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AN OTA HANDBOOK

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A HANDBOOK FOR OTA STAFFERS

PREFACE

This handbook is intended chiefly for those who are new to OTA -- as staff members, consultants, contractors, and members of advisory groups. It will help you more easily understand the Office, its work, and your role within it. The handbook will also be a source and compendium of useful information and advice for those who have already served their apprenticeship at OTA. It is designed as a looseleaf notebook so that you can add to it: amendments and comments on the information it contains, notes about lessons learned as you work through projects and problems, reminders about modifications of procedures and practices, or brief descpritions of techniques which have proved useful to you and others.

Most of the material in this handbook comes from the hard-earned experience of old hands at OTA. It was gathered through the efforts of the Task Force on TA Methodology and Management, which was appointed by Director John Gibbons. The Task Force met throughout 1980 to make recommendations to the Director about ways to improve, strenghten, and refine the work process and the productivity of the staff. OTA managers, professional staff, and support staff freely and enthusiastically shared their own observations and experience (and their honest and perceptive criticisms) about how things work at OTA.

This handbook briefly describes OTA, its sole client -- the Congress, and that complex and confusing thing called technology assessment. In considerably more detail it describes the flow of an OTA study from the earliest stages of planning through assignment of responsibilities to the celebration of the final report. A methodological section describes some analytical approaches and techniques which can be useful in assessments and policy analyses. Several sets of questions, checklists, and evaluation protocols suggest ways of critiquing assessments -- or better yet, of planning a project so that superior quality is built into it. Other sections of the handbook describe technology assessment and science/technology policy analysis in Executive Agencies and in other countries around the world.

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1. THE OFFICE OF TECHNOLOGY ASSESSMENT

OTA is a "think tank" established by and for the Congress of the United States. It gives Congress an independent source of information and analysis about science, technology, and related public policy issues.

OTA is one of only four agencies created by the Congress for its own analytical support. When it was established in 1972, it was the first such agency since 1921, when the General Accounting Office was established. The Congressional Budget Office began three years later. The earliest Congressional support agency was the Library of Congress, although its Congressional Research Service was organized much later. Congress has resisted the development of "bureaucracies" in the legislative branch of government except where it perceives an imperative and lasting need for assistance.

OTA is a small agency, with a staff of about 130 and a budget of under $10 million. It produces studies and analyses, generally at the request of Congressional committees, on a wide range of substantive areas. In all of these areas, science and technology promise both substantial benefits, and sweeping change which may bring with it social stress, environmental problems, and conflicts of interests or values.

The Technology Assessment Act of 1972 says that OTA shall "...provide early indications of the probable beneficial and adverse impacts of the applications of technology and...develop other coordinate information which may assist the Congress." OTA does this through multidisciplinary studies carried out by its own professional staff and a variety of consultants, contractors, and advisory panels. The advisory panels, a distinctive characteristic of OTA, are made up of carefully selected scientists, other experts, civic leaders, and representatives of actively concerned publics and other interest groups. They make substantive contributions to the studies and, more importantly, assure its balance, objectivity, and broad outlook.

To be useful to Congress, OTA studies must be focused squarely on current, emerging, and potential public policy issues. At the same time, they must be scrupulously non-partisan and non-ideological. The unique value of OTA to congress is that it can

-- reach outside of government to capture information from a rich variety of sources, institutions, and individual experts, and

-- present this information without advocacy or bias, in a form which is useable by and useable to the educated layman, who is a busy, harried lawmaker.

1.1 The Origin of OTA

In the 1950's and early 1960's, a series of disasters and public alarms shook the faith of Americans in the unmitigated benefits of technological progress. The killer smog in Donora, Pennsylvania, occurred in 1948. It was followed by the cranberry bog scare, the Thalidimide disaster, and at least a hundred other "technological shocks"* in which the by-products of industrial production or the side-effects of consumer products themselves had unforeseen and undesirable consequences threatening to public health. Air and water pollution became serious public concerns. The highway and airport development programs beginning about 1958 disrupted stable urban communities and brought unacceptable noise and pollution into middle class, affluent suburbs. Urban development improved central city districts, but often at the cost of pushing the poor or minorities out of the only neighborhoods available to them.

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* As chronicalled by Edward Lawless in Technological Shock, Rutgers University Press, 1977.

At times, Congressional Members who had always sought public projects for their districts, found constituents up-in-arms about the undesirable social and environmental consequences of such projects. Both established and ad hoc public interest groups were becoming more activist, and more politically effective; they were no longer the radical fringe but included the middle class, middle age, middle income core of the Congressional constituents.

Legislators came to suspect that Executive agencies, defending their programs and their budget requests, did not always tell Congress the whole story about the potential outcomes of federal projects. For eight years between 1947 and 1961, the Executive and Legislative branches were controlled by different parties; but the tension between the branches generally had more to do with the Constitutional separation of powers than with party differences.

In 1966, Representative Emilio Daddario was chairing an R&D-related subcommittee of the House Science and Astronautics Committee.* He proposed that Congress create an Office of Technology Assessment to give it "early warning" of the potential consequences of new technology and of large-scale federal projects. This idea had jelled in Mr. Daddario's mind during long discussions with his friend, Charles Lindburgh, an ardent conservationist. The bill was introduced in 1966, not so much in the expectation of early passage as to stimulate public discussion and begin to build Congressional understanding of the possibilities of such an innovation in the legislative process.

Daddario's subcommittee took the unusual step of commissioning papers by the National Academies of Sciences, Engineering, and Public Administration. They approved the concept and the conceptual approaches which they developed for anticipating the impacts of

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* Now the House Science and Technology Committee

technology strongly converged. Their papers were quickly supplemented by a large number of articles and professional papers from university interdisciplinary research centers and other research organizations. The National Science Foundation initiated a technology assessment program in 1970.* Well before the Daddario proposal resulted in a Congressional Office of Technology Assessment, there was an active and growing community of people with a professional interest and stake in technology assessment.

The Technology Assessment Act which was finally passed in 1972 differed from the proposal six years earlier, chiefly in making the new OTA more completely a creature of the Congress. Its governing board was made up entirely of Representatives and Senators. The Technology Assessment Board as originally proposed would have had many of its members appointed by the President. The basic structure of the Office is described below.

1.2 The Structure of OTA

The Office of Technology Assessment was funded in 1973 and began operations in 1974. Its governing Technology Assessment Board (TAB) is made up of six Senators and six Representatives, three of each from each party. While there are several permanent Joint Committees which serve both Houses, TAB is unique in giving parity not only to the Houses of Congress but to the parties. The Chairmanship of TAB alternates between the Houses, and the Vice-Chairman is selected from the other House and also from the other party. Thus, when the Chairman is a House Democrat, the Vice Chairman will be a Republican Senator.

The Board selects the Director of OTA, for a term of six years. There have, however, been three Directors, since neither of the first two served for a full term.

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* Described in Section 8 below.

The Technology Assessment Act also created a Technology Assessment Advisory Council, to advise the Board and the Director. The heads of two of OTA's sister congressional support agencies, the Comptroller-General of the U.S. (GAO) and the Director of the Congressional Research Service, are ex-officio members of TAB. (The Congressional Budget Office was created after the Act was passed.) The Director of OTA is a non-voting member of the Board. The other ten members are persons distinguished in scientific or educational fields or in industry, appointed by the Members of TAB.

The present internal structure of OTA -- divisions and programs -- has evolved since 1974 as the professional staff and the volume of work expanded. Projects fell into related clusters or were a logical outgrowth of earlier projects, and centers of strong staff capability and experience naturally developed. This gave rise to the Programs, which have changed in scope, title, and number from time to time. The three Assistant Directorships were created in 1978; before that, OTA had one Deputy Director.

Several important characteristics of OTA have also evolved out of the experience and lessons learned in the past eight and a half years. OTA was meant to be primarily a research contracting and management organization, with most of the work being carried out under competitive contracts. In the first two years and in the course of several large assessment projects, this proved to be an unsatisfactory model. There were no research contractors with experience in working for Congress. This work must be strongly policy focused and also finely tuned to the powers and the customary procedures of Congressional activities. There is now a strong concensus within OTA that only basic information-gathering and highly specialized methodological procedures or technical analysis is usually done in house.

The staff has gradually come to be made up mostly of generalists with long and varied experience in a broad substantive area, rather than highly specialized technical people or research scientists. This also reflects lessons from experience. Policy analysis is an art rather than a formal discipline, and a skill which not all scientists have.

Finally, the emphasis placed on outreach to both non-governmental experts and to especially concerned publics and interest groups has also developed gradually. This is now recognized as being particularly valuable to Congress. It provides a way of integrating the many conflicting viewpoints, judgements, claims, and assertions with which Members are continually assailed as they deal with issues related to science and technology.

1.3 Divisions and Programs

OTA's internal organization changes from time to time as a series of projects is completed, as congressional interest in a substantive area becomes less active, or as other areas become important in current legislative affairs. The present arrangement of divisions and programs is shown below and in Exhibit 1.1.

