts to engage in social assessment, either in formal studies or in public hearings, have lead to unsatisfying results for all concerned: technologists, governmental or industrial leaders, and individual citizens, as well as for the more organized intervenor groups. One important reason for this dissatisfaction, at least for the critics of development, is that the types of information available about the particular development mainly concern technical engineering results or highly aggregated economic estimates promising usually positive outcomes. Such information does not provide a

It is obvious that the central notion underlying these claims is that technology, in addition to being an intricate web of ideas, processes and methods based on scientific work, is intrinstically a human process. The active involvement of people working together is an absolute necessity for the overt manifestions of technical possibilities to be realized. Without a number of people cooperating together and following out the activities implied and necessary for realizing the technological design, its capacity will not be available to modify the physical environment, to enhance public health, to provide assistance for everyday labor or to use in the uncounted ways we find to apply new technical capacities. This view of technology as human activity has strong implications for the kinds of questions asked about technological development, the variations between technologies in the ways they affect our lives, and the manner in which we will develop the notion of technology's impact on social and political life. These questions are directly concerned with the interactions between the organizations that carry out or help to realize the potentials of technology as concept, the communities which are directly in contact with the technology, and the overarching institutions--legal, political, economic and social--within which both the communities and the technologies-as-organizations operate. In the next section, we develop further the view of technology as social activity.

Technology in an Expanded View

It is clear that "technology" means, in its usual, restricted sense, a system of ideas and concepts rooted in scientific principles, which are on the intrinsic operational logic of the technology as machine or structure are inextricable from them. These processes lay out, often in intricate detail, the imperative relationships of one machine to another and the standard operating procedures necessary for people to carry out if the technology is to fulfill its technical promise. The characteristics of analytical processes, e.g., the assembly line, the procedures for radar controlled missile intercepts or aircraft landing, the protocol for organ transplants, signal potentially different organizational imperatives and hence different consequences for those directly involved.

But in developing a conception of technology that will facilitate improved social impact analysis, as well as improved technical design for social purposes, something else besides the concept, physical laws, prototypes, and analytical processes must be taken into consideration. Beyond the external physical changes wrought by technological advance, changes occur in people's capacity to do things--to change the shape of individual and social life itself. These are changes, generally widespread, that stimulate both the enthusiasm and the uneasiness about technical development. Thus, it is essential to understand that "technology" is also a system of human beings cooperating in quite complex ways, ways combining to create a new or improved capacity which others may use to alter their life's experiences.[6]

For our purposes this means that engineers, managers, technicians, secretaries, etc., are involved in acting out the cognitive ideas of a technology so that its capabilities become widely available.

Thus, technology-as-organization can be seen as a system of cooperative relationships among those people who actually make available that which is promising in concept, prototype and analytical process.[7] This system includes those organizations that produce and distribute technical products and services as well as the firms which contribute both materials and trained personnel to these producing and distributing organizations. From this perspective, then, either assessing a technology or insisting on altering its design leads directly to considering the activities and thinking of the men and women who cooperate together in turning technical potentiality into actuality.

Figure 1 schematically summarizes this perspective. We argue that, for purposes of understanding its social impact, "technology" be conceived of as a human phenomenon which includes: (1) the cognitive theory and creative ideas that technical professionals--engineers, architects, physicians--use to fashion (2) prototypes of machines and structures and to devise analytical processes, and (3) the organizations of those who produce and distribute technical capacities to citizens and consumers. In various combinations, the activities prompt different ways of organizing to produce and distribute a technical capacity. And the analysis of systematic differences among them becomes the foundation for establishing the social properties of different types of technology. Without such work we can only rely on intuitive guesswork in directing which activities must be altered, and in which ways, if technologies are to be designed to enhance desirable social and political conditions--or perhaps more realistically to avoid precipitating unexpected conflict and serious strain.

FIGURE 1

TECHNOLOGY IN AN EXTENDED VIEW *

TECHNOLOGY AS:

		Potentiality		*Actuality*	
		Technical Conception	Technical Form	Social Behavior and Organization (techno-social system)	Effect and Consequence
TECHNOLOGY	Machine	Jumbo jets	prototype aircraft	aircraft assembly line	delivery of capacity
SEEN	Structure	radial loading stations	scale model	airport facilities	1st 2nd
AS:	Analytical Process	radar and control coordination	flight demonstration	ground controlled approach process	3rd order consequences

Potential Technical Capacity	Basis for Technological Delivery Systems

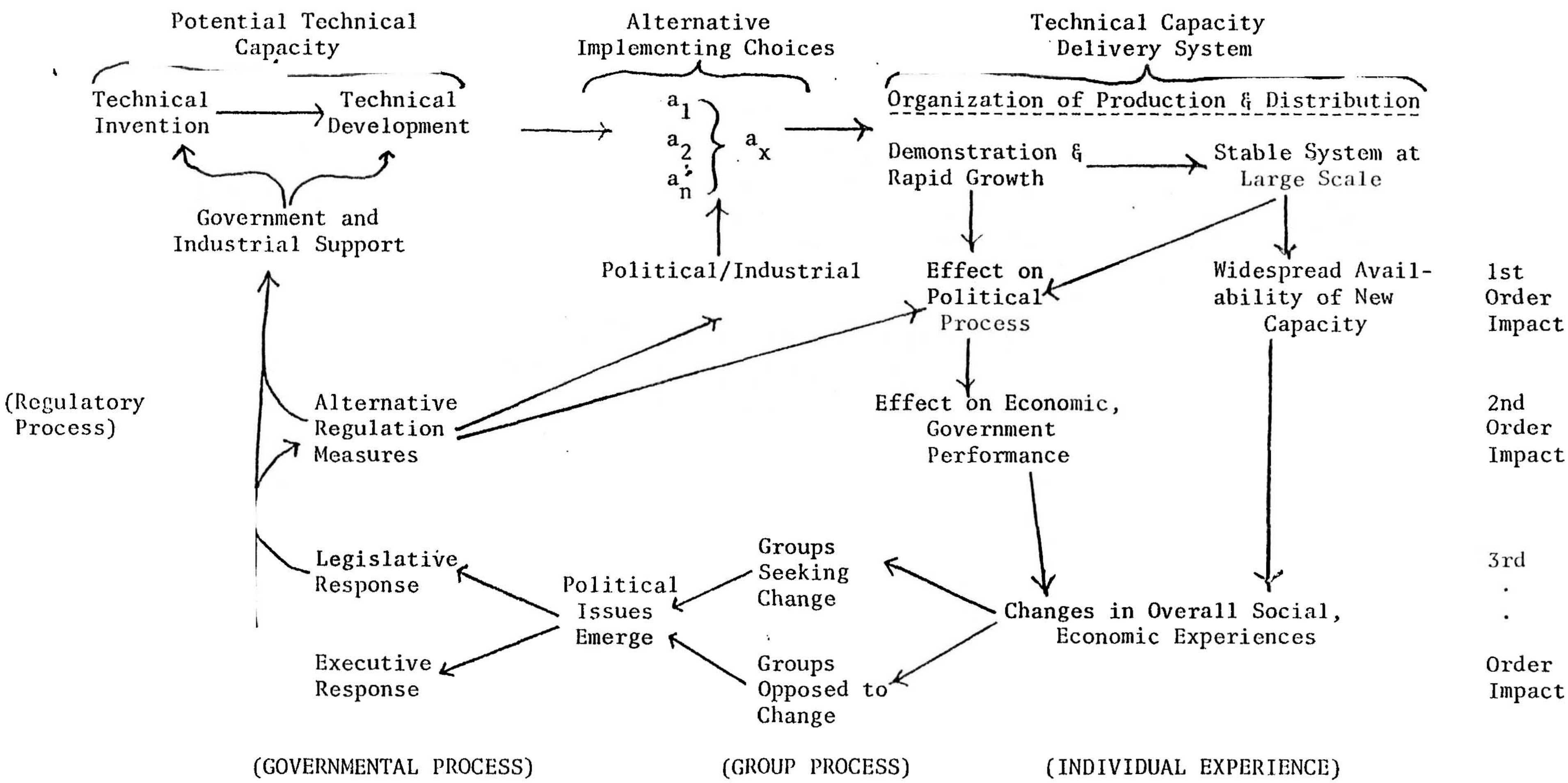
*Examples are taken from the airtransportation field.

It should be evident now that if technology is thought of <u>only</u> in terms of engineering concepts, the industrial manufacturing forms it take and the economic value of its products that analyses of social impact are likely to be imprecise, often wrongheaded and subject to inordinate error. This will especially be true if the organizational aspects of widespread delivery of technical capacity are allowed to remain vaguely and unsystematically defined. Therefore, the properties of both the new and improved capacities that a particular technological system delivers <u>and</u> the properties of the producing and distributing organizations become important. We now turn to those aspects of our discussion.

<u>Technology as Stimulus to Change.</u>[8] To be usable in social impact analysis technology-as-organization must be linked quite directly to the experiences of the public, organized groups, elected political bodies, administrative and regulatory organizations, and, finally back to the technologists themselves. Figure 2 provides a schema for relating (1) the properties of technology-as-organization, (2) the economic, human resources and organizational requirements necessary to introduce and then deploy a new or improved technology, (3) the economic and social consequences of having assembled financial and human resources and altering political constraints in order to deploy it, (4) the governmental responses to such economic, political and social changes, and finally, (5) the effects which governmental responses might have for further technical development and/or control.

FIGURE 2

SIMPLIFIED PATTERN OF TECHNOLOGY-SOCIETY INTERACTION



Only through elaborating these relationships in some detail for specific technological areas can policy-makers and citizens escape from the vague, generally inchoate syndrome of "what if" speculations which infect much technology impact analysis. At present we must depend mainly on impressionistic, intuitive feelings about "what will happen if...": if a large nuclear power plant is actually built along the seacoast; if a freeway really cuts through a ghetto; if biological engineering techniques determining the sex of unborn children really are employed; or if frequent reliable airtransport really becomes available to most remote rural communities.

The simplified schema in Figure 2 servies as a framework for specifying different aspects of technology-society interaction. Its utility depends on the following assumptions about the dynamics of social and political change most pertinent to technology assessment.

1. That social change is fundamentally a change in the distribution of economic and social privilege within a community or society. It is signalled by the relative increase or decrease in the capacity people have to accrue economic or social status and the amenities associated with that status.

2. That political change is a consequence of changes in and/or aspirations for a change in the distribution of economic or social privilege in a community or society. Political issues emerge and are brought into the public sphere when groups of people experience sufficiently similar experiences and/or aspirations so that they see it in their interest to organize and press claims on political institutions for change or for the maintenance of the status quo.

3. That technology, as understood here, combines new capacities to alter the world, to change personal experience, and to organize productive activity. With expected or actual widespread distribution of this capacity, the particular distribution of privilege within a community or society may be reinforced or altered: A new capacity often changes the relative advantage of groups or individuals in competition for economic and social status and may either reinforce or threaten existing patterns of privilege.

Technology, so conceived, can be thought of as a cluster of actually manipulatable "independent variables" as well as abstract analytical, descriptive independent variables. That is, along with the establishment of complex organizations of various sorts, technology is one of the few domains of activity that can be intentionally initiated and pursued by human beings in order to alter their own experience and the experience of others around them. Pursued systematically through economic and governmental organizations, technological development, and the social effects associated with it, do alter the world in important ways, and is one of the several ways men have of changing the conditions of their own experience. In this sense, "technology," along with formal organization, differs from "analytical independent variables," such as social class or income distribution, over which policy-makers have little or no control.

Technical Systems as Social Stimuli

Figure 2 presents the flows of interactions we believe characterize important relationships between technology and society. Across the top of the figure is the sequence of relationships associated with the Potential Technical Capacity we discussed earlier. These include the concept, technical inventions, prototypes or models, the analytical process, and the development phase in which the feasibility of the new technical potential is determined. A great deal of attention has been devoted to this phase in the research and development literature concerning the management of innovation and research administration. It is an area only rarely of concern in the assessment of technological impact, although occasionally relevant to studies of technical innovation.