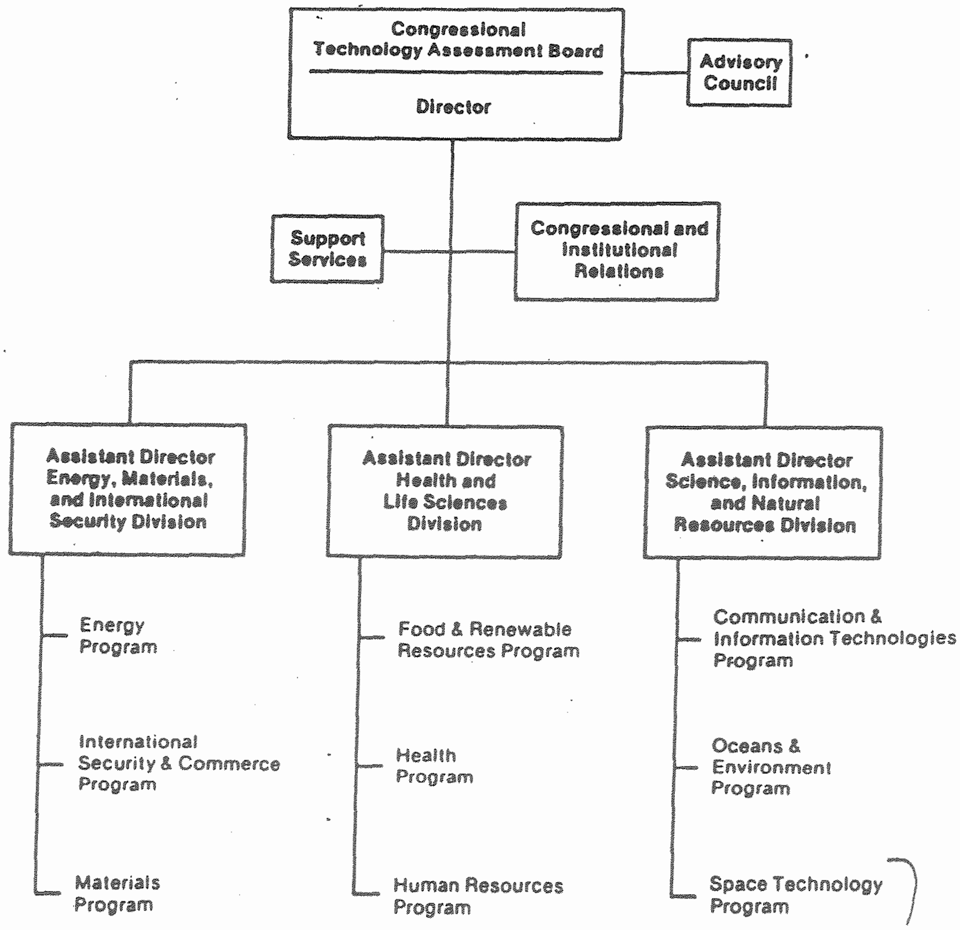
Energy, Materials, and International Security Division

The Energy Program is one of the largest and oldest programs. Energy issues have had much congressional and public attention for nearly a decade. The energy program has done assessments of almost every major category of energy source and technology from solar to nuclear power.

The Materials Program is also a long-standing program, which has done many studies of non-renewable resource issues and policies and of the metal industry technologies.

International Security and Commerce is a recent amalgram of several small programs. They studied technologies important to national security (nuclear weapons, MX missile bases) and issues related to the competitiveness of American industry in international trade.

OTA Organization Chart



Health and Life Sciences Division

The Food and Renewable Resources Program is concerned with agricultural technologies and food processing, distribution, and regulation. Studies have included several evaluations of federal research policies related to nutrition and food production.

The Health Program has done case studies of new medical technology in relation to cost-containment policies, and developed methodologies for evaluating medical technology and environmental risks to health.

The Human Resources Program was organized to pick up studies begun by an earlier Exploratory and Planning Group. It has studied population issues and genetic or bioengineering technology.

Science, Information, and Natural Resources Division

The Communication and Information Technologies Program does assessments in the burgeoning area of computers, telecommunications, and information systems. It is beginning an assessment of applications of these technologies in manufacturing -- i.e., factory automation and robotics.

The Oceans and Environment Program carried out some of the earliest large OTA projects. It has continued to perform assessments of technologies for exploiting renewable and non-renewable resources of the oceans and ocean margins.

The Space Technology and Transportation Program is a combination of two earlier programs. Transportation, one of OTA's early programs, produced assessments of the automobile, railroad safety practices and other railroad technology, mass transit technologies, and air transport technologies.

Other Activities

From time to time, exploratory and planning groups have been established within OTA to do preliminary studies or background analyses to establish the feasibility or scope of a larger assessment.

On occasion, these efforts have resulted in published papers or specialized reports -- e.g., papers on U.S. disaster assistance to developing countries, hazards management, and demographic trends.

OTA's annual reports are a rich source of information about recently completed and on-going assessments and about program activities. The Technology Assessment Board has held several Hearings which contain in the proceedings accounts of TA activities in industry, academic programs, and other agencies.

1.4 Operations Division

The Operations Division provides the necessary administrative and support services for all programs. It includes:

- Administrative Services, which takes care of contracts, legal services, management and financial information, and EDP services.
- Personnel Office, which takes care of the full range of personnel management from recruitment to benefits, and arranges for staff training, counseling, etc.
- Public Communications Office, which handles contacts with the news media, arranges press briefings, and takes care of public inquiries and public relations.
- Publishing Office, which produces and distributes OTA reports and provides editing and graphs services.
- The Information Center, which is described in more detail below.

The Information Center combines all conventional library services with modern information retrieval systems. Besides OTA's own reference collection, journals, books, and documents, the information specialists draw on the Library of Congress and can fill information requests from a variety of other government and non-government sources. Requests can be submitted in person, by phone, or by interoffice mail.

The Information Center also has an AudioVisual Center with television, video recorders, slide projectors, and audio tape equipment.

It arranges weekly Brown Bag Seminars with invited speakers, and puts out a biweekly newsletter, Focus. (All staff members are urged to suggest potential speakers for the seminars, and to submit items for Focus.)

2. THE CONGRESS -- OTA's ONLY CLIENT

OTA works only for the Congress; specifically, for congressional committees. This fact determines much about the structure of OTA, how it does its work, and the way it defines technology assessment.

Educated Americans assume as a matter of course that they understand what Congress is, what it does, and how it does it. But it is commonly observed within OTA that new staffers often need to relearn a great deal about the Congress. New OTA analysts who have previously worked for or in Executive agencies sometimes need to be reminded that the Congress is different from - as well as separate from - the other branch of the government.

This section highlights some important characteristics of the Congress and its Members that affect the need of Congress for policy analysis and the kind of policy analysis that is useful to them.

2.1 The Nature of Congress

(a) Congress is collegial, its members are equals. The Executive branch is a pyramid, a hierarchy, a bureaucracy. It is organized along principles of authority, specialization, and expertise to reflect the policies and pursue the priorities of the President. But in the Congress, Members derive their powers from the people, and all are equal. Members are not specialists or experts but representatives of the public. At the same time, scientists and policy analysts sometimes need to be reminded that a Member with long experience on his/her committee may know far more about the practicalities of the subject than any scientist, theoretician, or technician.

(b) The Congress is different from other national legislatures. It is not a parliament. It is constitutionally and in reality separate from the Executive branch and there is always a tension between the two even if both are controlled by the same party -- a tension which does not exist in parliamentary systems. It is this tension which caused Congress to want its own independent source of information and advice about scientific and technological issues rather that relying on

Executive agencies. Hence the establishment of OTA. Unlike other national legislatures, party discipline is seldom the only or even the most important factor in a Member's decisions and actions.

(c) The Congress has four major functions: to legislate, to raise revenue and authorise expenditures for the government, to oversee government programs, and to formulate policy. Members individually have a fifth role to which they give much (some say most) or their attention: acting as ombudsman and advocate within the government for their constituents.

OTA's major responsibility is to help the Congress with the first and fourth of these functions, legislation and policy. But OTA is often called on, formally and informally, to contribute to budget-related and oversight activities. Through its reports and its advisory panels and public participation activities, OTA also contributes to the fifth, constituency representation role.

(d) The real work of Congress is done in committees and subcommittees. It is through the committees and their staffs that OTA responds to congressional needs and contributes to the work of Congress. Because the committees are continuing work units, OTA assistance has a continuity which to some extent transcends the two year and six year election cycles and the one year budget cycle.

Committee staffs, however, usually change drastically if not completely when there is a change in the party holding the majority. This underlines and reinforces the need for OTA and its staff to be scrupulously non-partisan and to serve the Congress as a whole.

(e) The Congress works through negotiation, compromise, and coalition. Real decisions are made not through the yea and nay votes on the floor of Congress but through give and take, trading off, finding a middle way. An objective or priority determined by an Executive Agency gives little attention to competing objectives outside its jurisdiction or to the effect on other national needs and priorities. But Congressional policies are formulated in the context of broad national objectives and the need to maintain a shifting but stable balance between the diverse interests and values in a pluralistic society. The result is that Congressional decisions usually are made in a suboptimizing, satisficing mode. It is important for analysts to remember always that what often looks accidental, politically self-serving, inefficient, and contradictory is often, although not always, purposeful and judicious.

(f) <u>Congressmen individually and collectively respond to many constituencies at the same time</u>. Local districts for House Members and States for Senators are the primary constituencies. Whether the area is urban and industrialized or rural agricultural, these constituencies have diverse, cross-cutting interests. Most members have particular special interest constituencies to whose needs they are especially attentive; these may be related to their geographical constituencies or to their committee assignments. Then there are committments to the party and the party leadership, and finally the Member's own philosophical/ideological/political stance on broad national issues. Members work hard on, and become highly knowledgable about, the subject matter of their primary committee assignments. On many other issues they tend to follow the lead of trusted fellow Members belonging to the committee following that issue. However, support for and use of OTA projects is seldom limited to one committee and its members.

(g) <u>Workstyles in the House and Senate are different</u>. The House Members, because they represent local areas and must stand for reelection every two years, tend to specialize in narrower, more specific, and often regional areas of interest. There are more House committees and sub-committees with more specific jurisdictions. Committee work is the primary focus of the Member's activity outside of constituency service. For these reasons and because there are 476 Members, they get little attention individually from the national media and are seldom "stars". Senators, being fewer and elected from much larger areas, with six year terms, get more attention from the national media. They are watched closely because the Senate is the likely source of future Presidential candidates. Senators tend to identify themselves with broader national (and international) issues and concerns. There are fewer committees, with broader and more overlapping jurisdictions. Committee work is not quite the dominant activity for Senators that it is for House Members. A Senator's office staff is more likely to include "professionals" with advanced training in scientific/technical disciplines than are House office staffs.

(h) Neither House Members or Senators are likely to be highly educated in science and technology. While both groups are increasingly likely to be college graduates and to have higher professional training, and while their occupational backgroud is probably much more diverse that in the past (when most national legislators were either farmers or lawyers) there are still relatively few who have more scientific background than the average educated layman.

Yet increasingly Congress must deal with complex issues of science and technology. In fact, few issues of public policy concern do not have some scientitic/technical aspects.

(i) Members have multiple - and often conflicting - sources of information. On any issue Members are likely to get information, advice, and demands from

- their own constituents, through letters, phone calls and visits,
- public interest group activists, both those based in their home districts and national or regional groups,
- special interest groups and paid lobbyists, who are likely to visit them personally, invite them to lunch or arrange trips, etc
- family and personal friends, and
- the media.