Less attention has been paid to the processes of deciding which of several technological alternatives to implement, but it is clear that when a new technical potential is recognized and partially developed, choices are made. Based often on political as well as economic grounds, the diffusion of innovation is a matter of interest in technology assessment. On what grounds, for example, are automated rapid transit systems developed rather than manually controlled trains; kidney machines concentrated in large centralized facilities rather than being designed for home care; or airports capable of accepting huge jumbo jets built rather than futuristic supersonic transports? In effect, political and social choices are made by both industry and the government to pursue one technical alternative or another within the same general technical area. Particular alternatives, especially if their organizational imperatives vary, are likely to have quite different social, economic and political consequences.

In making such decisions, both the knowledge of the economic and social experience likely to be changed by each technical alternative and the political knowledge of who will benefit and who will be disadvantaged (and to what consequence) by these same alternatives, is at least implicitly assumed. In this sense technical development is not a straightforward "technical" matter. Rather these decisions often have far-reaching social and political consequences for those who produce machines and structures and for those who are benefited or are harassed by their use.

Sources of Impact

As a new technological capacity is developed through the earlier stages of demonstrative and emerging growth to a fully mature, widely deployed technology, three sources of social impact become apparent: the first stems from those changes in the economic and often regulatory systems necessary for this new technology to flower and grow, second, the changes likely to occur because of the widespread availability of new opportunities for consumers, and finally and less obviously, changes in response to the behavior of the organizations whose economic and political power is based on the production and distribution of the new capacity. While these sources of impacts appear in this sequential order, their affects are cumulative, additive, if not multiplicative, and are intensified as a function of the overall scale of the technical system.

The first source of impacts rarely included in technology assessments are those changes in economic conditions, such as concentrations of capital, deferred return, etc., and local, state, and national regulatory constraints, such as building codes, labor laws, and environmental and health and safety regulations, that might be required for reasonably rapid deployment of the technology at moderate to large scale. Such changes trigger often surprising second order consequences (i.e. impacts) in the structure of the law, relationships between economic institutions and governmental agencies, and the dynamics of social organizations which at small scale do not seem troublesome. The "technology" has effected a "graceful entry" into the society.[9] It is only after "it" emerges fully blown that "deferred regrets" or "technological serendipity" is evident. Of course, there are also cases in the early phases of new technological development where considerable conflict has been evident in efforts to mobilize the "political energy" either to maintain or to alter the legal and often the attitudinal environment so that promoters may gain the economic and political resources they believe required to "get the technology in place."

While there are obviously numerous examples of both short-term conflict regarding a new technology and now more awareness of the "graceful entry-deferred regrets" situation, we do not yet have a refined way systematically to anticipate which kinds of affects will be associated with particular technological potentials, nor the sorts of "deferred regrets" likely to appear as the technology-as-organization matures. This is most unfortunate for it is the absence of just this sort of analysis--of the more immediate, and hence more likely changes that can be seen as potentially disturbing changes in the middle future--that fuels technological conflict most directly.

The second source of impacts, most often highlighted in technology assessments, is schematically represented on the extreme right of our general perspective depicted in Figure 2. Every technology as it reaches industrial maturity has both intended and unintended capacities. The full range of uses to which a new widely dispersed technical capacity would be put is difficult to predict but we do have an intuitive sense of some: We do know that people are quite capable of inventing uses never envisioned by those who design a particular technology. Improved air transport capacity, say by the development of efficient shorthaul, STOL aircraft, provides a new option to move people and freight about a region more frequently, more reliably and more flexibly; it would very likely increase the flow of commercial goods throughout regions within the U.S. And because executives would be enabled to travel around more in remote regions, it could contribute to the growth of local factories and, perhaps indirectly, prompt population increases associated with industrial development. Other uses as well, can be imagined: new educational opportunities, medical services, and recreational options pursued as a result of reliable transport according access to wilderness areas.

But there are also unintended capacities: STOL aircraft and STOLports have the capacity to deepen our dependence on liquid fuels, to pollute the air, disrupt the ecological balance of the airport environs, and increase noise levels significantly. If widely available this development could so increase our capacity to transport people and materials that rural communities might be inundated with strangers to the point where the community's own social balance is threatened. Thus, better information and understanding about the effects of both the intended capability, but especially unintended spinoff capabilities (both positive and negative) is required in the context of a technology as "it" might operate after reaching a stable "share of the market."

The third source of consequence, the behavior of the organizations that produce and distribute new technical capacities, has not drawn much systematic attention in studies of technology and social change. There is almost no attention to such matters in technology assessments. Through their activities within the processes of political decision-making at national, state and local levels, these organizations seek economic and operational advantages which make their work both more profitable and easier to carry on. Keeping with our airtransport example, we see at the national level the aircraft industry lobbying for advantages in public subsidies and tax allowances. We see as well, airline interests pressure both national and local bodies for special prerogatives in airport locations, landing fees, and for special routing benefits. Also evident is the intervention of employee organizations attempting to upgrade their own working conditions and salaries. Unsettling strikes and work slowdowns by airline personnel and air-traffic controllers exemplify the kind of pressure on both local government and national agencies that can accompany the improvement of airtransport capabilities.

It is obvious that these kinds of activities are of a piece with attempts by promoters or opponents in the earlier, more precarious stages of technical development to alter the social and political context into which the technology is being introduced. It should be clear now that the salience for social impact analysis of similar organizational activities seeking to reduce operational uncertainties and enhance the organization's advantages in carrying on the technology increase markedly in proportion to the numbers of people involved and especially as the interdependence grows between and among public agencies and private firms....that is, as the technology grows in scale.

Figure 3, in schematic form, arrays some of the implications of our perspective thus far. These are the several types of changes, sources of impact if you will, that require explication as intermediate analytical steps <u>prior</u> to advancing on toward an estimate of the "second order" changes potentially to be experienced by the society as a consequence of approving and supporting a technology for full scale deployment. In this sense, those <u>characterizing or describing the technology</u>, in its social manifestations, should anticipate a call for these "first step" changes, so that more credible estimates of longer term social impacts may be made. In this latter case,

FIGURE 3

AREAS TO BE ANTICIPATED IN SOCIAL IMPACT ANALYSIS

		Sources of Social Impact		
		Altered Institutional Conditions	Widespread New Capacity	Behavior of Successful Deployers
Scale of Development	Early Deployment	Important Precedents for future	(Not relevant yet)	(Not relevant yet)
	Later Full Maturity	Changed institutional structure	Changes in citizen & firm behavior	Changes in political situation

let me assert without supporting argument, though I can provide it if warranted, that, in terms of the positive political functions of OTA, fashioning a much better analytical perspective regarding technologies that are or become seen as potentially quite risky as well as beneficial may be its most important contribution to moderating the political conflict now engulfing one technical area after another.[10] Following this point, the discussion that follows will be laced with illustrations taken from the radioactive waste disposal area and will demonstrate the special demands emanating from this class of technologies.

Functional Elements. In establishing and managing a new technology four usual functions or activities must be carried out, with two additional ones in the case of "risky" technologies. The four customary ones include: the construction of the facility and the transportation links between them if they are not already in place; the operation of these facilities once constructed; transport and movement of the key feed stock, products, or other essential movables within the operational system; and the administrative oversight and coordination of these activities (as well as the two additional functions when "risky" technologies are involved.) The special risk related nature of some technologies, such as the handling of radioactive materials, prompts two special requirements: continuous attention to assuring the reliable, nearly error-free handling or operation of the facilities, and the provision of security for internal systems and external approaches to guard against intentional releases of materials. The specific technical character of these six functions vary, of course, as a consequence of the particular design options chosen and the deployment strategy employed.

When these areas are arrayed as I have, it is immediately apparent that the implied analytical and data requirements are very heavy, often beggered by the absence of data or even guides specifying the sorts of data likely to be useful. In a sense, we need much more carefully calibrated measures of the social stimulus to the immediate changes from which management challenges issue and changes in social experience result: in analytical terms, the independent variables associated with subsequent change or the dependent varibles. What categories of social and economic data should be collected, how should it be organized in this most necessary and least carefully done segment of technology assessment thus far?

Bases for More Credible Estimating Operational Impacts: Enhanced Characterization of the Technology

More accurate analysis of impact, benefit and risk requires knowledge of or credible assumptions about the changes necessary to nurture a new technology and what its widespread deployment would mean in terms first, of its direct affects, locally and nationally, upon employment, capital expenditure, and dislocation and advantage to existing economic and political interests, and second, of the subsequent reactions and reverberations to these initial changes, especially as the network of facilities involved expands to full operational maturity. Outlined in this section is an approach which would fill some of the existing gaps in information and knowledge essential for the analytical phases of technology assessment and would provide a firmer basis for public discussion and policy choice.

To provide the sorts of information of the technology necessary for improved social impact analysis, at least three types of data are necesary: 1) functional descriptions of what activities are necessary in general to establish, deploy and operate various steps in the technology; and 2) analyses of the resources and social requirements needed to realize each function for each step. For a special, but perhaps most important class of technologies, those that are benefit rich/high risk technologies, 3) a clear specification of the technical step and operational "extras" necessary for the technology to operate at very high levels of reliability is also crucial.[11]

Resources and Social Properties. This array of general functions provides a first step in ordering more specific information about a technical system from which the character of its social impact and management challenge may be developed. The next steps are to develop an estimate of resources necessary to realize each function at desired levels of reliability, and an analysis of the social properties of the organizational systems likely to be developed to meet these performance objectives. Table 1 shows a matrix of the various functions outlined above and the more detailed array of categories of resources and social properties that would characterize each major step of the technical process.

TABLE 1

ACTIVITIES AND RESOURCE/SOCIAL REQUIREMENTS MATRIX FOR EACH PHASE

A. Resources Requirements		Functional Activities: Construction (1)	Operation (2)	Transport (3)	Administrat. (4)	Assurance* (5)	Security* (6)
Capital Investment	(1)	a_{11}	a_{12}				a_{16}
Operating Costs	(2)	a_{12}					
Logistics	(3)	a_{13}					a_{36}
Labor Force	(4)	a_{14}				a_{45}	a_{46}
B. Social Requirements							
Skills Profile	(1)	b_{11}					b_{16}
Training Programs	(2)						
Admin. Complexity	(3)	b_{13}					b_{36}
Network Properties	(4)	b_{14}	b_{24}			b_{45}	b_{46}

*Benefit rich/high risk technologies only.

There are a number of ways resources required to deploy a technical system may be categorized. The set used here--capital investment, operational costs, logistics and labor force--is by now familiar for it is found in a number of TA's although not fully related to the functions as noted above. The first two, capital investment and operating costs, should be estimated in terms of the annual totals necessary during the life of the various facilities involved; the amounts and proportions of payroll likely to be disbursed through local facilities as contrasted to facilities elsewhere in the system; and money likely to be spent locally for equipment and services compared with those purchased outside each region. Perhaps more difficult to estimate but of equal importance is a review of the likely sources of financing capital investment and running costs as the system grows to large scale, especially the proportions of income likely to be necessary from public funds and from private sources or users. Some estimate of the industrial groups likely to be involved in construction and operations of an expanding waste management system would inform us of the benefits protentially to accrue to local as contrasted to national economic interests, a matter of analytical concern when second and third order impact are considered.

Estimates are also necessary of the logistical requirements and material needs for each function as various technical steps are expanded. Both the material and natural resources potentially threatened by short supply as the technical system grows to full maturity would be identified. Are rare metals needed? What requirements for special transportation facilities or vehicles are likely?

Labor force requirements should be calculated in terms of the total numbers of workers likely to be necessary. The ebb and flow of their numbers and occupational mixes, both locally and system-wide, are of special interest as the various stages of deployment and scaling up to a national system is carried forward. These data, together with payroll and capital investment information, provide an essential element in estimating local economic impact.

Other information, not usually included in the estimates for industrial planning, also is necessary: first, the magnitude and mix of occupational skill levels--skilled, semi and unskilled--exhibited by the employees and management in local facilities allows a beginning estimate of the social influences likely to be extended in communities and regions with the advent of industrial operations. Though more difficult to provide in the absence of decisions about the actual locations of industrial facilities, estimates of the likely dispersion of housing for workers over the areas adjacent to the facilities and the proportion of workers who would be found in the local labor force as compared with those brought in from outside it gives us an indication of the character of potential benefit and/or stress for the communities involved.

Second, and of heightened interest in "risky" technologies like nuclear waste handling, is an estimate of the character and costs of the training efforts necessary to assure reliable, consistent performance in operating the various components of the waste processing and emplacing system. At present there is little experience to draw from in providing these estimates, although lessons may be learned from the training and safety experiences in the Air Force ICBM forces, the system of air traffic control across the U.S., and the large volume processors of toxic chemical compounds such as Du Pont and Dow Chemical.

The character of the administrative systems designed to coordinate and control a multiplying number of facilities, transport links, assurance and surveillance systems is also of signal interest. As the number and size of "component-to-be-coordinated" increases, so often does the scale and internal complexity of the administrative system developed to accommodate them. Such increases in administrative complexity, a key source of operational error, will vary from function to function and for different steps in the long-linked technical process. The costs of control measures and difficulties in assuring rigorous processes of administrative oversight without loss of flexibility are an important element in gauging the implications for potential regulatory reactions, especially as the demand for nearly error-free performance grows.

Finally, information that, as far as I can tell, has never been developed in describing the social properties of large-scale technical systems, but is another element in gaining a sense of the likely pressure for external regulation or the stringency of the nearly error-free requirement, is an estimate of the complexity of the networks of facilities, transport and assurance/security activities that increasingly would be necessary as such systems as nuclear waste management developed to its full maturity. For example, the dispersion and density of a national, perhaps international network, encompassing the nuclear reactors and other sources of spent fuel and nuclear wastes, storage and processing facilities, etc., will vary depending on the particular alternatives for final disposal actually instituted. Each configuration would have potentially rather different economic, social and political consequences. Very likely these would occasion different regulatory and operational consequences as well.

For technical areas where significant operational error results in bearable consequences and where trial and error learning can be a useful and usually cost effective tactic for operational improvement, further analysis is probably not necessary. But for the benefit rich/high risk technologies, the usual process of successive approximation--on the basis of errors committed and then corrected--does not win great enthusiasm. The consequences of error may seem so egregious and potentially catastrohpic that learning from them appears to be a dubious strategy for policy improvement. It is in cases, such as nuclear waste management and the nuclear fuel cycle more generally, that additional more careful analysis seems warranted. This is the detailed specification of the technical and managerial processes proposed in order to estimate the potential for reduced reliability and/or significant error if the technology is widely deployed at large scale.

In the case of nuclear waste management, for example, the long-linked and relatively complex character of the technical and management processes necessary to deal with both military and commercial wastes markedly increases the challenge of providing the information needed for credibly estimating the costs and impacts of actually disposing of these wastes safely. The list of steps in Table 2 outlines roughly the radioactive waste management sequence regardless of which specific options are ultimately chosen to handle and emplace wastes. There may be significantly different collection and handling processes for the various types of waste forms in mining and milling the fuel stock, in fabricating fresh fuel, in burning it up, in removing the resulting spent fuel, and in decontaminating facilities. Systematic processes are also required for transforming original wastes into forms that can be solidified, and finally emplaced for perpetual burial. Of course, both transportation and security activities are mixed in with the primary processing and emplacement steps.

Using this rough form as an ordering scheme, then, the information called for above characterizing the particular functions involved in each of the steps could be arrayed for the entire waste management process. If this were done, planners and citizens alike would have a much better basis for beginning to understand the magnitudes of costs truly required and the character of the impacts likely to occur. It would in such cases add greatly to the clarity of debate and provide a more balanced basis for discussing fears and hopes.

Developed as the list of sequential steps displayed in Table 2, the management of radioactive wastes, as is likely for many "risky" technologies, appears fairly straightforward. The simplicity of tables like this are deceiving, however, and, as a guide to TA often result in a sense of spurious reassurance, especially where nearly

TABLE 2

STEPS IN THE MANAGEMENT OF RADIOACTIVE WASTES

1. Collection of the various waste forms
   (i) spent fuel (if designated as waste)
   (ii) mine tailings, fabrication plant wastes
   (iii) decomissioned plants and other irradiated equipment
   (iv) low level wastes from reactors
2. Initial handling prior to reprocessing
   (i) on-site storage, packaging
3. Reprocessing of spent fuel (with variations for militarily and commercially produced wastes)*
4. Solidification
5. Interim storage
6. Long term to ultimate disposal

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*This phase should include partitioning of actinides if space disposal option is analyzed.

error-free performance is demanded. First, the actual technical systems are likely to be relatively complex and, second, as scaling-up occurs in reaching toward a mature nuclear economy, the <u>annual</u> "through-put" of toxic materials could result in operating stress and/or quality assurance lapses. Both properties, if they occur simultaneously and rapidly are error inducing. The degree of actual internal complexity likely to characterize the systems for processing, transporting, and emplacing nuclear wastes is not now known. We can, however, get some sense of the potential for confounding complication in analysis and in operation by reviewing (in schematic form) the more completely described systems that identify the origin and disposition of wastes, first, from a power reactor (Figure 4) and the character, treatment and disposition of wastes from a reprocessing plant (Figure 5).

To this range of potentially complex stream of activities, add the others, many significantly different from those noted in Figure 5, necessary for dealing with wastes generated for military use over the past 35 years. Include, for complete technology assessment analysis, a parallel set of activities for dealing soon with the waste of significantly different forms from breeder reactors. Finally, there are the as yet unexamined complexities of transportation requirements as the system expands to lace together increasing numbers of facilities across this country and overseas. It seems clear that the management/coordination challenges necessary for nearly error-free performance becomes both considerable and costly. How costly in resources and in requirements for social conformity will be strongly dependent

FIGURE 4

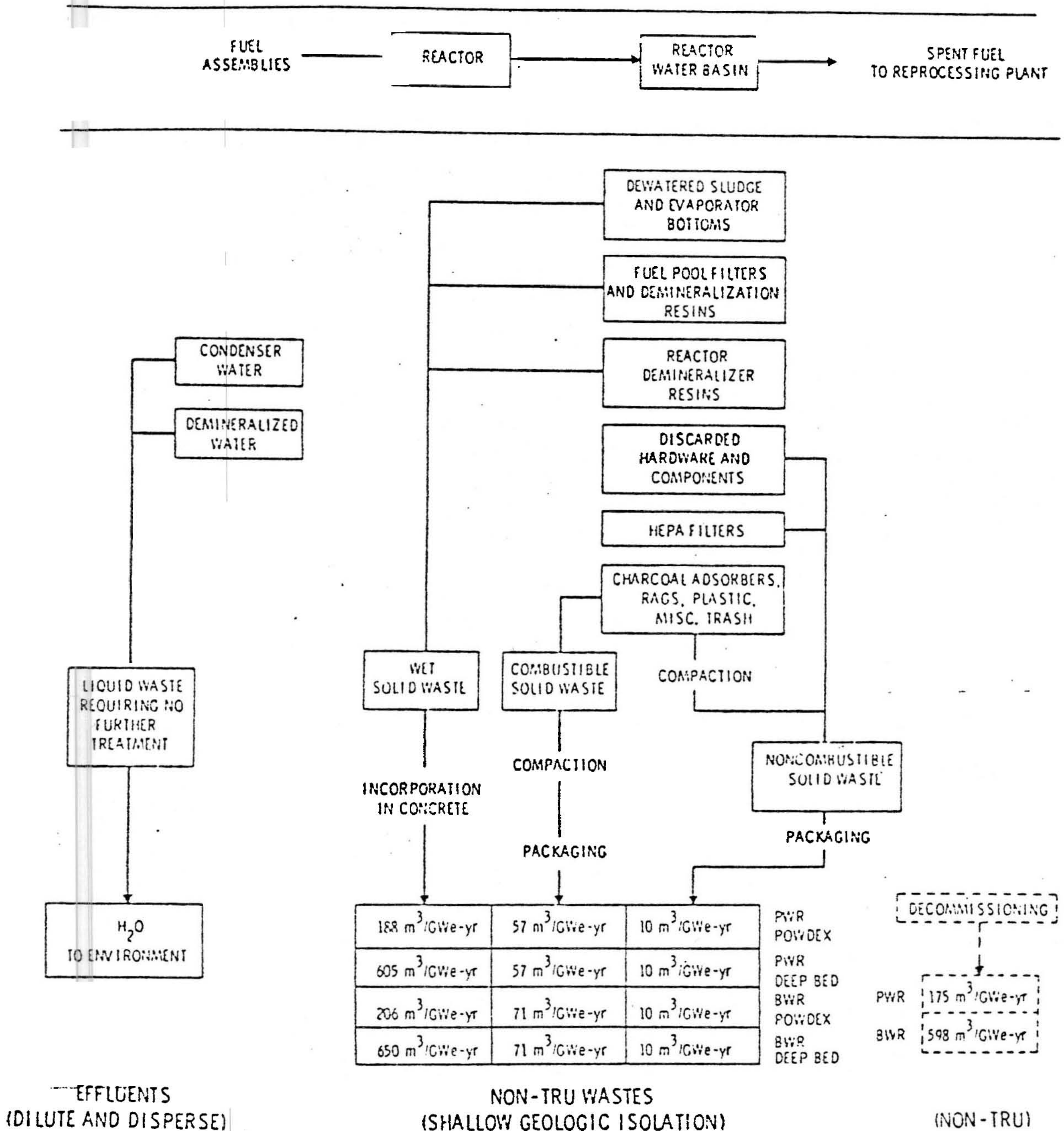

FIGURE 1.2. Origin, Treatment and Disposition of Radioactive Wastes from a Power Reactor (Modes II and III)