They also may request (or get without requesting) technical information from

- Executive agencies,
- their own office staff (usually not professional analysts),
- their committee's staff (usually professionals, but generalists),
- Scientists invited to appear at Congressional Hearings,
- National Commissions or special task forces,
- Congressional support agencies: GAO, CRS, CBD, OTA

All of those in the first list are apt to be advocates for one or the other viewpoint on the issue. Executive agencies are concerned with justifying projects and programs and in reflecting Presidertial policy. The Member's problem is usually not a lack of information but a welter of information that is inconsistent, contradictory, partial and selective. Members (and their staff) have neither the training nor the time to sort, verify, absorb, and interpret this information nor indeed to think deeply about its implications for public policy. This is the reason for Congressional support agencies -- and with particular regard to science and technology, for a support agency which can go beyond library research to original research and analysis.

(j) Congress needs both immediate and long term information and advice. When Congressional committees are actively considering an issue, that is, framing and marking up lehislation, they need immediate information. In this case OTA assistance must usually be based on studies which have already been completed or are well undersay, and is often extended on an informal basis - conferring with committee staff, preparing material for hearings, etc. Congressional attention is of course driven toward the short term by the yearly budget cycle and the two year election cycle. However few issues reach the stage of Congressional action without long inculcation. National issues have usually been discussed by expecially concerned groups, been subjected to controversy and agitation, debated in the media, etc., for years before legislation is contemplated. Many issues grow out of long standing government research and development programs. Presidents or presidential candidates begin to build support and constituencies for emerging policies long before legislative proposals or budgetary items are transmitted to Congress. Thus Congressional interest is not or need not be nearly so foreshortened as it is sometimes perceived.

The creation of OTA om ;973 was moreover explicitly framed to provide an additional early warning system to alert Congress to the need for information, analysis, and advice well before its immediate need arose.

(k) Congress is jealous of its prerogatives as the Constitutionally annointed body representing all of the people in its plurality, diversity, and multiplicity of interests and values. It is the people, not the experts, who are the ultimate decisionmakers; and it is the Congress, not scientists, who translate information into policy. OTA's mandate is thus to lay out options, not recommendations; and to expand rather than limit the options which Congress can choose.

2.2 Talking to Congress

Congress is OTA's only client, and a major channel of communication between them is the staff of Congressional committees. The committee staff people are of necessity caught up in matters of immediate concern to the members of the Committee. They have little time to explore emerging issues and anticipate research needs for next year. Although the committee staff sometimes takes the initiative in opening discussions about potential studies, it is also necessary for OTA people to look ahead for them, suggest the kinds of analysis they will need to have on hand when issues reach the point where committee action is feasible or necessary, and begin to cultivate active interest in and support for a request from the committee to OTA.

This is a necessary and vital activity, which benefits both Congress and its committees, and OTA, But it must be done with judgement and discretion. A too enthusiastic "hard sell" can appear pushy and aggressive, and cause resentment. Far worse is that you may promise what cannot be delivered. There is always considerable uncertainty about OTA's final budget or how far it may have to stretch. It is important to avoid forcing the Director to say no to a project which you have implicitly promised will be done.

Helping a committee, through its staff, conceptualize its future needs and generate a long term agenda is only one important reason to talk frequently with committee people. It is also important o maintain communication

- o throughout a project, to stay aware of changing issues and changing Congressional needs,
- o when a study is in the home stretch, to build interest in the final results,
- o to present the draft report, to be sure that it is fully understood, and to encourage its use by the committee,
- o to follow up the study, helping the committee to apply your findings, and assisting them with Hearings or other follow-up activities.

It is certainly easier to build and maintain good relationships with some committees than with others. Some of OTA's program areas are of interest to a number of committees and yet may seldom have critical, key issues of immediate and focused legislative attention. Other program areas have a plethora of requests for short-term, focused, and often very narrow studies but have trouble persuading the relevant committees to think in terms of longer-range, more comprehensive issues. Patience and persistence in cultivating the committee staff can however help them develop a broader appreciation of the value of OTA's work to Congress.

It is particularly important to initiate discussions with committees after an election, when there may be new Members and new staff people who are not familiar with OTA's work. This is even more important, of course, if there has been a change in the party holding the majority role.

While the object is to build a continuing professional relationship and mutual respect between OTA staff and committee staff, it is also necessary to aviod the appearance of being "captured" by some members of the staff, and above all to avoid any hint of being partisan. The recognition that OTA is thoroughly and consistently nonpartisan is one of the Office's proudest achievements.

OTA works directly with the Congress in many ways other than staff discussions. For example, in 1980

- o OTA analysts prepared or presented testimony for 17 Congressional Hearings,
- o the Director met with 34 Members and Committee Staff Directors,
- o OTA prepared written responses to 63 inquiries from Members,
- o OTA analysts made more than 150 presentations or briefings for 33 committees and subcommittees.

2.3 OTA's Sister Congressional Support Agencies

In nearly two hundred years the Congress has established for itself only four support agencies: the Library of Congress and its specialized Congressional Research Service (CRS); the General Accounting Office (GAO); OTA; and the Congressional Budget Office (CBO). In theory at least the four organizations have quite different functions, and Congress has directed, through legislation, that they assist each other without duplication of activities, but inevitably some overlap has developed among their activities.

The General Accounting Office was established in 1921, but many of its functions go back to the Treasury Act of 1789. The GAO's basic mission is to make sure that public monies are spent as Congress intended, and are used efficiently, effectively, and with full accountability to Congress and the public. It is the nation's bookkeeper, auditor, and -- to some extent -- inspector heneral. Since much of the budget today is directly related to science and technology, GAO has increasingly come to have a voice in science policy issues. It has developed a policy analysis capability that is a long way from its old image of green eyeshades, quill pens, and long rows of neatly added figures. The several dozen

Reports of the Comptroller-General to the Congress which are issued each year are often right on the mark of technoloy-related issues being analyzed by OTA. Their emphasis however is more narrowly focused on whether specific government programs and actions related to the technology (or area of scientific R&D) are effectively carrying out the will of the Congress as expressed in legislation and annual budgets.

GAO's broad responsibilities are:

1) legal, accounting, auditing, and claims settlement services for Congress;
2) assisting the Congress in carrying out its legislative and oversight functions; and
3) making recommendations to the Congress related to more efficient and effective government operations.

Accounting and auditing responsibilities extend to all departments and agencies of the Federal government including OTA. GAO makes the final determination of the legality of all Federal actions with regard to the accountability of expenditure of public funds.

The other two categories of responsibility more directly involve GAO in substantive matters and issues also of concern to OTA. GAO helps both committees and individual Members, by request, in gathering information and analyzing issues, drafting legilsation, and reviewing Federal agency programs. Congressional committees have several times asked OTA also to undertake special reviews of Executive agency programs which are critical to Federal Science policy initiatives; for example, a review of ERDA's initial research plans in 1975 and again in 1976, review of EPA's research plans in 1976; and critique of DOE's solar and conservation programs in 1980.

The Comptroller-General, who serves a 15 year term as head of GAO, is an ex-officio member of OTA's governing Board, and OTA's legislative charter directs GAO to provide OTA with financial and administrative services and "all of the services and assistance" which GAO is authorized to perform for the Congress.

The Congressional Research Service is a department of the Library of Congress, which was established in 1800 for "service to the Congress." The Library's first responsibility is still to the Congress, but because its range of service has steadily been broadened and extended to the entire government establishment and to the public at large, CRS was organized to work exclusively for the Congress.

CRS analysts respond to requests for information and analysis from committees or from individual members. Their responses - about 300,000 per year - range from briefs requiring a few hours or a few days work by one analyst to occasional multiperson, many-month long efforts. Many of these reports involve science and technology, especially those from the Science Policy Division and the Environmental and Natural Resources Policy Division. When OTA was established it was assumed that there would be a more clearcut difference between the work of CRS, as "library" research, and that of OTA, then envisioned primarily as a contractor/manager of research. As more and more of OTA's work is done in-house, while CRS has tended toward more multi-disciplinary and broader scale efforts, the distinction has become less obvious, at least to some Congressmen, who have several times suggested combining the two organizations. However OTA, through its consultants and advisory groups, continues to provide Congress with a broad outreach to non-governmental scientists and experts, and to concerned publics and "affected parties", which CRS does not provide. CRS continues to concentrate on highly skilled, broadly informed, and issue-sensitive but objective compilation of existing information from published sources.

The divisions of CRS illustrate the breadth of topics on which it provided information to Congress:

- American Law
- Economics
- Environment and Natural Resources Policy
- Government
- Science Policy
- Education and Public Welfare
- Foreign Affairs and National Defense
- Futures Research

CRS maintains a roster of several hundred "issue briefs" which periodically updated -- topics might include, for example, trucking deregulation, V/STOL aviation development, the 200 mile fishing limit, or the financial crisis at Chrysler. There are also weekly (or even more frequent) seminars on current issues. Some issue briefs are available cn audio casettes that can be heard, for example, while you are driving to work.

The head of CRS is also an ex officio member of the Technology Assessment Board, and CRS is directed by law to provide for OTA all of the services and assistance which it provides for the Congress. The Library of Congress itself is of course an inexhaustable resource of information and search services for OTA; staff members should consult OTA's Information Specialists as to how they can most efficiently use these resources.

The Congressional Budget Office was established under the 1974 Budget and Impoundment Act, which reformed and revised the yearly budget cycle. CBO is intended to help Congress gain control of allocations and authorizations and anticipate their impact on the public debt and the national economy. It provides the Congress with basic budget data and analyses of alternative fiscal, budgetary, and programmatic policies. Specifically CBO is responsible for:

- economic forecasting and fiscal policy analysis,
- score-keeping, or monitoring of Congressional actions in terms of the targets set for expenditures and outlays in broad functional areas,
- five-year projections of the costs involved in proposed bills and continuing government programs and commitments,
- an annual budget report and special studies requested by Congress.

CBO's work also has a bearing on science policy issues, since it provi-es Congress with detailed analysis of the costs and overall economic effects of scientific initiatives and technological projects.

2.4 More About Congress: Some Recommended Readings.

Effective policy analysis for Congress requires that the analyst understand how Congress works, how Congressmen and congressional staff perceive their needs, and how information and analysis can be most usefully presented to them. A few readings which may be particularly helpful are listed below. (Lengthy excerpts from these readings were compiled for OTA staff in a reader which is available in the Information Center.)

Nelson W. Polsby, "Strengthening Congress in National Policy-Making," from The Yale Review.

Abraham Holtzman, Legislative Liaison : Executive Leadership in Congress, American Politics Research Series, Chicago, Rand McNally & Co.