Source: ERDA 76-43, Vol. 1, p. 1.3

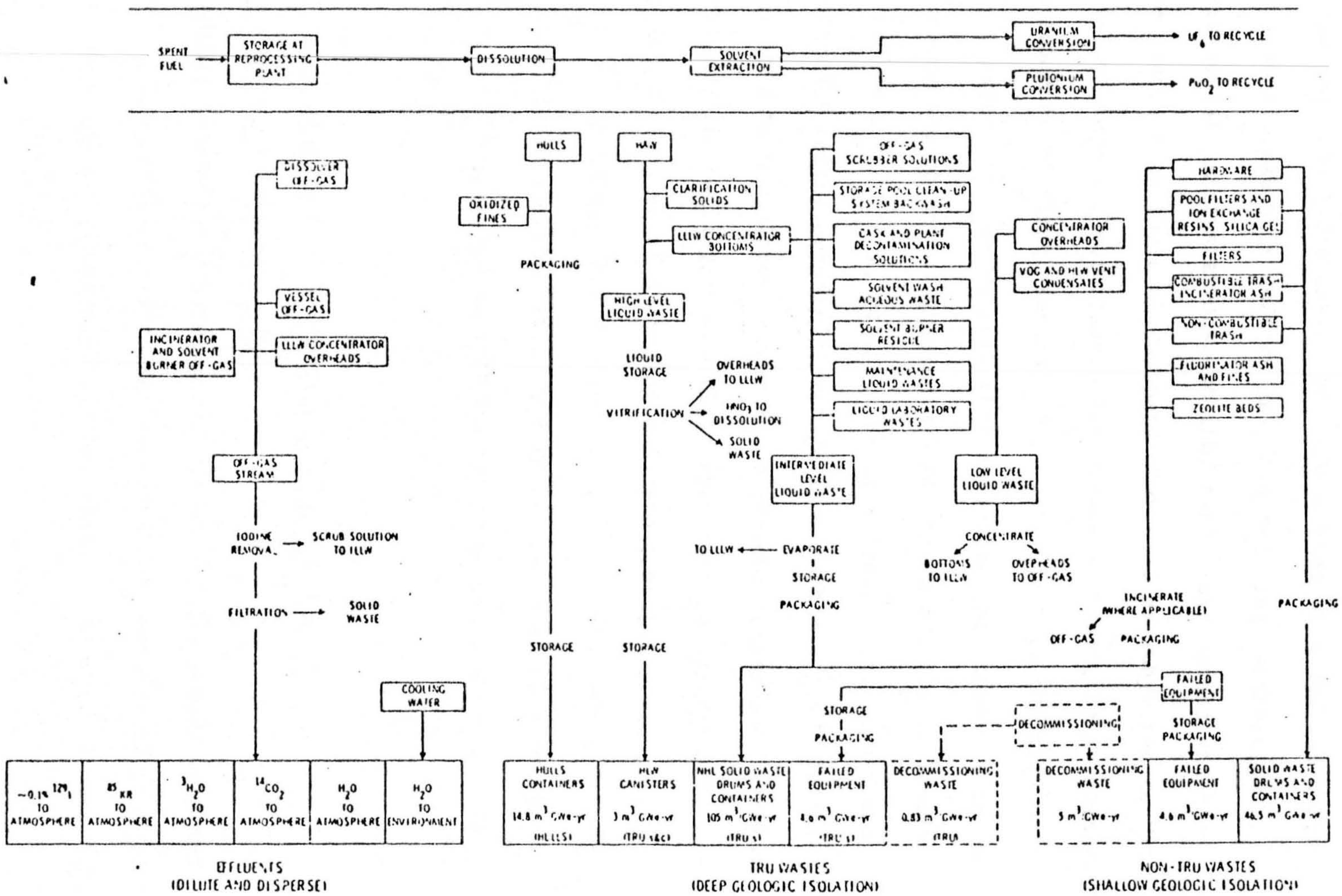

FIGURE 1.4. Origin, Treatment and Disposition of Radioactive Wastes from a Reprocessing Plant (Mode III)

Source: ERDA 76-43, Vol 1, p. 1.8

FIGURE 5

may go be matched by a similar level of refinement for measures of the stimulus variables, i.e., the social properties of the proposed technology at both its early and potentially mature stages. Thus far, a reasonably well elaborated characterizations of the sources of change have not been available and the implicit equations of technology and social change have been quite unbalanced: the state of the receiving regions much more susceptible to detailed description than the candidate technology-as-social-organization. If the suggestions outlined above--or ones similar to them--were followed this imbalance would be redressed somewhat. More analytical symmetry, thus, would allow the panoply of materials from the social sciences to be brought into the analysis with much greater utility. But if the implicit equations of technology and social change remain unbalanced--the technology-as-organization "side" of it underdeveloped, its dimensions mainly unspoken and vague--then linking the initial changes involved in technical development with the subsequent appearance of social and political change must remain itself inchoate and unsatisfying. Conflicts of interpretation will be based as much on unrecognized confusions about the character of technical change as over differences of political or social values. Allowing this imbalance to persist is, in a word, "bad science," as well.

At a general, abstract level, it is not difficult to outline examples of how the affects of initial technical development have triggered chains of responses along the pathways displayed schematically at the bottom of Figure 2, page 15. As we move along them, we enter the arena of social conflict and political and governmental dynamics about which a good deal is known at least descriptively. For those in OTA certainly there is no need for me to illustrate that technologies newly introduced find advocates who believe that they will be advantaged by control over it or many who feel that some of their cherished values are threatened by the same technology's development. OTA staff also see, indeed, are subject to, situations in which the perception of benefit or harm are intensive enough that the antagonists may bring pressure to bear on them as well as other public bodies at the local, state and national levels either to impede or foster the conditions necessary for rapid deployment. In those phases of analysis we move into the world of social and political exchange so familiar for many areas of life in this country.[13] But at this time it is difficult to assemble much more than stories and personal experiences in developing systematic estimations of the sorts of changes likely to be expected with technologies of one type of social property as against another. And we have little to alert us to the potential for increasing social strain in regions of particular properties when they become involved in the deployment of technologies themselves having varied properties. This is most unfortunate for I would argue that these are just the sorts of insights that OTA is charged with laying open.

Conditions of Social Strain

The conditions associated with technology and the emergence of social strain and conflict will be as much a function of the properties of the communities and regions into which a new technology is introduced as it is of the peculiar properties of the technology itself.[14] It is the interaction of new forces attending the development of a technology with the patterns of social and economic dynamics already in the region that will shape the intensity and character of strain and conflict there. In this section, I nominate several hypotheses about this relationship cast at an intermediate level of generality so that they may help order research on specific technologies and particular regions. Two of them focus on properties of the technologies, two others take account of important aspects of the receiving regions. All four suggest additional types of data rarely included in TAs.

Both the degree to which a new technology provides increased technical capacity to do things and the increase in the size and scale of industrial operations are under certain conditions a source of social strain and emerging conflict. But in both cases, it is less the absolute increases in these properties than their growth relative to that already existing in the receiving regions. Therefore, <u>the greater the capacity added by the technological advance relative to existing capacity, the more likely the development of social strain within the region.</u> Technical innovation almost by definition provides a greater capacity for people to do something new and more efficiently than before it was available. The increment of increased capacity may be small, with only modest impacts, as in the introduction of radial tires for automobile or probably the adding of taggants to explosives. It may also be enormous as with the development of rural electrification. The key notion underlying this hypothesis is that the greater the newly available capacity, the more people or organizations would take them up as an opportunity, thus potentially unbalancing the social networks ongoing at the time the new technology was introduced. Thus, a relevant measure, for the purposes of technology assessment, is the absolute increase in new capacity that would be provided by the new technology compared to the capacity in the same technological area that already exists. Two conditions in the local region are necessary, however, for there to be "maximum strain": that there be only modest levels of expectation about what will happen before the technology is deployed, and that nearly all of its "products" be consummed within the region. Often, as in the case of electrical power generation or agricultural developments, much of the products are exported out of the region and have little effect, in the sense of direct usage. Effects in these cases issue from the economic benefit usually disproportionately won by elites, on the one hand, and on the other, from the behavior locally of the successful deploying organizations. For a situation in which local expectations are only modest regarding the expected change, if substantial change does in fact occur, then considerable surprise and conflict may emerge.

It has been a continuing theme of this paper that the scale of a technology as it reaches full deployment or maturity is a significant source of impact. As an hypothesis, <u>the greater the social scale of the implementing organization relative to the scale of the social organizations in the receiving region, the more likely strain will</u>

arise within it. I am assuming that the greater the relative size of the deploying organizations, the less the disturbing affects of new patterns of behavior can be successfully integrated into the existing social fabric without considerable strain. In quantitative terms, the relevant measure, then, would be the scale of the technology in terms of its social size, financial magnitudes, etc., compared to the size of the community and region and the organizations-in-contact, especially locally. A distinction between the social scale of the technology during the construction phases contrasted with the later operational periods is important for some technologies, particularly labor and capital intensive technologies during the construction period, such as large power plants require only relatively modest operating crews after construction is completed.

At a general level, this hypothesis seems straightforward enough but we have little sense of the points at which a small community or larger region begins to experience the adjustments to growth as burdensome and difficult to cope with through the existing infrastructure of governmental services and dynamics of social control. At some point, the local and regional social systems become stretched uncomfortably and disintegration begins. When these inflection points are being approached is not now predictable, nor do we know much about the sorts of local adaptations that might be effected before such a point is reached.

Two properties of the regions into which technologies may be introduced prompt our two other hypotheses: the degree to which political leadership is dominantely or marginally in control. Of these two factors, the first is the most difficult to calibrate. It is more abstract and global in character, but probably of greater significance for social impact analysis. At one extrme, the regions could have many different groups with heterogeneous values; semi-autonomous groups or enclaves that have little interconnectedness or interdependence among them. At the other extreme, the regions may be highly integrated with quite homogeneous values and norms, minimal degrees of differences between groups which are tightly knit in patterns of mutual economic, social and political interdependence.

I expect that the greater the differentiation of the region, the more likely the effects of a technological intervention will remain relatively contained within the group or sector of its original establishment. Though the impact on the people associated with a particular sector is likely to be relatively greater than in "surrounding" sectors, beneficial or disruptive effects are less likely to influence groups not directly associated with the technology. Another way of stating this is that the more integrated a region, the more smoothly technological change will be incorporated into it, if this change is moderately paced, if it is sought by the region, and if it does not approach the threshold of overall regional strain. In a more integrated community or society, however, changes which occur within a sector tend to be moderated by the influence of other groups or sectors upon which the initial sector is dependent.

But there is a complication here. When a relatively integrated region is confronted with considerable pressure for change, it is, in a sense, more vulnerable than a community which is highly differentiated. In communities or societies which are not tightly knit, disasters as well as benefits are relatively contained, kept within a sub-set of the community; the ripple of consequences extends only a little beyond the group that experienced the problem or benefit in the first instance. But in well-integrated, interdependent communities, the consequences of strain are shared more fully by everyone. Up to a point, this moderates the impact upon those initially affected. But as the absorptive capacities of the total community are approached, the increased strain is distributed over the whole community more evenly than in a differentiated one. If the threshold of tolerance is reached, the situation threatens to swamp the whole community or region bringing problems of overload and potential breakdown.

Figure 6 presents, in schematic form, the mixture of our first three factors or variables in terms of the degree of expected change stimulated by a technical change. The general hypothesis is that as each of these factors increases the degree of change to be expected increases as well. As the increment of technical advantage grows, so does the likelihood that more people will see it in their interests to take advantage of the technology--in ways that strain relationships within the region. If the region is relatively differentiated, this is contained but in more integrated regions, the strain is shared more generally. If at the same time the social organization of the

FIGURE 6

DEGREES OF TECHNOLOGICAL IMPACT ON RECEIVING SYSTEM

Social Scale of Technological Development

Degree of Technology Improvement

	Small: Community Structure		Large: Community Structure	
	Differentiated	Integrated	Differentiated	Integrated
Modest	Least change absorbed within sub-groups 1	Little change absorbed within community 2	Modest change adjustment among sectors 5	Substantial change adjustment throughout community 6
Great	Minor change within one sector 3	Some change for whole community over the long term 4	Great change strained adjustment between sectors 7	Greatest change overload and potential breakdown 8

technological program grows dramatically in relation to the size of the existing community, the impact of funds, new people, and breadth of effect increases the strain until it bursts the bounds of any one sector, finally involving the whole region.

The second hypothesis concerning the properties of the regions speaks to the relationships of political competition and new technology.[15] It is obvious that the hold over a community or region by its political leaders may vary from a quite secure, entrenched situation in which the leadership is very dominant with few if any rivals to a situation of near paralysis among evenly divided, intensely committed rival factions. <u>The more evenly divided the political groups and interests within the region, the more likely a new technology will become the focus for political competition and hence increase the socio-political strain on local or state institutions.</u> A new technology usually represents, at the time of authorization, a part of the "program" of whatever group is in legal authority. It also represents potential benefits or disadvantages to various interests in the region. If the technology results in the predicted benefits, this redounds to the benefit of the existing leaderships and weakens rival groups' claims on future leadership. On the other hand, the results of technological development may fail to meet expectations for it and/or produce unpleasant surprises. If this occurs, rival factions may see it in their interest to use this disappointment or distress as a basis for political criticism and with promises of rectifying past mistakes, challenge those in power for control of the technology. The more precarious the hold of one faction on legitimate political power, the more likely will other factions seek issues to loosen that hold still further. Technological projects, therefore, may become the focus for political conflict as political rivals become more and more evenly matched.

It should be evident that the political situation within receiving communities is likely to be altered considerably as conditions summarized in Figure 6 change from the configuration in cell 1 to those combined in cell 8. That is, as the regions begin to experience changes associated with technological development, the opportunities for identifying the technology as the source of problems or benefits increases. Depending on the character of political rivalry as the changes become magnified, the more likely the technology is to become a matter of political and public concern.

The Dynamics of the Receiving Regions

Linking technological development to social changes draws our attention to the changes within receiving regions and prompts a requirement for information about their character at the time the technology is first deployed. For credible social and economic impact analysis, then, several types of information are called for, although it is rarely gathered, or is in such aggregated form as to diminish its usefulness. First, what are the social properties of the industrial infrastructure likely to confront the challenge of deploying a new technology? Though not always the case, new technologies in the advanced industrial nations are initially deployed within well established industrial sectors where pools of skilled employees are available and the large scale organizations necessary for aggregation of resources and administrative coordination are already in place.** To what degree will the requirements for the new technology disrupt or reinforce existing patterns of action within these sectors? Do these sectors have particular characteristics such that technologies will vary significantly in the amount of conflict they may stimulate. Of special interest here are the differences among technical alternatives in the same general area, e.g., energy or transportations, in their conflict evoking potential. To what degree do properties of the producing and distributing organizations themselves constrain their leaders in making investments in funds and organizational changes apparently required to deploy the technology? To what degree do the relationships between important producing and distributing organizations enhance or enhibit the deployment of one technological alternative as against another? If the changes apparently necessary for the relatively rapid deployment of various technologies actually take place, would they result in significant restructuring of industrial relationships? To what effect?

These and other questions arise as the notion of technology-as-social-organization is elaborated for it is the existing organizations of industry and government that may absorb and act out the organizational requirements of the new technology, and in the process, be changed to some

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**This varies to a considerable degree, even among advanced societies. The absence of industrial infrastructure undergriding many of the requirements for deploying advanced technologies (that we assume almost unconsciously to be available in the U.S. and Western Europe) is most evident in the Third World. Without the development of this infrastructure, as well as that associated directly with the technology, it's potential often cannot be effectively realized. Of course, such a requirement adds greatly to the "sources of impact." But there are cases in the U.S. where we find a parallel situation. Perhaps the most dramatic has been the development of NASA and the industrial system symbiotic with it. Something like this may also be involved in the development of synfuels. Certainly, during WWII and shortly thereafter, the development of nuclear power and weaponry provides an important historical example.

more or less significant degree. Or they may resist such changes and force the development of separate, perhaps competing, organizations if the deployment of the technology is to occur at all. In either case, the social character of technology itself will have potentially important impacts on existing large scale industrial, and possibly public, organizations as well.

A second type of information has to do with the networks of existing public organizations and special interest groups that are already involved with the industrial sectors in question. Are there significant numbers of agencies and pressure groups, that must, perforce of the law and/or political dynamics, become involved with the new technology as "external watcher," either attempting to promote or regulate the shape of its development? What are the relationships between them vis-a-vis the type of technology proposed? To what degree do the properties of that technology suggest that it will require or draw the attention of these "watcher-in-the-public-interest" during the deployment process?

Thirdly, for more finely tuned estimates of social and political impact, an explication of the more general patterns of social development is necessary. Here the social and economic descriptions of the receiving regions, and perhaps their national context, are appropriate. Demographic and economic trends and social and cultural patterns evident in the society require elaboration. And some attempt to articulate the dominant value themes of the region is useful. This segment of the work will be the most difficult to refine with any sense of precision or accuracy. But it will be important to have a clarified sense of the larger social context into which the technology may go.

For this task, I would argue on two grounds that a rather close analysis of existing patterns should take precedence over attempting to divine changes in values likely to be held by the public in the future. First, what is now present is likely to continue with little fundamental change for the near future, say over the next ten to twenty years, and changes that do occur during that time due to technological introduction require detailed analysis of present structures. But more importantly, attempts to forecast changes in future value preferences, even in the near term and certainly in the longer term, are condemmed to such errors of hopefulness and/or wishful thinking as to be nearly useless as a part of specific technology assessments or in more general terms for technology assessment methodology. This is not to say that prescriptive writings should not be done. Rather that for analytical purposes, it must remain quite speculative and subject to such misuse as to ask for much more difficulty than it is worth. If forecasting speculations are done at all they should be in the spirit of an exercise in which several significant shifts of value consensus are postulated, followed by an exploration of the implications of such shifts for the emergence or reduction of social strain and political conflict as a function of the "imperatives" of the new technology were these values shifts to occur at different stages of technological deployment.

I will insist that the types of information discussed above are crucial for credible analysis in technology assessment. At the same time, the recommendations are likely to levy rather heavy demands on T.A. assessment teams. It is my impression that what data are available only scantily covers the range of information called for and then their reliability is most uncertain. This means that the T.A. team may be confronted with gathering a good deal of it themselves. This could become a formidable challenge, but one that must not be ignored by assessment teams lest the errors in their work be so large as to vitiate its analytical usefulness.

A good deal more should be said about the detailed methodological refinements of specific assessment projects and the processes of data collection regarding the properties of both the deploying and distributing organizations, and the structure and dynamics of regions into which the technology may go, but time and length allotments do not allow it here. Suffice it to say that methodological experience in the social sciences speaks directly to these matters and can readily be drawn on to improve the scope and quality of information necessary for more credible technology assessment analysis. An effort is now underway in California, sponsored by the National Science Foundation, to explore the promise and the difficulties of integrating social science materials into technology assessment in the context of alternative energy producing technologies and their potential impacts upon institutional developments in that State.[16] The project's key features are: the description of alternative energy technologies in their social, as well as their engineering, manifestations; a detailed description of the lineaments of California's present energy producing, distributing and regulatory system; and a two phased effort of field research attempting to identify and then verify the "rules of the game," or norms, used tactily by the major organizational actors in that system in their dealings with each other. The object is to predict the conditions associated with different reactions to the introduction of particular mixes of alternative energy producing technologies, especially those likely to produce significant social conflict. More details of this research program can be made available to OTA if it seems warranted. (See the attached "Project Work Plan" for a glimmering of its complexity, the requirements and implied level of effort.) While this project is unusual in the sense that its Principal Investigators were able in advance to specify the particular technologies "to be assessed," something of this sort is probably optimum (perhaps necessary) as a basis for the technology-impact-on-society types of technology assessment.

Part II. Implications for Office of Technology Assessment Processes

The perspective developed here, if taken seriously, provides a basis for altering both the design of technology assessment tasks and the data collection and analytical work of technology assessment teams. In Part II of this essay, the "review" OTA reports are discussed in terms of the types of analytical problems they pose and the assumptions about our knowledge of the social properties of technology they seem to reflect. I also include a report of an exercise in support of this paper attempting to elaborate its perspective in terms of the standard bibliographic sources and categories likely to be encountered by an OTA staffer who was given such an assignment.

Reflections on the "Review" Technology Assessment Reports

Practitioners of technology assessment, especially in OTA, rarely control the specification of the projects they take up. Rather clients or sponsors call for technology assessments on the basis of the decision situations they confront. If the several OTA reports nominated for review can be considered representative, the analysis of at least three rather different types of problems is sought:

The first emphasizes the changes in economic and social experience likely to result as a consequence of improving an existing technology or deploying a significantly new one. Schematically, the relationships involved in this "cut at the T.A. problem," are played out along the right side of Figure 8, p. 61 (a reproduction of Figure 2). The type of conceptualization and analysis called for in this essay speaks most directly to this kind of assessment task. Three of the "review" OTA reports are of this type and represent the lion's share of OTA's work. Ranging from the least to the greatest technological scope and potential change, they include:

Taggants in Explosives (OTA-ISC-116, April 1980)

Gasohol: A Technical Memorandum (OTA-TM-E-1, Sept. 1979)

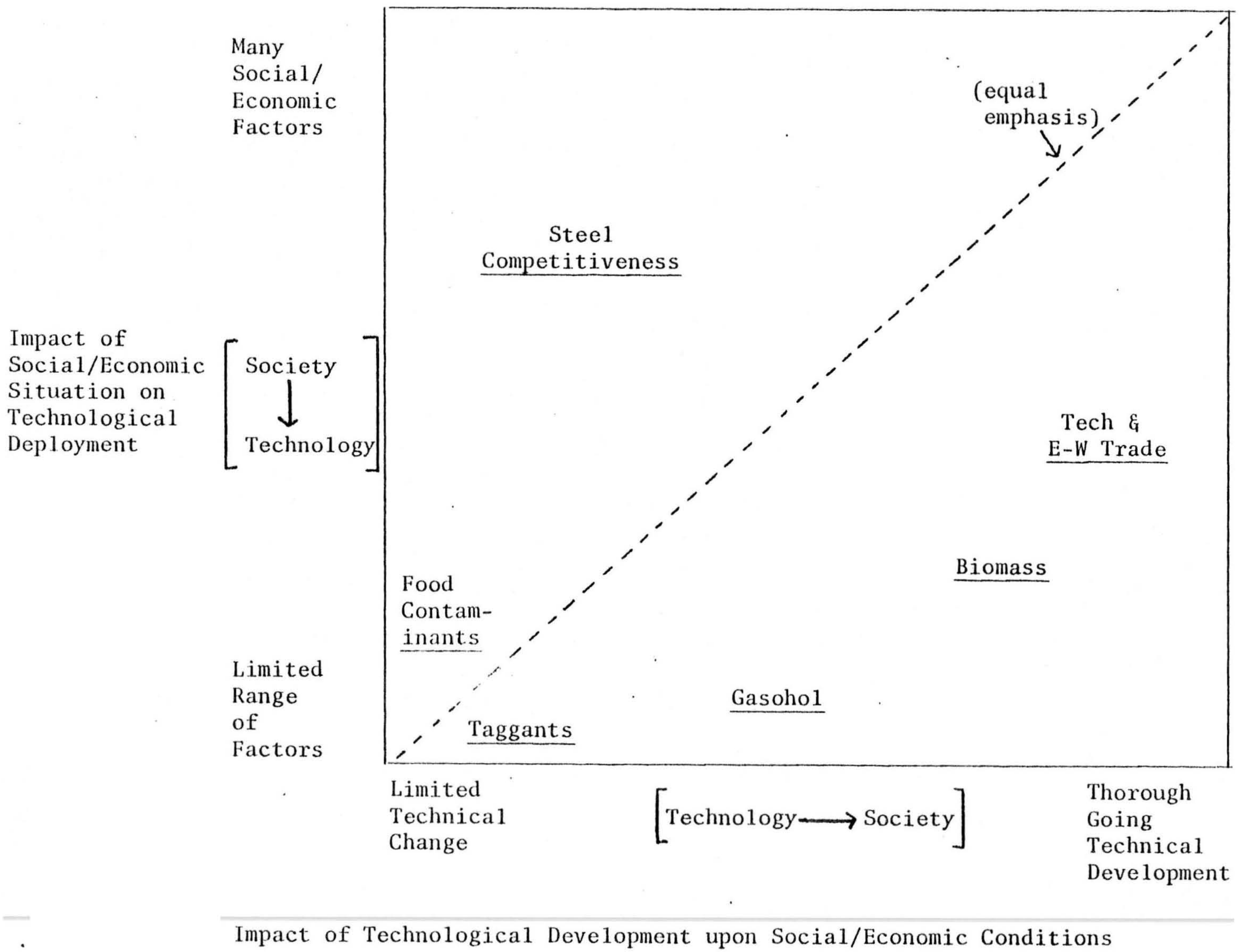
Energy From Biological Processes (OTA-E-124, July 1980).

A fourth report, Technology and East-West Trade (OTA-ISC-101, Nov. 1979), adds to this emphasis another one reversing the focus on the effects of technology upon society. (See Figure 7 for a schematic ordering of the T.A. reports included in this type and the one following.)