Franklin P. Hiddle, "Political Suboptimization and the Legislative Model," prepared for a Dartmouth/OECD Seminar on Social Research and Public Policies, Sept. 13-15, 1974.

"How a Bill Becomes Law," from the World Book Encyclopedia.

Walter J. Oleszek, "House-Senate Relationships: Comity and Conflict," Annals of the American Academy.

Carl McGowan, "Congress and the Courts," American Bar Association Journal.

Charles O. Jones, "Why Congress Can't Do Policy Analysis (Or Words To That Effect), "Policy Analysis.

Michael J. Malbin, "Congressional Committee Staffs: who's in charge here?", The Public Interest.

Michael Andrew Scully, "Reflections of a Senate Aide", The Public Interest.

Mark J. Green, et al, Who Runs Congress?, A Ralph Nader Congress Project, New York, Bantam/Grossman Books.

"Congressional Support Agencies: What They Can and Cannot Do", Staff/4.

Clement Bezold, "Congress and the Future," The Futurist, June 1975.

3. WHAT IS TECHNOLOGY ASSESSMENT?

Technology assessment is policy analysis. Policy analysis is intended to assist and improve the making of public policy by

- o exploring and clarifying public policy issues,
- o broadening and strengthening the information base for policy making,
- o helping decisionmakers to identify and understand the full range of options available to them,
- o helping decisionmakers invent new strategies for resolving issues or solving problems,
- o helping decisionmakers think through the possible effects of their choice among available options.

Technology assessment is that part of the spectrum of policy analysis that deals with issues related to

- o science and technology
- o their effects on society and its institutions and processes, and
- o their effects on people.

Technology assessment is concerned with the benefits of science and technology and the opportunities they offer for solving national problems or achieving national objectives. It is also concerned with problems that may arise from science and technology. Because it is policy analysis, technology assessment is particularly concerned with conflicts of interests and values, and with questions of equity. Finally, because the United States is a pluralistic democracy with a mixed economy and a government of limited, delegated powers, technology assessment is concerned with the economic, political, and social feasibility of public policies that attempt to deal with scientific and technological issues.

4. THE ASSESSMENT PROCESS AT OTA

4.1 Introduction

The OTA assessment process has a number of built in conflicts. There is never a single right way to resolve such conflicts. Carrying out a high-quality and useful assessment can be understood in part as dealing creatively with the tension between conflicting goals. Examples of such tensions include:

- the need to approach problems with an innovative, responsive, flexible assessment process, balanced against the need for an accountable, documented, credible, and replicable process;
- the mandate to assess technologies, which requires understanding the technology in depth, balanced against the Congressional requirements for assessments whose relevance to current problems and policy issues is clear;
- the desire to produce an assessment which covers all the major aspects of its subject in depth, with all the key findings checked and documented (which many Advisory Panels will urge), balanced against the desire to get the assessment out quickly (which every requesting Committee will urge);
- the need to strike an appropriate balance between full-scale assessment lasting a year or more (which in effect build OTA's intellectual capital) and short-term responses to Congressional needs (which in effect make use of the capital).

4.2 Selecting the Subjects of Assessments

The first step in carrying out a technology assessment is deciding on the technology to be assessed, or otherwise defining the problem to be studied. There is a set of formal procedures for initiating a study, but these procedures do not really describe the process by which a decision is made.

4.2.1 The Formal Process of Initiation

The Technology Assessment Act says: "Assessment activities undertaken by the Office may be initiated upon the request of (1) the chairman of any standing, special, or select committee of either House or of a joint committee, acting for himself, or at the request of the ranking minority member, or of a majority of the committee members; (2) the Board, or (3) the Director, in consultation with the Board." (S.3(d))

Most studies have been initiated by committee requests. The formal mechanism is a letter or letters from committee chairmen to the Director. But this is the last step -- not the first step -- in the process.

Formal letters of request are nearly always preceded by long discussions between congressmen or committee staff and OTA staff as to what needs to be done. Even so, not all requests can be honored. The Board and the Director make the final decision.

TAB has itself initiated studies, especially in the early years when it was necessary to build a constituency of congressional users by demonstrating the value of OTA assessments. Self-initiated studies, the third mechanism authorized by the Act, has been a sensitive subject, and is discussed below as "priority setting."

As to the kind of studies which should be requested, the Act says:

> The basic function of the office shall be to provide early indications of the probable beneficial and adverse impacts of the applications of technology and to develop other coordinating information which may assist the Congress. (S.2)

4.2.1.1 The special case of mandated studies. A fourth means of initiating assessments was invented by the Congress after the Technology Assessment Act was passed. On several occasions Congress has passed legislation which required that a particular study be performed by OTA. For example, the Federal Railroad Safety Authorization Act of 1976 (P.L. 94-348) provided for an OTA assessment of the effectiveness of earlier railroad safety legislation. Such legislative provisions provide welcome evidence of the value which Congress places on OTA assessments. But they cause serious problems for the office since they do not automatically provide funds. Money has to come either from OTA funds already budgeted for other studies, or from special appropriations which sometimes arrive after the day by which the law says the study should be delivered.

4.2.2 The Continuing Dialogue

As already noted, formal requests for assessments usually result from an understanding between the committee and OTA staff members. The original idea for the study indeed may well have come from OTA. As OTA staff members become immersed in their program areas, as they monitor scientific and technical developments through the literature and through continuing contact with experts outside of government, and as they closely observe Congressional activities and interests, they develop a broad perspective on their subject. Often they have a keen sense of where unsolved problems and unresolved issues are hidden. At times they are able to foresee Congressional needs earlier than can the Congressmen themselves, or the committee staff, who are necessarily more tightly focused on immediate problems of formulating legislation, negotiating budget allocations, or staying abreast of Executive agency programs. At a minimum, OTA people are able to help legislators and their aides to translate concerns into questions amenable to research and analysis.

The legislative history preceding the Technology Assessment Act makes it clear that OTA is to give Congress early warning of issues emerging from science and technology. The Act itself says, " . . . it is essential that, to the fullest extent possible, the consequences of technological applications be anticipated, understood, and considered in determination of public policy on existing and emerging national problems." (S.2.)

4.2.2.1 A continuing dialogue between OTA and Congressional committees aimed at stimulating requests for OTA assessments is clearly one way of fulfilling this function of early warning and calling attention to emerging national problems. It is not a sub rosa marketing activity but a necessary and valuable service to the Congress.

The most successful and productive OTA programs do maintain close contact with several committees and talk frequently with the staffs about the progress of current assessments and an agenda for further assessments. When a committee is preparing to request an OTA assessment, it is also useful for OTA people to identify other committees and Congressmen with overlapping and related needs, and to talk with them. This can broaden Congressional interest in the study, stimulate supporting requests, and in some cases, broaden the scope of the proposed study or reorient it to meet a wider range of Congressional needs.

But it is important that false expectations not be raised which would lead to disgruntlement if a committee request cannot be honored. Policy as to who talks to Congressional staff and who should be informed about such discussions differs from Division to Division. Check with your Program Manager.

4.2.2.2 Problems and Comments. There is, and there has always been, tension between the obligation to carry out broad, anticipatory assessments which fulfil the objectives of the Technology Assessment Act, and the obligation to be fully responsive to Congressional needs as perceived by Congressmen. Often committees want narrowly defined technical advice or a quick-and-dirty answer to an immediate problem. Or they have phrased a problem in a way which seems to the OTA staff to be scientifically inaccurate, shortsighted, or not amenable to analysis. Frequently, patient explanation and discussion will lead to a compromise. "It is hard to find Congressional staff willing to talk about next year's problem," an OTA program manager says. Another insists, "For OTA to be important, it must work on longer term projects, with broader scope, but Congressional staff has little interest in them." Another problem, program managers point out, is that they often have too little knowledge of how many assessments, of what size, they will be able to undertake under the next year's budget.

The following section suggests ways of thinking about what assessments should be done. The best way to help Congress formulate better assessment requests is to have an agenda which anticipates Congressiona needs with a set of thoughtfully structured, persuasively formulated study topics. These can be presented to those struggling to conceptualize and state their concerns.

4.2.2.3 Generating a Program Agenda. OTA program groups nearly always have an agenda for future research, or a wish list, although it may not be written out or even explicitly formulated. They report that the items on their future agenda usually come from several sources:

- issues and problems which are suggested by on-going assessments -- the natural next step;
- papers heard or discussions held at professional association meetings;
- scanning professional journals;
- discussions with Advisory Panels or with scientists outside of government;
- questions arising with regard to Executive agency programs or actions; and
- talking to Congressional aides.

Often a program (or personal) assessment wish list is a record of frustration -- some interesting, and quite possibly highly needed, assessments will never be done. "It is harder to do selection adequately in the face of project pressures and board ideas regarding appropriate projects," says one program manager who longs for a more rationally selected menu of projects and more control over their selection.

Exhibit 4.1 shows two sets of questions, or criteria, which can be useful in selecting (or comparing) assessment topics. The first, which appears in OTA's Annual Report, emphasizes the intrinsic value

EXHIBIT 4.1

QUESTIONS TO HELP IN SELECTING OR COMPARING SUBJECTS FOR ASSESSMENT

- Is this now or likely to become a major national issue?
- Can OTA make a unique contribution, or could the requested activity be done effectively by the requesting committee or another agency of Congress?
- How significant are the costs and benefits to society of the various policy options involved, and how will they be distributed among various impacted groups?
- Is the technological impact irreversible?
- How imminent is the impact?
- Is there sufficient available knowledge to assess the technology and its consequences?
- Is the assessment of manageable scope—can it be bounded within reasonable limits?
- What will be the cost of the assessment?
- How much time will be required to do the assessment?
- What is the likelihood of congressional action in response to this assessment?
- Would this assessment compliment or detract from other OTA projects?

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o Can OTA contribute significantly to the decisions to be made by Congress?

o Can the assessment be done within reasonable time and cost?*

o Is it worth doing, from the standpoint of OTA? the Program? yourself?

o Will it enhance our (your) ability to do other work in the future?

o Is the timing right?

o Would the project size be right, in relation to the Program's other work and other priorities?

* Keep in mind that a project budget below some level (possibly $200,000) may not justify the fixed costs of any assessment -- e.g., a project manager).

of the assessment; the second, contributed by a program manager, complements the first list by emphasizing the implications for the OTA program. A longer list of questions, which can be used for the same purpose, appears below, under "priority setting."