A second emphasis seeks insight regarding the changes in the dynamics of economic and political institutions--industrial corporations, governmental agencies, legislatures, and the courts--which would improve (or impede) the deployment of new technologies. This type of analysis usually addresses the political, economic, and sometimes regulatory conditions that seem to thwart the diffusion of technical innovation. Again, schematically from our perspective, these relationships are indicated along the bottom and left side of Figure 8, p. 61. In these studies, particular interest is put on exploring various types of incentives which could encourage the industrial producers and consumers of new technologies to invest in them. Technology and Steel Industrial Competitiveness (OTA-M-122, June 1980), clearly has this impetus.

FIGURE 7

ANALYTICAL EMPHASES IN APPROACHING TECHNOLOGY ASSESSMENT PROJECTS



Finally, a third, much less often sought, type of analysis is the evaluation of techniques bearing on impact analysis or governmental programs having significant technical content. Similar to many studies done for Congress by the General Accounting Office, these studies attempt on one hand to evaluate, for the purposes of public policy analysis, various numerical techniques for determining the costs and/or benefits associated with specific policy areas. On the other hand, occasionally evaluations are sought regarding the adequacy, for effective administration, of the organization and management of technology based governmental agencies.

The Implications of Cost-Effectiveness Analysis of Medical Technology (OTA-H-125, Aug. 1980), and

Conservation and Solar Energy Programs of the Department of Energy: A Critique (OTA-E-120, June 1980) are examples of these evaluation studies.

The last study, Environmental Contaminants in Food (OTA-F-102), Dec. 1979), while clearly an evaluation of public programs, seems more fitting for OTA attention and represents an emerging type important in its own right. What is at issue in this study is the effectiveness of public institutional response to a technologically induced problem, the pollution of foods by toxic chemicals. It is a problem born of benefit rich-high risk technologies, the special type of technology, noted much earlier, to which I will return in my conclusion.

What implications for these three types of studies arise when they are seen from the conceptual and methodological perspective of this paper?

Taking up the "evaluation" tasks first: my perspective adds little if anything to enhance or improve reviews of the organizational structure or processes of agencies charged with technological promotion or regulation. Organizational evaluation is not addressed directly by notions of technology-as-organization and, though I have a number of notions about the process and efficacy about such evaluation studies, this paper is not the place to air them.

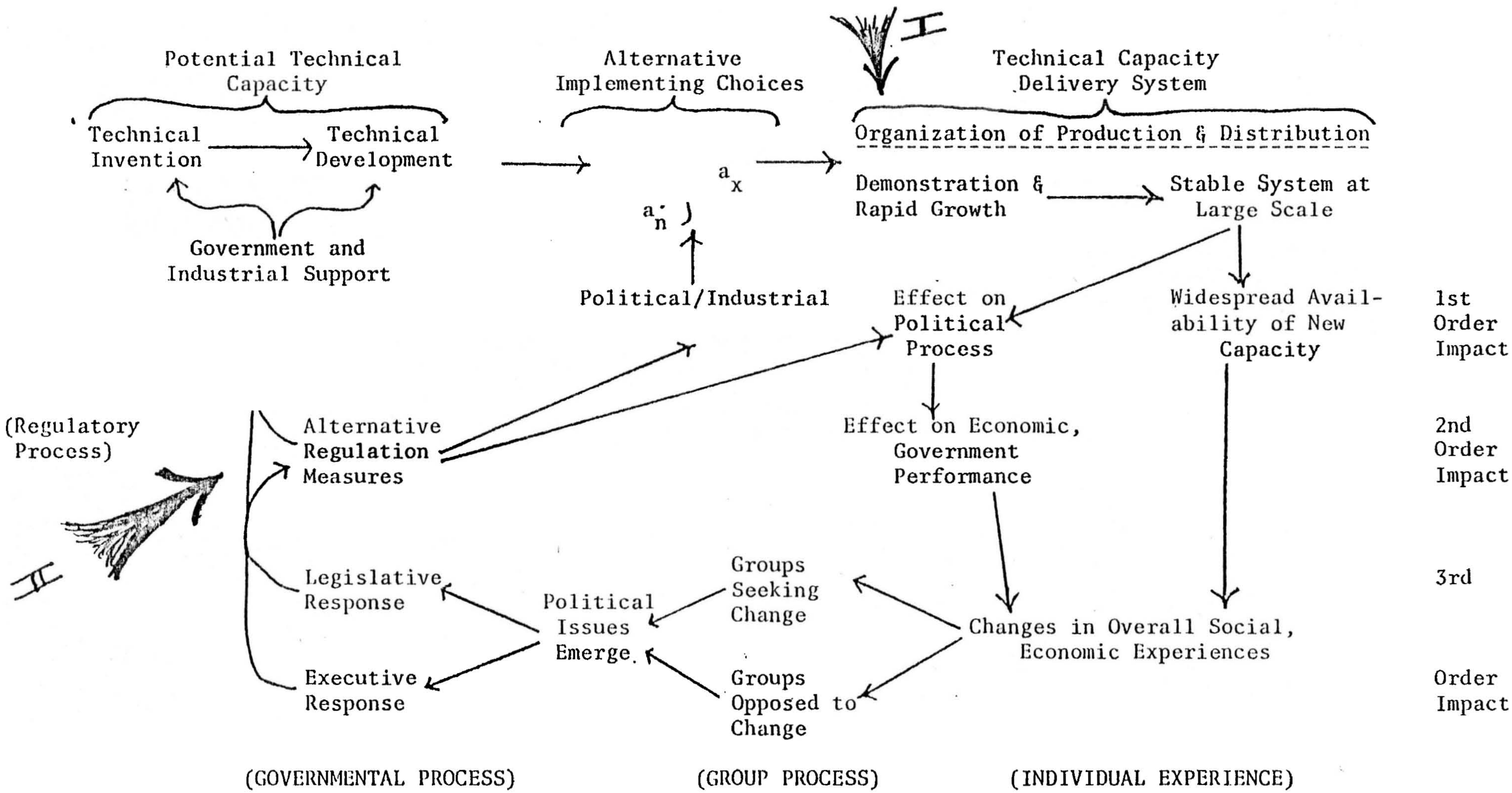
Evaluating the utility of various analytical techniques, such as cost/benefit or risk/benefit analysis, that promise to increase the precision of impact analysis should be based in part on judging the techniques' capacities to include the measures of a full range of affects of implementing alternative policy options. When these are not fully or credibly explicated then cost/benefit analysis is trucated and often a spurious guide to policy choice. If the underlying conceptions of technology-society interactions are incomplete or flawed then so is the cost/benefit analysis associated with them. Thus, insofar as my perspective increases our capacity accurately to identify the full sweep of short and longer term impact of a technology, it could alert an evaluator to the weaknesses of particular cost/benefit analyses. Of special importance in my view are the impacts of full scale, mature deployment of a technology and the identification--really a forewarning--of potential "deferred regrets." These are the hurtful conditions that sometimes become apparent only well after a "graceful entry" and widespread deployment of a technology into society when such dependence on its benefits has developed that the technology is not likely to be altered much even in the face of the newly recognized costs.

The two other types of assessment problems noted above represent, essentially, different "points of entry" into the skein of reciprocal affects that "technology-as-organization" and the institutions of society have on each other. As these two types of problems are put to OTA by various clients, they in effect serve to direct the TA team's formulation of its analytical problem from different points of departure: either with the introduction and deployment of a new technology (Entry Point I, Figure 8), or with worrying the problem of the institutional context into which a new technology might go in order to facilitate its development (Entry Point II, Figure 8). The implications for conceptualizing the problem and for data collection of "cutting into the problem" at these different seams in the technology-society-technology cycle are quite significant, each with particular types of potential errors and gaps in analysis.

In this essay, I have taken it that the primary analytical task for technology assessors is to anticipate the potential positive and negative affects on society of deploying a new or improved technology. The point of departure is, then, the availability of one or several technologies which could be introduced in the near future. The analytical challenge is to describe the technology in its social organizational manifestations in preparation, first for examining the potential changes likely to be necessary for relatively rapid

FIGURE 8*

SIMPLIFIED PATTERN OF TECHNOLOGY-SOCIETY INTERACTION



*Reproduction of Figure 2, p. 15.

deployment. "What has to happen so that the technology can be put in place?" What changes in existing institutional patterns and dynamics would have to occur for these operational imperatives to be realized? In this cut at the problem no assessment is made, however, of the probability of such institutional changes actually occurring or the character of conflict if they were attempted. The second increment of analysis, then, is to explicate the subsequent changes likely if full scale stable market levels of deployment were to be attained--given the institutional changes apparently necessary for early deployment.

For this pathway into the assessment problem, it is the political structure of the industrial setting that is being "held constant." In effect, this approach begs the question about the potential dynamics of choice that might actually occasion the selection of one technical alternative over another. While this analysis provides information and insight that would inform the judgments of those, such as Congressional Committees or executive agencies, involved in decision combat, attention is not devoted to that process in any detail.

In terms of the perspective outlined above, what can one say about the several OTA reports of this type?

Before plunging into a discussion of the gaps and "missed opportunities" apparent to me in the three studies, let me say that OTA has developed a very effective mode of presenting what data and analyses can be mounted in the various areas under review. The style is clear, usually free of technical jargon, and the reader is drawn effectively into the analysis and interpretation through the successively more detailed summaries and data displays. Perhaps the one exception to this generally admirable process is the absence of comment on the quality of data in its various guises. As one reviews the reports an uneasy feeling grows about the accuracy of the data used, especially by OTA contractors in support of specific studies. In the reports' texts there are few expressions of caution or the reporting of uncertainty bounds associated with the data upon which analytical conclusions are based. When sources are in the open journal literature (as contrasted to contractor reports which are rarely available without extraordinary effort), this is not a serious problem. One can go check the data and its credibility. But when such analysis is really part of that "gray literature" of government contractor reports, especially when it is in direct support of OTA projects, some expression of the quality of the underlying data base is warranted, at least in the appendices. This is particularly important if the time and resources available were limited...as they seem always to be. Along this same vein, let me urge that the level of effort expended in dollars and manpower and the time period of the study be clearly stated in the report's introduction. It is important to have fixed in one's mind the level of effort applied against the magnitude of the problems taken-up.

The three reports of the "technology's-impact-on-society" sort each have two important properties in common. They bring together, often quite sensitively, existing data and analyses regarding a particular technology or set of them in the most balanced manner now available; and they each lack the sort of information that would assist decision makers in understanding very clearly much about the social, institutional, or often economic impacts of the technologies under review. This is particularly the case if the identification of social strain associated with mature development is sought. In a sense, what is commendable in the first instance--drawing together existing work--results in the unfortunate absence of insight in the second instance.

From the perspective of "technology-as-social-organization," three "gaps" in the analyses are most crucial. There was scant systematic attention paid to: the potential impacts associated with mature, widespread deployment of the technologies; the second order impacts of deploying a candidate technology that issue from effects on other requisite technologies; or the sorts of infrastructural changes which would likely attend the deployment of these technologies, especially the requirements for additional state and national regulatory apparatus. The importance for technology assessment analyses of these gaps grows as a function of how much technical change is associated with deploying a specific technology.

The taggant study, the narrowest technically of the three, was bounded nicely and keyed to the scale of the explosives industry itself. While there was no attempt to forecast the increasing scale of that industry in the next twenty years (one has the sense that it would remain more or less stable) the social impact of wide dispersion of taggants is built into the problem from the beginning due to its "add-on" nature. And its social impacts would mainly meld into the much larger social impacts of the regulation of explosives, a function already established, more or less effectively, in the society. In addition, it seems evident that there are relatively more technical uncertainties for this technology than for the others in the reveiw set. Rather what was missing from an otherwise quite complete assessment was an analysis, important from our perspective, of the economic and regulatory changes necessary to deploy this add-on technology; and an attempt to explore the longer term consequences for law enforcement agencies as they might respond to counter measures if the taggant option actually were to become widespread. In effect, the taggant assessment team did not confront many social science opportunities because the technology in question is not likely to become particularly large in terms of its social scale. This is not the case, of course, in either the gasohol or the energy from biomass projects.