4.2.3 OTA Priority Setting

Even though the Technology Assessment Act says that the Director, in consultation with the Board, can initiate assessments, no effort was made to exercise this authority until 1978. By then, OTA had developed the competence, the track record, and the internal confidence to assure the Director and the staff that they could increase the value of OTA to Congress by moving toward a more active role. They could alert Congress to broad, long-term, and more comprehensive issues which often cut across the jurisdictions of committees. Director Russell Peterson initiated a priority-setting effort within OTA.

The priority-setting exercise is described in detail in OTA's Annual Report for 1978, Section IV. It was open and broadly participatory. All groups within OTA from senior professional staff to support staff participated. Thousands of organizations and individuals, within government and the private sector, were actively solicited for suggestions of critical technological issues and problems. Nearly 2300 topics were suggested. These were winnowed, sorted, combined, evaluated, and ranked through a multi-step process, using criteria developed by OTA Senior Staff and shown in Exhibit 4.2. A working list of fifty high-priority topics was produced (see Exhibit 4.3) and 32 of these items were selected as OTA's 1978 priority list. In the fall of 1978, the Board approved seven of these topics as OTA assessments (Items 1, 4, 7, 8, 22, 27, and 28). A revised list of 30 items was then selected as a priority list for future assessments.

The final list contained a large number of items which originated with OTA programs, a number of items which were proposed both internally and by external contributors, and some items which were wholly outside suggestions. Thus the process demonstrated that (a) OTA analysts have a good grasp of what is important, (b) their evaluation coincides with that of a highly informed and concerned public, but (c) outreach can nevertheless identify critical issues which may have been missed or undervalued by OTA staff.

The original list of 50 and a long list of 286 items, together with the evaluation criteria, is still useful in beginning to build a research agenda. The techniques used in the mammouth outreach program, which contacted 5,000 individuals and scores of institutions and organizations, would also be useful in some forms of public participation efforts. The process is described in detail in project notebooks available in the Information Center.

Priority setting at OTA is currently done informally, by program groups. Many program managers believe that systematic process should be resumed. Some say that as many as 40% of the projects should be selected in this way.

EXHIBIT 4.2

CRITERIA FOR JUDGING SUGGESTED PRIORITY ITEMS

Organizational:

1. Can OTA make a unique contribution?
2. Does the project have an early warning or impacts analysis component?
3. Is it doable?
4. How much time will it take to do?
5. Is the project manageable and capable of being bounded?
6. Will an analysis or knowledge on the subject make a difference?
7. Is OTA qualified to address this issue?

Client-Related:

8. What is the likelihood of congressional use?
9. Is it policy relevant?
10. How important is the item to national priorities and needs?
11. Can this topic or a series of studies on it yield information for Congress?
12. Can a study be completed in time to influence key decisions?
13. Is the item focused on development of policy rather than program evaluation or implementation?
14. Is the subject an appropriate one for Government consideration?
15. Is this now or likely to become a major national issue?

Topical:

16. Is this a systems problem with links to other systems?
17. Will this be a significant issue or opportunity in the future (10 to 30 years)?
18. Does this item represent a major new national opportunity?
19. Will it affect the societal infrastructure to a great extent?
20. Will a study help structure national debate?
21. What will be the impacts on human needs?
22. What will be the effect on the quality of life?
23. What is the national importance of this item?
24. How many people are likely to be affected?
25. What is the intensity, dimension, and duration of the potential impacts?

EXHIBIT 4.3

PRELIMINARY WORKING LIST, AUGUST 1978

1. Alternative National Energy Futures
2. Alternative Global Food Futures
3. Alternative National Water Futures
4. Impacts of Genetic Engineering
5. Impacts of Food on Health
6. The Potential of Preventive Medicine
7. Technological Innovation (The Federal Role: Regulations, Patents, and Basic Research)
8. Impact of New Telecommunications Technology (Microprocessing, The Information Society)
9. Impact of Technology on World Population
10. Deterioration of Life-Support Systems (The Carrying Capacity)
11. Peace Technology (Satellite Surveillance, Economic Conversion)
12. Impact of Technology on Weather and Climate
13. U.S. Vulnerability to Imports of Materials
14. Impact of Wastes on Marine Resources
15. R&D Priorities for U.S. Food Production (Nitrogen Fixation, Photosynthetic Efficiency, Genetics)
16. Potential for Food from the Ocean
17. Impact of Technology on Employment (Automation, New Businesses, Job Satisfaction)
18. Technology and Inflation
19. Technology and Education (Telecommunications, Scientific Illiteracy)
20. Application of Information Technology to Health Care
21. Allocating the Electromagnetic Spectrum Globally
22. Potential for Advanced Air Transport
23. Implications of High-Speed Ground Transport Technologies
24. Telecommunications and the Automobile
25. Energy Technology and the Environment
26. Designing for Conservation of Materials
27. Furthering the Efficacy/Cost Ratio in Health Care
28. Impact of Technology on National Defense (Risk of Nuclear Warfare and Terrorism, U.S. vs U.S.S.R. Capabilities, Command and Control Utility of Surface Naval Vessels)
29. Potential for a Totally Replenishable Energy System
30. Technology and the Developing World (Meeting Basic Human Needs—Food, Health, Water Education)
31. Effect of Technology on Small Business
32. Technology and Mental Health
33. The Future of Wood
34. Ratio of Civilian to Military Technology vs. Economic Prosperity (West Germany, Japan U.S.S.R.)
35. Technology and Decentralization (Risks of Centralization)
36. Impact of Technology on Risks to Humankind
37. Impact of Technology on Gross National Product and on the Quality of Life (Social Indicators)
38. Role of Technology in Meeting Housing Needs
39. Potential of Ocean Minerals
40. Impact of the Breeder Reactor
41. Space Utilization
42. Potential for Controlled Nuclear Fusion
43. Impact of Non-Ionizing Radiation
44. Chemotherapy and Vaccines for Infectious Diseases
45. Prospects for Increased Longevity
46. Technology of Prophylactic Dentistry
47. Prescription Drug Use
48. More Efficient Energy Utilization
49. Electric Utilities and Solar Energy
50. Technology and Antarctica

The Final 1979 Priorities List

The OTA priority list for 1979 is as follows:

1. Impact of Technology on National Water Supply and Demand.
2. Alternative Global Food Futures.
3. Health Promotion and Disease Prevention Technologies.
4. Technology and World Population.
5. Impact of Technology on Productivity of the Land.
6. Impact of Technology on Productivity, Inflation, and Employment.
7. Technology and the Developing World—Meeting Basic Human Needs.
8. Peace Technology.
9. Impact of Microprocessing on Society.
10. Applications of Technology in Space.
11. Designing for Conservation of Materials.
12. Future of Military Equipment.
13. Impact of Technology on the Movement of Goods.
14. Weather and Climate Technology.
15. Allocating the Electromagnetic Spectrum Globally.
16. Implications of Increased Longevity.
17. Controlled Thermonuclear Fusion.
18. Technology and Mental Health.
19. Technology and Education.
20. Prescription Drug Use.
21. Forest Resource Technologies.
22. Health Technologies and Third-World Diseases.
23. Electric Vehicles: Applications and Impacts.
24. R&D Priorities for U.S. Food Production.
25. Alternative Materials Technologies.
26. Deep Ocean Minerals Development.
27. Energy Efficiency in Industry.
28. Role of Technology in Meeting Housing Needs.
29. Ocean Waste Disposal.
30. Technology and the Handicapped.

4.3 Pre-Proposal Planning

Letters of request for assessments from committees do not automatically initiate a study; there must be approval from the Director and, on the basis of a proposal, from the Board. The planning which goes into the preparation of a proposal is an important step, which can prevent problems during the later phases of a study, as well as increasing the probability that the study will be approved and funded.

4.3.1 The Formal Proposal Process

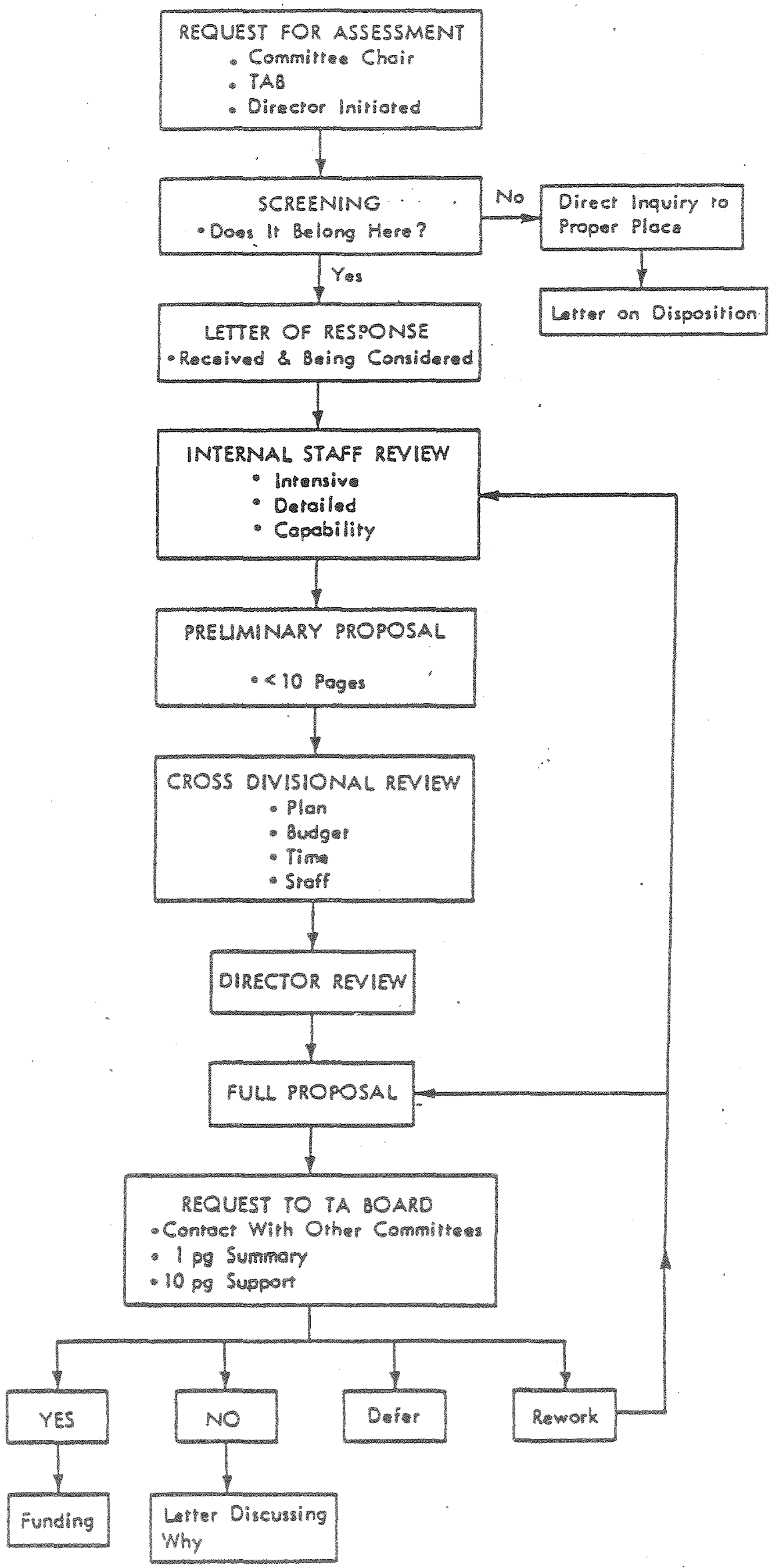
The formal procedures for initiating a study are shown in Exhibit 4.4. As with most formal procedures, this does not accurately picture what happens within an OTA program. The last few pages described what can take place before the official request for assessment is received. The next few pages will describe what takes place between the receipt of the request for assessment and the writing of the full proposal.

4.3.2 Six Guidelines

Here are some questions which should be thought through during the screening and the internal review before a proposal is written.

(1) Is the topic best stated as (a) a technology-driven impact assessment? or (b) a problem-driven issue analysis? (Read Sec. 5 on Conceptual Frameworks.) Most assessment topics could be stated in either form, but depending on the topic one form may be more easily comprehensible and more immediately persuasive than another. A technology driven impact assessment is best if the topic concerns an emerging technology, little known and little understood today, but having the potential of significant impact on the economy, employment, balance of trade, consumer prices, the environment,

EXHIBIT 4.4


REQUEST FOR ASSESSMENT
• Committee Chair
• TAB
• Director Initiated
SCREENING
• Does It Belong Here?
No
Direct Inquiry to Proper Place
Letter on Disposition
Yes
LETTER OF RESPONSE
• Received & Being Considered
INTERNAL STAFF REVIEW
• Intensive
• Detailed
• Capability
PRELIMINARY PROPOSAL
• < 10 Pages
CROSS DIVISIONAL REVIEW
• Plan
• Budget
• Time
• Staff
DIRECTOR REVIEW
FULL PROPOSAL
REQUEST TO TA BOARD
• Contact With Other Committees
• 1 pg Summary
• 10 pg Support
YES
NO
Defer
Rework
Funding
Letter Discussing Why

regulatory processes, or other societal institutions and processes. In this case, the policy issues and political controversies which will develop around the technology may be only conjectural, dimly understood, and hardly articulated as yet. A major objective of the assessment will be to identify and explicate these issues on the basis of a discussion of the technology, its potential impacts, and the groups who will be significantly affected.

If the topic is already controversial (a matter of public argument and articles in the popular press, and a subject on which special interest groups or even public interest groups have adopted positions) then it should perhaps be presented in the form of an issue-analysis. Here the objective is to probe questions on which there is contradictory evidence from the experts, identify and define conflicts of interest as precisely as possible, make explicit the points at which further information is needed and the points at which some compromise between competing interests/values must be arranged, and lay out a broad set of political options and alternative strategies for Congressional choice.

At the pre-proposal planning stage, the objective in answering this first question is to make a linkage between scientific/technological uncertainties which need to be studied, societal concerns which should be defined, and decisions which will eventually have to be made in Congress. The task at this stage, then, is to define the topic in such a way that it can be attacked through research and analysis, while preserving the option of restating the problem when more information has been gathered.

(2) Why should the Federal government be involved in this technological development or societal problem? Since we have a constitutional government of limited, delegated responsibilities and powers, the burden of proof is on the analyst to demonstrate why the topic may, should, or will become a subject of concern at the Federal level for the Congress. The expenditure of public, Congressional, and OTA resources on this assessment must be justified.

Ask the following questions:

- o Have public resources been invested in this technology? Will such an investment be proposed? Are other public resource investments threatened or compromised by the problem to be addressed?
- o Are there potential public benefits from this technology (or from the solution to this problem) which can only be captured by policy interventions at the Federal level?
- o Are there potential social costs involved in this technology (or associated with this problem) which can only be avoided, reduced, or compensated by Federal policy intervention?
- o Are there potential inequities in the distribution of benefits and costs which may require Federal policy intervention?

The answers to all of these questions, at this stage, must be uncertain, but thinking through the questions will give a feel for the scope of assessment and will help in formulating a creditable research proposal.

(3) Who are the potential users of the assessment, and how should it be structured to meet their needs? How narrowly or how broadly should the research question be framed? Make the critical linkage between the topic and the perceived needs of the Congress.

Explore and dissect the problem from the standpoint of the separate and overlapping responsibilities and jurisdictions of Congressional committees. A block of information may meet a number of separate needs. A gap in information may frustrate the efforts of a number of committees to resolve quite different issues. A comprehensive assessment can serve a variety of decision-makers.

Experienced OTA program managers identify several factors which tend to broaden the scope of an assessment:

-- Multiple expressions of interest or letters of request from committees, which can be combined to support one assessment proposal;

-- A very complex set of potential impacts and policy issues;

-- A technology at an early stage of development, of which the eventual design and configuration is still uncertain, or

-- A cluster of alternative, competing, or complementary technologies which cannot be clearly distinguished or compared at this stage of development;

-- potentially large differences in impacts across geographical regions;

-- a complementary relationship of this topic to other on-going OTA assessments or to several program areas?

-- sharply different disciplinary perspectives on the topic.

Factors which tend to narrow the definition of an assessment topic are:

-- the immediacy of Congressional needs for information;

-- constraints on time, budget, and available expertise;

-- the lack of sources of data to address broader questions.

(4) What time-horizon should be used for the study? Is it aimed at short-term (1-4 years) policy consideration only, or is it intended for longer range, strategic planning? Some questions here are:

- o Is the technology at an early stage, so that the potential issues and impacts will not be important for some years?
- o Will decisions made now foreclose options and block alternatives for many years? Or will the decisions be incremental and reversible?
- o Are there impending events or developing trends that will increase or decrease the urgency of the topic? How far ahead?
- o Is the technology (or problem area) highly interrelated with other technological developments or other problems in ways that will either create or block options with regard to other problems? When are these leverage points likely to occur?

- o How long would it take to create regulatory mechanisms or control technology to deal with any problems? A long time? Or can the problems be handled by existing mechanisms?
- o Are the potential effects of the technology (either beneficial or detrimental) likely to be immediate and highly visible? Or subtle, incremental, and cumulative?

The trade-offs in choosing a time-horizon for an assessment are obvious and important. Technical, economic, and social forecasts are more difficult and less credible for the long range, and long-range studies are less likely to have an impact on decision-making. But studies which look only to the present and immediate future may completely miss critical costs and benefits which come about only over long periods of time, but which may be irreversible and disastrous.

Judgments about the appropriate time horizon for an assessment must be made at an early stage of planning, because they will help determine the scope and structure of the study. But these judgments are subject to change as information is gathered and analysis proceeds.

(5) How long will it take to do the study? This depends in large part on the complexity of the subject, but there are other factors to consider. How much data must be gathered? Is it easily available? Will there be questionnaires, surveys, or delphis which depend on mail returns? Must contracts be let? Are there models to be constructed, or special techniques to be developed? Will it be necessary to spend time on background papers, technical memoranda, or interim reports? Must workshops be held? Is the staff available, or must some of them be phased in as they finish other work? Will there be new hires, or internal consultants to be brought in?

These things require time. But the two most important factors probably are: (a) how much learning time will be required before the group can really do productive research? or is everyone already familiar with the topic or problem? and (b) will the staff on this project be full-time, or part-time?

Most experienced OTA staff believe that the minimum time for a useful assessment is between six and eighteen months. All agree that the length of time required for assessments has been frequently (some say, consistently) underestimated at the planning stage. This causes problems not only within OTA but with the requesting committees.

(6) What level of effort is necessary? How much will it cost? The answer depends on many separate judgments about duration of the study, disciplines required, and the necessity of consultants or contractors. "It is much easier to fit a project into a budget," says one program manager, "than to estimate a budget to fit a project plan." A realistic budget projection, however, is a far better way to assure the quality of the research and prevent management headaches.

Is there a minimum level of effort for this assessment, or can it be tailored to fit almost any necessary budget limit?

Some OTA managers maintain that nearly every study could be usefully done at almost any level of effort, down to "one person with a telephone and library card for three months." Others say that there is some level of effort below which nothing useful can be done, because of the fixed costs of research. (One suggests that this level is probably around $200,000, because below this amount a full-time project manager could probably not be justified -- see Section 4.6.)

The answer probably depends on whether the topic is new and largely unexplored, or a well-recognized, highly controversial problem. In the first case, an exploratory, broad-brush effort even at a very low level of effort might be very valuable. It could pull together and integrate what is known, flag the major uncertainties and gaps in knowledge, and identify significant potential impacts and conflicts of interest. In the second case, it might take a great deal more time and effort to add anything of significance to the discussion, or to compare and reconcile many bodies of conflicting evidence.

4.3.3 Helps in planning

Four steps are necessary to pre-proposal planning:

(1) Review the most important and most recent literature;

(2) Find the knowledgeable people within OTA and discuss the subject thoroughly with them, pencil in hand;

(3) Telephone experts inside and outside of government (ask them about critical impacts and issues, and what the most important unanswered questions may be);

(4) Brainstorm with the program's Advisory Group, if there is one.

4.4 The Proposal to the Director and to the Board

A preliminary proposal is written and then reviewed across divisional lines.

The Director reviews and approves it. A full proposal is prepared and sent to the Technology Assessment Board for review and approval. The Board has a number of options: to fund, to not fund, to defer approval and funding of the activity, or to suggest that it be reworked.

4.4.1 Writing the Proposal

If the pre-proposal planning had been well done, preparing the proposal involves only a cogent, clear, and logical statement of what needs to be done, for whom, how it will be accomplished, and what resources will be used.

There is no set length for proposals. Perhaps 15-30 pages is about right if it is tightly written. It should include:

- A clear statement of the topic, problem, or research hypothesis.