These reports, the first essentially a lessor included part of the second, speak to potentially quite widely spread activities, amounting on a national basis to a large scale industry. It is possible that a great many people would become involved in deploying and operating various options for extracting energy from biological processes were they to reach their practical potential. Therefore, it is warranted to make more explicit the estimated economic requirements and employment and skill demands implied by a fairly rapid deployment policy to attain that practical level. It would have been useful, for expositional purposes, to have included figures for analogous industrial activities that had already reached approximately the social scale potentially attainable for the biomass energy production modes.

If the scales of these technologies were to grow so would their potential impacts upon the technologies needed to service them. At least first approximation analyses should be included regarding the character of the demands upon other technical areas...and to what affect. Some of these are identified, e.g., the probable use of coal in the production of ethanol, with a note that this requirement, at some unspecified level of demand, could add to pollution and hence to regulatory problems. But due to the inability of OTA to go much beyond existing data, not much more could be said for there has been almost no attention in the past to developing the necessary data, especially in terms of several scenarios of potential market penetration. One is left to wonder just how serious to take these scantly founded assertions. The upshot of such "identification-without-analysis," for those already committed to promoting or to opposing a technology, is the temptation to discount or dismiss whatever assertions might contradict their preferences. This may be all right in areas where mistakes or social surprises are seen to be small or their effects to be reversible. But if the consequences of error turn out actually to be quite punishing, the absence of analysis on the impacts of technologies as they grow in social scale and on their impacts upon service technologies simply lays the groundwork for potential very unpleasant surprise and public resentment later on. Nor is the absence of such analysis a matter of data esoterica; rather it is one of inadequately perceiving the phenomenon, if not one of inattention and misdirection.

An example is in order, from the benefit rich/high risk technologies of radioactive waste management; in this case the surprises that may arise from the demands for very reliable transportation of a considerable volume of spent reactor fuel in trucks and/or railcars from existing and planned reactors either to temporary above ground storage or to permanent repositories. Estimates of transport requirements are tricky, but they can be made for about how many truck and railcar trips would be needed under various conditions to service the some 150 nuclear power reactors now operating or authorized. Depending on the particular assumptions and operating procedures, transportation needs for peak years (about 2020) would range from between 6900 truck and 2200 railcar trips each year (if temporary storage were instituted) to about 4900 truck and 600 railcar trips per year (if spent fuel were taken directly to permanent burial).[17]

Ordinarily these numbers of transport shipments do not excite much interest. But they are likely to present some interesting, perhaps unsettling operational problems, if, for purposes of maintaining public confidence, it seems prudent to be able relatively quickly to know if a shipment had become lost in transit. On the average, under the assumptions of this analysis, on any particular day for each day of the year, there would be as many as 100 trucks and 100 railcars (with a low of 70 trucks and 30 railcars) on the move in widely dispersed regions of the U.S. At this time, railroad companies are able to locate a missing car dispatched on regular trains in something like 10 to 14 days. If this was thought to be too slow a response in discovering the "state of the waste transport movement," substantial changes in rail operations appear necessary. Say that it seemed warranted to get a "lost vehicle" notification within a working day (8 hours). This seems to require either a special dedicated train (doubling the costs of transport), or some sort of on-car/truck-monitoring system. If on-vehicle monitoring and reporting capabilities turned out to be necessary, it would require the development and operation of a coordination and communication system supported by special technologies and monitoring organization. How sizable would this have to be? How many people and with what skills would be needed? What would it cost? Should it be publicly operated like air traffic control is by the FAA or privately run through the railroad? If it is quite costly, with special training required, how would the funds and training programs be developed? How would we assure operational reliability over the long number of years it would be needed?

As far as I know, these questions have not been raised, at least in print. Nor would they likely be raised if the perspective toward nuclear waste management focusses only on problems and opportunities of waste management at its early stages of deployment. Rather the matters of scale and "service technologies" prompts us to think rather further into the future and more broadly. And it is not in terms of the possible changes in social values held by the public in that future, but in terms of the operational dynamics that might follow from deployment whether it has a "graceful entry" or a more acrimonious one as in the radioactive waste management example.

A third type of analysis missing from the "technology's-impact-on-society" OTA reports is a systematic exploration of the changes in social and governmental infrastructure potentially required for the satisfactory operation of a candidate technology. If the technology, in its social manifestations, fits nicely within an existing market structure, there is usually no need to take up this question. However, this requires that the technology is susceptible to impersonal regulation in the market place <u>and</u> that the economic sector into which it is introduced is <u>at the time of introduction</u> relatively market-like, i.e. many potential <u>producers</u> as well as buyers, so that there is likely to be competition both in the production and in the consumption of the new capacity. But if either of these conditions does not hold, then analysis of the degree to which the technology can be produced by many firms and consumed by many buyers <u>is</u> warranted. To what degree, for example, is the "product" such that it is likely to require only market forces for its "regulation"? Does it produce, as it is developed to large scale, secondary effects (externalities, in the awkward language of economics) that are not effectively subject to market forces? If so, would its deployment implicitly stimulate a parallel call for governmental regulations? At different levels of government? To what degree do regulatory "carrying costs" reduce the cost/benefit ratio of the technology-at-scale? Must we assign to it, the political costs of seeming to require, in order to receive its material benefits, an increase in the very conditions--increased government involvement in private life--that serves to lower our regard for government?

These matters were only scantly noted in the three impact reports; and there was no analysis suggesting the extent to which regulatory pressures were potentially associated with the candidate technologies. The most useful discussion (and the least likely candidate for problems in this regard) came in the taggant report. While the potential regulatory challenges for various biomass energy sources were noted, i.e., asserted that the problems might exist, there was almost nothing to signal their extent or character. One was struck by how often it was asserted, in the Energy From Biological Processes report, that uses of forests and agricultural lands for energy supply could be both efficient and environmentally acceptable if careful management were accomplished. And it turned out that "careful management" meant, not just economically careful administration, but very tightly co-ordinated and balanced growing, harvesting and fertilizing practices... all of them quite difficult to guarantee across the widely dispersed areas from which biomass materials would be produced. In the face of such a situation, decision-makers should be advised regarding the types of solutions attempted in areas having special properties similar to those of the candidate technologies, with their histories of conflict and affects.

I have no illusions about the difficulties both analytical and political of attempting to increase the precision of insights regarding potential social and institutional affects of implementing particular technical programs. A good deal of fundamental work is required before substantial improvement will be won. But a review of the social impact segments of the review reports reveals even less precision than could be expected at this stage of social science development. It is true that the phenomenon is both much less studied and much more complex than physical and biological and certainly engineering phenomenon. And this should give technology assessors pause. However, it need not result in the degree of vagueness and simplisticness presented in the review materials.

[A fourth report fits uneasily in the technology's-impact-on-society category, Technology and East-West Trade, but it is cast at such a level of abstraction that our perspective of technology-as-social-organization, et al, cannot address it even indirectly. In that report, "technology" is aggregated in terms of foreign trade, the value of the new technical capacity to national governments stemming from its part in judging their positions of advantage or disadvantage with each other in military and economic competitive terms. The notions of technology used in that report are quite vague and undisciplined and the discussion very speculative. It takes on the characteristics of much of international relations--speculation and attribution of motives without the possibility of test or verification. The report is useful in summarizing perspectives and assembling data, though it seems of uncertain quality. It will be, I suspect, as dated as foreign policy analysis is in the face of rapid changes in geopolitical conditions, nearly all of them unpredicted.]

Finally, in this reflection on the review OTA reports, we turn to a study which represents the "enhance-technological-diffusion" perspective. Quite different from the perspective we are taking in this essay, this approach to technology assessment, (in a sense, not technology assessment at all, rather "institutional assessment" in terms of governmental policy encouragements or impediments to further technical development), assumes the appropriateness of technological development. The analytical issues involve explicating regional, national, and sometimes international economic and industrial conditions in such a way as to facilitate the search for legal and regulatory changes which would foster technological deployment in industry. The Technology and Steel Industry Competitiveness report fits squarely in this category. The "assessment" objective is an explication of the new technologies in steel making and of the industry into which it is desired they go so that economic and regulatory measures may be altered to improve the economic efficiency and hence international competitiveness of that industry.

In this "change-governmental-measures-to-foster-technology" approach, what is being "held constant" analytically is the level of information about the potential social impacts of the new technologies in question. It is tactically assumed that what is known already about the social and institutional impacts of deploying the new technical alternatives is either enough to take up the task mainly of sorting out policy options and their political and economic contexts for fostering the technology or cannot be improved soon enough to make much difference for the dynamics of policy choice. Since it is assumed outright that the industries involved "need" the new technologies, the sorts of impacts on the receiving regions, or in prompting more or less governmental regulation if the desired technologies are deployed at scale, do not have much salience. In effect, the benefits of deployment appear so self-evident that an examination of potential unsettling, longer term consequences or costs seems a silly use of scarce analytical resources. The shorter term economic or military benefits are so obvious that the efforts to alert us to longer term potentials for social strain seem only divisive and carping.

The steel competitiveness report is an excellant example of this approach. Everything in it informs the social mission of stimulating a reluctant industry to do what would be in its own longer term interest... an industry which if left to its own devices in the current economic and organizational circumstances would behave in the short run in a way which would result in its longer term failure. The implications of this stance to framing the problem for the "assessment" team is, of course, quite different than for a team interested mainly in the technology's impact on society. The key analytical elements center on the current structure of the industry and the underlying reasons for its tardiness in taking up technical innovations; the current behavior of the governmental and financial institutions which are an important part of the industry's environment; and finally, the range of options available to the governmental agencies or legislatures to reduce the risk to the industry of incorporating such efficiency enhancing innovations as exist. Usually in the process of working out this analysis, more information about the social properties of the technologies and the organizations of production and distribution is developed than now accompanies the data for "technology's-impact-on-society" projects (though it is just as necessary for the effective application of that approach). What is missing, clearly evident in the steel competitiveness report, is much consideration of the potentially negative affects of actually deploying the technical innovations. Thus, the most significant "hidden" error in this approach--one that could be overcome if an improved version of the other approach were joined to it--is the gross oversimplification of or unwarranted confidence that the prized technical innovations will have minimal or quite acceptable negative consequences upon social or institutional changes as it becomes deployed fully. Oddly, such a discussion seems rarely to be included in such studies as the steel competitiveness project. From the "technology-as-social-organization" perspective this "gap" seems both unwarranted, though perhaps understandable if the object is to insure the acceptance of a particular option rather than to understand the consequences of policy choice, and needlessly opens up the OTA team to the charges by opponents to the technology of biased analysis.

Throughout these reflections on the review technology assessment reports, there has been a repeated call for more finely grained conceptualization of the phenomenon to be analyzed--technology as social organization, the industrial and governmental systems into which they would go, and the impacts of potential changes on the regions within which all these activities would go on. Obviously, additional types of data should supplement the information already collected by OTA analysis teams. And the tone of my remarks might suggest, at least implicitly, that if one took these ideas up with a will they could turn to the literature for assistance in explicating the conceptual elements, if not for data on specific technologies. Knowing something of the traps such an expectation might hold for the able staffer, we have attempted a reconnaissance of that terrain. In the next section a modest probe in the literature conducted for this essay by such an able young professional is reported. Its intention is to alert OTA staffers to the pitfalls of depending on standard bibliographic categories in card catalogues and professional indices.