  Be neither cryptic nor long-winded. Summarize the case for doing the assessment in a few sentences.

- The potential users and uses of the assessment result.

  The requesting committee or committees, if any, are most important, but other users -- especially in the public interest and industry sectors -- should also be mentioned.

- Further justification for the assessment.

  Points summarized in the initial statement of the topic may be expanded and discussed. For example, indicate the range of potential important impacts, both beneficial and detrimental; the most critical policy issues which may arise; specific decisions which Congress may have to make; evidence of public interest in the topic; the relationship to other national problems or priorities; and the relationship to other OTA projects and programs. Emphasize the link to specific Congressional interests and responsibilities.
- Brief description of the planned approach or study structure.

  Detailed discussion of methodology is not necessary, but mention should be made of major sources of information and plans for an advisory panel, for public participation, and/or for contractors.
- The resources required for the study, including:
  - funding: a tentative budget
  - duration
  - staff, with allocation of time
  - new staff requirements
  - contracting requirements

4.4.2 Suggestions for improving the proposal

- In laying out the research proposal, use a conceptual framework to give order and clarity to the work plan. Make visible the nature of the outcome and the logical steps toward reaching it.
- Use the proposal preparation phase as the first iteration of your study (See Section 5). Work through the topic, outlining what you know, identifying what you need to know, and indicating what you expect to find. Abstract this material for the proposal. Use it again in the more detailed study planning which is the next step.

- o As you develop the proposal, discuss it with the requesting committee staff, with colleagues in other OTA programs, with members of the program advisory panel, and others.
- o Ask some OTA colleagues to sit as an ad hoc advisory panel or a surrogate TAB, for a dry run at presenting the proposal.

4.5 <u>Selecting and Using an Advisory Panel</u>

The systematic use of advisory panels and groups at both program and project levels is an outstanding characteristic of the OTA style. Most of the programs have one or more standing advisory panels. But a specially selected panel is usually needed for all but very small projects.

Advisory panels serve several different functions:

- o They contribute substantively to the quality of a project by providing a source of outside review and criticism calling attention to deficiencies, gaps, and biases.
- o They help by contributing data, or by opening access to new sources of data.
- o They provide a broad range of viewpoints, interests, and values. They protect the project and the project manager against either the reality or the appearance of being captured by one set of interests.
- o They act as a surrogate for "the public" and speak for the public interest. Individually they help to legitimate the study to a wide range of potential audiences and users.
- o Because they represent important constituent groups, they can help bring the study to the attention of congressmen.
- o They help in disseminating the study results.

4.5.1 Selecting a panel

Selecting panel members is important and it is time consuming. It can take up to two months. This is one reason that it should be done in the pre-proposal planning stage. Invitations should not be issued until after the project is approved, but expressions of willingness to serve can be informally sought. Keep these suggestions vague and tentative however; you do not want to be locked in if the project changes in scope and scale during planning, or if you just think better of the choice.

How many members? Most program/project managers recommend nine to twelve. Most agree that "too many" is somewhere between 15-20. If a dozen cannot provide the diversity you need, consider two smaller panels if the topic can be logically divided in some way.

The Chairman is especially important. He or she should be skilled in getting other people to work together and should thoroughly understand:

- o the role and functions of advisory panels,
- o OTA's mission,
- o what is useful to Congress, and
- o the technology or problem to be studied.

Of these, the last is least important. A widely recognized expert will confer credibility and prestige on the study and will help persuade other top-level people to serve on the panel. But it is more important that the Chairman be able to guide or control the panel so that it is productive and useful, and not overbearing or obstructionist. Panel chairmen, especially those with great prestige, have been known to try to push a project manager aside and run the project.

The Chairman may be able to help persuade other desirable members to serve on the panel. But the project manager and team should select the panel members, so have the selection made before you approach a chairman.

Who should be selected for an advisory panel? Consider the functions which the panel should serve. Seek a balance:

- o between experts in the technology or problem, experts in impact assessment and policy analysis, and representatives of potentially affected groups and stakeholders;

- among competing interest groups (including general interest groups);
- by geographical representation, especially if impacts and issues may differ significantly across regions.

It is desirable to have one or two people with widely recognized reputations as an expert or as a public spirited citizen, but only if they will not dominate the panel or intimidate others by their reputation or their manner. Include representatives of minority groups, but try to choose those who fill other roles as well. Be especially sure that the panel is not made up solely of male WASPS. Diversity, balance, critical judgment, expertise, and the ability to work together are the five criteria for developing a panel.

Generally speaking, avoid lobbyists, public relations people, and those who are known as fervent single-issue advocates.

How to find them. First make a detailed list of the kinds of people you need. Then collect names from your own knowledge, from the literature, from colleagues, from the program advisory panel, from experts from whom you are in contact. Call those people -- but not with an invitation to serve. Explain what you are doing: the study and the role of the advisory panel. Ask them to suggest people. Mention that they have themselves been suggested. But emphasize that you are still exploring possibilities and final selection will be made to get a careful balance of categories. Ask whether there is any impediment to their serving. As they suggest people, inquire about each person's ability to work collegially and cooperatively.

What you are looking for is convergence. If many of the people you contact suggest the same person, that becomes a strong indicator. Then make up a balanced list with a second choice for each position.

Invite your preferred chairman first, and check out the other names with him or her. He or she should have a veto power (within limits). The others should be told who the chairman will be before they accept or decline. If you have selected a good chairman, that can be a strong inducement to some of the others.

Convey your invitations by telephone followed up by a letter. Be sure that you explain fully what will be expected, in terms of the time they should expect to give, compensation or lack of it, other administrative details, and most importantly, the role of the panel. Stress that it is advisory, and will not have a controlling voice in decisions. The most common problem with advisory panels is that a strong panel sometimes tries to run the project. After all, some of these people are very much accustomed to authority.

4.5.2 Using the Panel

<u>Orientation.</u> The first meeting of the panel will be largely spent in educating them. You (the staff) and they must get to know each other, and the panel members themselves must get acquainted. Be sure that they understand the role of OTA and how it relates to Congress and the committees. Introduce the study plan, especially its scope and boundaries. Run through what you already know, and lay out the assumptions with which you are working.

In this first meeting, it is often helpful to end with a small assignment or request for each panel member: contacts or data which they have volunteered to supply, a memorandum to you of their thoughts about some aspect of the work plan, a document or related research report which you do not have. Besides its substantive usefulness, this helps keep the panel involved during the first phase of the study, when you will probably have relatively little need for review and criticism. A phone call or two during this period to keep them informed and ask their advice will also help.

<u>What to expect.</u> According to project directors, you may as well expect that:

- o Panel members will be most helpful through review and criticism of working papers, background papers, and early drafts. They need something on paper to react to.
- o Some panel members will become very much involved with the project and be very helpful.

- o Some panel members will contribute useful comments and ideas at meetings but will never get around to reviewing papers and returning comments, in spite of good intentions.
- o Some will contribute nothing, period. See below.
- o A few may be prima donnas, become obstructionist, bad-mouth the project. It's a risk you cannot avoid.
- o Nearly all will take much longer than you expect to review papers. Leave plenty of time for review, but set your deadline earlier than it has to be, remind them by telephone 2-3 days before the deadline, and do not hesitate to nag frequently if the deadline passes by. Not only does the squeaky wheel get the grease, but the greaser feels important -- and also concludes that the squeaker is an important wheel.

<u>What to do when panel members do not contribute.</u> Project managers disagree on what to do when a panel member doesn't perform: doesn't come to meetings, or comes but never contributes ("There's always one whose only activity is to collect his per diem," was one comment). One or two program managers suggest that such people should just be quietly dropped -- not informed about meetings, and not sent drafts. (This can cause some hard feelings that may hurt the agency.) Others conclude philosophically that (a) the project may still benefit by having his/her name on the panel list, and (b) he or she may still help with dissemination and visibility for the final report by passing it on to interested people and organizations. Sometimes a few phone calls or letters ("We really miss your special expertise") will help.

4.5.3 After the Ball is Over

When it's all over, it would be helpful to others if you put into a memo some comments on your experience with this panel. This is especially important if you discovered a chairman or panel members who were outstandingly productive and might be appropriate either as members of some future panel or as consultants.

And of course, each panel member should get the kind of letter of thank-you and acknowledgment that he or she will be proud to show, copies of the report to pass out, and a request for names of others who should get a one-pager or summary of the report.

4.6 Post-proposal Planning: An Operational Work Plan

The pre-proposal planning and the writing of a proposal was the first step, not the last step, in planning. The next step should give you a day-to-day battle plan. Everything that went into the proposal should appear in your work plan/management plan, but now you know you will have to live with it. It must all be rethought and reworked. The constraints -- especially staff availability, budget limitations, and time -- are now known. The inevitable characteristic of all three is that they will prove more binding than you now foresee. Therefore always estimate generously what you will need to accomplish each step -- err by overestimation rather underestimation.

4.6.1 What a Work Plan Should Do

The substantive aspect of the project work plan is discussed in Section 5. Here we are concerned with management aspects, primarily with structuring and scheduling the work flow. The work plan should:

- o Break down the work into doable tasks or chunks, each of which has an expected outcome. That expectation should be summarized on paper so that everyone can refer back to it later.
- o Make explicit the relationship between the tasks, that is, chart the desired flow of information through the project. The tasks need not be, and probably should not be, successive steps or a chronological progression. There should usually be multiple feed-back loops and reiterations between tasks.

- o Make explicit the proportion of resources -- time, dollars, effort -- that should be allocated to each task. This has to be flexible, but every over-expenditure in accomplishing one task means that some other(s) will be stinted.
- o Set milestones and deadlines. (More discussion of scheduling follows.) This too must be flexible. It is often better to recognize a dead-end and start over early in the project, even if this means a serious delay for other tasks, than to find near the end that a major salvage operation is necessary. But a common mistake is to use far too much time at the beginning in exploring the technology and have far too little time later on for exploring impacts, issues, and policy options.
- o Assign responsibilities. Who is going to do what? Who else is going to be involved in it? Sometimes this is an easy task, when special expertise is needed. But most OTA staffers are or quickly become generalists -- or multi-specialists. This allows some redundancy in assignments and considerable flexibility. The complicating factor is that some people probably will not be assigned full-time on this project. It helps if they can lay out for you the schedule/deadlines/milestones on their other projects. Try to foresee the crunches.