Technology, Organization and Social Change: A Promise Unfulfilled

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This paper begins by noting that its focus is more narrowly confined than similar efforts supported by OTA. By concentrating on only one important element involved in the "methodology" of technology assessment (TA) and proposing an expanded view of "technology-as-organization," the paper attempts to improve the conceptual foundation of TA. The purpose of this section was to see if a useful starting point for the individual seeking to understand the concepts explicated in this essay might straightforwardly be found in the existing literature. I had been asked to assume the role of an OTA staff member assigned to investigate the "technology and social change" literature. This investigation was to yield a lucid analysis of how and where "technology-as-organization" fits with other aspects of technological impacts. The result was an exercise in frustration.

I bring to my role an academic background in business administration/ economics and political science. I have done work (both classroom and applied) in the area of organization theory. My previous experience in the dynamics of technology and social change has been limited to the social-psychological treatments of the influence of technology on attitudes and values. (Representative of this genre are The Technological Society by Jacques Ellul, The Homeless Mind by Peter Berger, et.al., Future Shock by Alvin Toffler, and The Great Transformation by Karl Polanyi.) Prior to this "assignment" I had no experience in the area specifically known as TA, although I am familiar with some of its techniques, e.g., delphi, time-stream analysis, and forecasting. Despite being a novice in these matters, I expected my review of the TA literature to be rather routine. I was familiar with the concept of "technology-as-organization," therefore my task would consist of scanning as much of the literature as possible seeking connections in that literature to the expanded view and noting examples of its use. My expectations were much too high.

I adopted the following strategy: (1) Identify "key terms" likely to guide me to the proper source maaterials; (2) locate them in the periodical indexes and subject catalogues; and (3) review the relevant books and articles found there. The intention was to review the period from 1970 to the present. However, the large amount of information contained under the headings and its repetitive nature made this both impossible and, to some extent, superfluous. Due to a limited amount of time, the search could not be comprehensive. I am not convinced, however, that a substantial increase in both time and resources would result in a proportionately better understanding of the subject matter.

I began by looking under the card catalogue subject titles: "technology," "technology and social change," "technology and organizations," and "technology assessment." All of the entries were subsumed under the heading of "Technology and Civilization." As one can imagine a number of titles appear under this broad topic. (See examples of this material in the bibliographical Appendix I. This quite selected bibliography is a cross-section of references from each index consulted to give a "feel" of the literature.) As the titles indicate most of the entries treat the relationship between technology and society in the broadest of terms. Covering a full range from textbooks approving of technological development to books that are avowedly "anti-technologist," the general orientation of these works is at the quite macro-level of analysis, e.g., the impact of the television, technology and values. Unfortunately, these efforts lack conceptual clarity and thus do little to help us understand the specific problems of doing TA.

There are virtually no entries in the subject index under any combination or use of the terms technology and organization.

It was clear from the outset that assistance might be found in the technical-engineering literature, as well as that in the social sciences. I relied on two widely used indices of periodical literature: The Applied Science and Technology Index (ASTI) and The Social Science Citation Index (SSCI). ASTI provided me with a guide to what the "technicians" are writing about on the subject of TA, while the SSCI was an entry into the social science literature.

ASTI was reviewed for 1976 to 1980 on the basis of the following key terms: Organizations, Social Change, Technological Change, Technology, Technology: social aspects, and Technology Assessment. (See Appendix II for sample titles.) Several observations are in order: (1) In general, the articles deal with the necessity of adapting to technological change but offer few guidelines to evaluate this change. This is especially true of the more narrowly focused journals. (2) What articles do address the methods of TA do so from a descriptive standpoint. They recount the application of existing TA methods, i.e., cost-benefit analysis, time-stream analysis, or environmental impact statement, to specific technologies. There is usually no discussion of the criterion used to determine which information and data is utilized. (3) There is widespread agreement that TA must adopt a more "holistic" approach. TA, it is argued, is a unique, cross-disciplinary undertaking, and as such must be examined on a case by case basis. One of the most striking features of this literature is how little agreement there is about what "technology" is, (i.e., the phenomenon being assessed), or about what procedures and information should be used to assess it.

The SSCI revealed similar problems. The key terms are: Technology Assessment, Technological Change, Technological Evaluation, Technological Forecasting, Technological Impact, Technology and Organizations, and Technology and Society. (See Appendix III.) Articles from this literature provide information describing the application of TA to specific cases, the influence of technology on organizational structure and design, the epistemological issues of TA, historical views of technological change, and so on. From our view, there is little that adds conceptual specificity to the repeated argument, documented time and again, that, yes, it is very important to evaluate technology and its impact on society. How one would frame the analytical problem or hit on the parameters of these evaluations is very much an open question.

Even from a short and "forced" review of the literature potentially of use for refining the bases of technology, it is obvious that there is a variety of disparate perspectives being employed. It is also obvious that "TA" has become a pretty popular sport with what seems to be a great many players in a game in which the definition of technology is unclear and the "tools" of TA are only vaguely understood. After spending considerable effort trying to organize this material to inform the perspective taken in this paper, I have failed to find within the literature itself even one principle that provides a basis for ordering the literature or bringing coherence to it.

In this respect, I hope I have not sounded an unwarranted warning. But this literature in its present state poses obvious problems for the individual who hopes to make sense of it, especially in terms of actually improving the substantive quality of specific technology assessment projects.

Conclusion

In this paper I have tried to provide the concept--Technology-as-organization--that could be the basis for drawing together the various threads of technology assessment as an exercise in analysis, as well as a means of sorting through the utility of various policy options available to Congress or to the Executive agencies. At this time, the practice of technology assessment is unbalanced with more care and weight (and resulting cogency) put on the explication of policy issues in terms that Congress can deal with than on thoughtful work to improve your understanding of the phenomenon that is being assessed. And within this latter emphasis another imbalance is evident. There is a dependence on techniques of data analysis or arrangement with less concern for the quality and cogency of the data so analyzed. It is to the matter of improved understanding and meaning of data that this essay is addressed.

The brief report about probing the literature that seems logically to be the basis for technology assessment suggests indirectly a new departure for OTA. In the past, it is my understanding that OTA has not seen it possible or perhaps necessary to encourage basic research in the problems of technology and social change, nor has it been particularly concerned about improving the data gathering methodology associated with the information upon which analyses are done. That is, the time pressures have been such that these concerns have seemed to be luxuries in the face of strong demands for production as-soon-as-possible. This paper challenges this apportioning of effort and concern, and if it is taken seriously should prompt a two step response. First, a rigorous examination would be mounted to see if my impressions are correct; that OTA staff and TA practitioners generally have a varied and often undisciplined conception of the phenomenon involved. And second, if this turns out to be the case, the OTA would institute an effort to review and improve the conceptual and, in the social science sense, the methodological skills and rigor applied to future OTA projects. This could require OTA to devote some resources to work not in direct support of particular projects sought by members of Congress. And it may result in what seems to be limited progress in the near future. These efforts may be difficult to sustain, but I believe they will be required if the cogency of future assessments are to be improved.

I take it that the fact of the Task Force signals a similar concern within OTA as well. I hope this paper will forward that intention.

Notes

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2. Ibid. p. 3f, and M. R. Berg, J. L. Brudney, et al., Factors Affecting Utilization of Technological Assessment Studies in Policy-Making, (Univ. of Michigan, Institute for Social Research, Ann Arbor, Michigan, 1978.)

3. See J. K. Fiebleman, "Pure Science, Applied Science, Technology, Engineering: An Attempt at Definitions," Technology and Culture, 2 (Fall, 1961), 305-317, and C. Mitcham and R. Mackey, eds., Philosophy and Technology (New York: Free Press, 1972); C. Susskind, Understanding Technology (Baltimore, Md: John Hopkins Univ. Press, 1973); and N. B. Hannay and R. McGinn, "The Anatomy of Modern Technology: Prolegomenon to an Improved Public Policy for the Social Management of Technology," Daedalus, 109 (Winter 1980), 25-54.

4. For a cogent discussion of the quite different implications of these two types of physical objects for political and social criticisms see D. P. Billington, "Structures and Machines" The Two Faces of Technology," Soundings: An Interdisciplinary Journal, (Fall, 1974), 275-288.

5. T. R. LaPorte, "Beyond Machines and Structures: Bases for the Political Criticism of Technology," Ibid., 289-304.

6. For exaples of other work with similar concerns see L. Marx, "Technology and the Study of Man," in W. R. Niblett, ed., The Sciences, the Humanities and the Technological Threat, (London, U.K.: London Univ. Press, 1974); and L. Winner, Autonomous Technology: Technics-out-of-control as a Theme in Political Thought, (Cambridge, MA.: MIT Press, 1977.) See also Hannay, op. cit., (This issue is devoted to the theme - Modern Technology: Problem of Opportunity?)

7. Early work at the Tavistock Institute in England has drawn some attention to this way of exploring technology-society relationships though it has not gained much adnerance in the U.S. See, for example, F. E. Emery and E. L. Trist, "Socio-technical System," in Management Sciences Models and Techniques, Vol. 2, (New York: Pergamon Press, 1960); K. DeGreene, Social-technical Systems, Factors in Analysis, Design and Management (Englewood, Cliffs, N.J.: Prentice Hall, 1974.)

8. For an attempt to use an earlier version of the notions developed above and in this section as a basis for field research see T. R. La Porte, et al, Interactions of Technology and Society: Impacts of Improved Airtransportation - A Study of Airports at the Grass Roots (Berkeley, CA., Institute of Governmental Studies, Univ. of California for Ames Research Center, Dec. 1974); Issues as NASA Contractor Report CR-2871, Washington, D.C., July 1977. See also a quite recent development from a Soviet Scholar, G. M. Dobrov, "Technology as a Form of Organization," International Social Science Journal, 13 (April 1979), 585-605.

9. I am grateful to John Andelin for this felicitous phrase.

10. In this regard see T. R. La Porte, "In Search of Nearly-Free Management: Lessons from U.S. Air Traffic Control for the Future of Nuclear Energy," Paper presented, Woodrow Wilson International Center for Scholars, Washington, D.C., 14 November 1980.

11. Ibid., T. R. La Porte, "On the Design and Management of Nearly Error-Free Organizational Control Systems," in D. Sills, et al, eds., The Accident at Three Mile Island: The Human Dimensions (Boulder, CO.: Westview Press, 1981); and T. R. La Porte, "Nuclear Wastes and the Rigors of Nearly Error-Free Operations: Problem for Social Analysis," Society/Transactions, (forthcoming).

12. For an extended discussion of these effects see T. R. La Porte, "Nuclear Wastes: Increasing Scale and Sociopolitical Impacts," Science 191 (July 7, 1978), 22-29, and La Porte, "On the Design of Control Systems," Ibid.

13. In subsequent versions of this essay, much more could be done to explicate the patterns of social, economic and political conflict and their dynamics apparently associated with developments that unbalance the social accomodations among groups in communities and regions hard won during periods of relative stability. More work should be done to refine what is generally known about such dynamics in terms of particular types of social properties. In the absence of this systematic work, OTA and other T.A. practioners are forced usually quite intuitively and implicitly to estimate the sorts of causal relationships involved. A practice which inenivitably leads to significant error and often to political conflict as well.

14. For a more extended discussions of these conditions and a report of field work done involving nuclear power plant development and airtransport affects see, T. R. La Porte, Exploring the Impact of Large Scale Advanced Technologies: A Report Upon Returning from the Field, Report to Ames Research Center, NASA, (Institute of Governmental Studies, Univ. of California, Berkeley, CA., June 1977.)

15. A direct test of this hypothesis in the area of air transportation can be found in J. D. Starling, et al, Technology and Politics: The Regional Airport Experience. Report to Ames Research Center, NASA, Center of Urban Studies, Southern Methodist Univ., May 1976.)

16. Assessment of Alternative Energy Technologies: An Institutional Assessment. NSF Grant PRA-80-14195. Institute of Governmental Studies, University of California, Berkeley, CA.

17. Analysis based on data in A. Ghovanlou, L. Ettinger, et al, Analysis of Nuclear Waste Disposal and Strategies for Facilities Deployment. April 1980, ch. 6.

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(See page 77 for an explanation.)

Appendix I

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