  Most important is deciding <u>now</u> what will be done by contractors. Get them started as soon as possible. (See Section 4.8.)

4.6.2 About Scheduling

What follows is distilled from the experience (and scars) of old-hands at OTA. Consistently, they lament: we did not foresee how much time we would spend getting the final report right. We didn't expect that the review process would be so slow. We didn't anticipate we would have to go back and do X over again. We didn't know the contractor report would be almost worthless, and we would have to salvage that task.... Their recommendations converge:

- Recognize that an assessment project requires multiple iterations, at least three. Also recognize that you will find unexpected lines which must be explored. If you knew enough to do everything thoroughly in a once-through fashion, you wouldn't need to do the assessment. If you did the pre-proposal planning thoroughly, that and writing a proposal constitute one iteration -- but you probably still need three more.

- The following rough outline of what you should plan for assumes an 18-month project.

  The first six months. Prepare a work plan. Get all contractors underway, and so far as possible, get most of their work done in this period. Work through all of the tasks, preparing working papers wherever appropriate, for every task if possible.

  At the end of this six months, have a detailed working outline of the final report. If your work plan was a good one, there should be some correspondence between it and the report outline, and some of the working papers, at least, may be in effect first drafts of sections of the report. Your may want to revise the rest of the work plan here.

  Second six months. Work through each task again. But now your allocations of time and effort will be different. Write the first draft of the report as you go, planning to finish at about the fourth month (ten months into the project). Write a second draft in the next two months. Send this one off for review by the advisory panel.

  Third six months. This is for review (by your team, by program and other colleagues, by your advisory panel, by anyone else who may be helpful). In the meantime, you are revising, refining, and polishing, in effect conducting one last iteration of the project. Before the end of this period you should have a thoroughly reviewed, final draft undergoing final copy editing.

- In scheduling the work be sure that you have scheduled workshops and panel meetings where they can be most useful to the project: not before you have something for them to react to, not too late to respond to criticism.

4.6.3 When You Think the Work Plan is Completed

Have it reviewed by the advisory panel; talk it over with colleagues and staff of the requesting committee. A major factor in formulating a work plan that will really work, and one that is often overlooked, is this: give a lot of thought and attention to the assignment of support staff, and consult with these people before you finalize the work plan. See section 4.7.3.

4.7 Staffing the Project

4.7.1 The Project Manager

He or she is uniquely responsible for:

- o keeping the project on schedule and on budget,
- o overseeing contracts and contractors,
- o meeting internal reporting requirements,
- o answering inquiries from Congressmen and congressional committees, and others,
- o working with the advisory panel.
- o quality control over every step of the work,
- o directing the staff on a day-to-day basis,
- o and, of course, contributing substantively to the research and analysis.

Full-time? Or can a project manager manage several projects? Most of the OTA program managers feel strongly that a project manager should, if at all possible, be assigned full-time to the project. This is not always possible under present staff limitations, especially for small projects -- which is one reason that some program managers resist accepting very small projects. A few program managers argue that a good project manager can oversee several adequately staffed projects at the same time.

Must the project manager be an expert on the subject? That is not always possible. A few program managers argue that the project manager should always be an expert, in order to command the respect of the requesting committee, the advisory panel, and the outside specialists with whom he or she must work. At the least, the manager should know more about the subject (as a whole) than the other analysts on the project.

Other program managers argue that, given the management responsibilities listed above (which will consume much of the manager's time), it would be a gross waste of expertise to assign the specialist to manage the project. In addition, they point out, project management and team integration require skills the technical expert very likely does not have. Finally, and most importantly, the technical expert is likely to be just that, with little or no understanding of impact assessment and policy analysis. The technical expert tends to produce a technical report --which is usually not what is needed.

While there is still some disagreement on this point, after nine years of OTA experience the weight of opinion is in favor of the "generalist" side of the argument. In many cases, a technical expert would have to be brought in from outside, but experience through several OTA projects helps the director avoid common mistakes and pitfalls.

4.7.2 The Professional Staff

4.7.2.1 <u>Who do you need, and how many?</u> The two questions are closely related. The "how many," may be translated as: "fewer, full time?" or "a larger number, and therefore more disciplines or skills, but part time?" Sometimes, of course, this means: one person, full-time, or two, part-time. One program manager says, "A project should always have at least three people, with two of them full time. Otherwise, if one leaves, the project may lose all continuity." With part-time assignments, during the inevitable times when one project necessarily consumes all of a staff member's time, attention, and worry, his other project or projects will suffer. Not only will schedules slip, but the interruption will let ideas fade and information be forgotten.

These considerations must be balanced against others. One, two, or three people may not have all the disciplinary skills needed.

There are projects on which an engineer, sociologist, econometrician, legal analyst, marine biologist, or what-have-you may be essential. You may need them off and on throughout the project, but not 100 percent of their time. For specific tasks, outside consultants may serve the purpose. Another program group may have the specialist you need and it may be possible to borrow her for brief periods.

4.7.2.2 Where do you get the people who are right for the project? If they are already within the program, and available, your guardian angel has been on duty. If not, you must decide between:

- o finding someone in another program who is becoming available,
- o a new hire (if that is possible),
- o an internal consultant or contractor, for the duration of the project,
- o a detailee from another agency of the Federal government,
- o a Congressional Fellow.

4.7.2.3 What about project-duration personnel? Bringing in an analyst for the duration of the project for an even more limited time gives you a wide choice. There are several disadvantages, even if you have your eye on the right person and she can be persuaded to join up. A longer orientation may be necessary. The person may not fit well into the team effort. If the agreed-upon stay runs out before the project is finished, you may be in trouble. A program manager says, "There are problems in bringing people on for one assessment. They may work well if they see it as educational and a professional stepping stone, but they may also lack commitment and dedication... and they may be lured away too soon by that can't-be-missed opportunity."

4.7.2.4 How to go about hiring new staff. It is difficult to create a new position at OTA, since there is a tight ceiling on personnel. If the Program Manager is convinced that it is necessary, he or she initiates the request, which must be approved by the Assistant Director. A personnel officer in the Operations Division's Personnel Office will help you find a suitable person and guide you through the recruitment and appointment procedures, including determination of the appropriate salary. See the Operations Manual for details.

4.7.2.5 How to arrange an in-house consultant or contractor. Consultant appointments are most often used for members of TAAC, advisory panels, or advisory groups who are to give more extensive help with a project. The Program Manager will initiate a request, the Assistant Director must approve it, and it then goes to the Personnel Officer who handles the appointment. The daily consulting rate is a maximum of $200 per day, and consultants may not be used more than 260 days during the first year and 130 days for a second year.

Other individuals needed for specific tasks may be placed under contract. The Program Manager again initiates this arrangement with the approval of the Assistant Director, and it is handled by the Director of Contracts in the Administrative Services Office.

Neither consultants nor contractors are counted under the staff ceiling. It is usually up to the project manager and the program manager to find an appropriate person with the necessary skills but the Personnel Office can often help. See the Operations Manual for details on these procedures.

4.7.2.6 What about a detailee from an Executive agency? The OTA legislation says that OTA can request the head of an agency to detail personnel to assist OTA, with or without reimbursement. This arrangement depends, of course, first on an OTA project manager and program manager (with the help of OTA's Personnel Office if needed) being able to identify the right person in an agency; secondly, on that person being willing tc make the shift; third, on the agency head (or the person's superior) being agreeable; and fourth, on the Director approving the arrangement and signing the formal request -- a letter prepared by the Program Manager with adequate documentation about the potential detailee's qualifications. The Operations Manual has full details.

4.7.2.7 <u>The Congressional Fellows.</u> The OTA Congressional Fellowship Program was established in 1977. Fellows are selected through a nationwide competition and serve for one year in a specific program. Selections are made on the basis of interests and research competence and the overlap with OTA program and project interests. Congressional Fellows are often university professors, but may come from a wide range of occupations. In some situations a Fellow is a valuable addition to a project staff. There are several cautions: the selection process and the project staffing period may be so far out of synch that such assignments are not possible. If the project runs longer than a year, the Fellow may leave at a critical time. In spite of these limitations, the Fellows program is a valuable source of expertise.

4.7.2.8 <u>Other special needs.</u> When staffing a project, think ahead to see if there are special needs: an editor? a public participation specialist? a mathematical modeler? a survey questionnaire specialist? a statistician? In many cases there may be people within OTA, although in other program areas or directorates, who could fill these needs. In other cases an outside consultant or contractor will be needed. Start these arrangements early; don't wait until the need is immediate.

4.7.2.9 <u>Project communication.</u> Assessments must be interdisciplinary. That is not the same as multi-disciplinary (See Section 4). Policy analysis, although it should rest on a broad base of information, basically rests on understanding and judgement. It requires that insight as well as information from all sources and disciplines be integrated and synthesized. The project director is ultimately responsible for this synthesis, but he or she cannot produce it alone. It comes from the team.

This means that all team members must be aware of what is being done throughout the project. Regular, frequent staff meetings are necessary, but not enough. Continual discussion among the people working on the project is the essential activity. There are ways to encourage this: by the arrangement of work space, by providing informal opportunities throughout the day for exchange, by assigning tasks along non-disciplinary lines, by having all or several staff members review each person's work, not "even though" but <u>because</u> they are not familiar with the material.

4.7.3 The Support Staff

The project support staff is important. They expand the effective worktime of the project manager and analysts and help them work more effectively. If they are involved personally in the project, they can contribute to its substantive and stylistic quality in uniquely valuable ways. They also can make life easier for everyone concerned.

4.7.3.1. <u>What is the role of the support staff?</u> Administrative assistants, secretaries, typists, clerks, and other support staff can:

- handle the production of reports and other documents from beginning to end,
- take care of many of the telephone calls related to project work, and generally assure the flow of communications to and from the professional staff to other parts of OTA,
- keep all data accessible and in order
- keep track of administrative requirements, and coordinate administrative and support services,

- arrange meetings and handle their logistics,
- arrange travel for the staff and for the advisory panel or consultants,
- arrange for temporary help (typists, etc.) and direct their work,
- handle much of the routine mail,
- coordinate the flow of information and activities within the project,
- keep track of the budget.

Beyond these standard activities, however, the support staff can make other valuable contributions. They can, for example, serve as a surrogate for the lay public who will eventually read the reports: are the explanations clear? is it interesting reading? does it answer the questions that come to mind? has esoteric jargon crept in? does the message come through clearly?

The support people in many ways represent the project, the program, and OTA to the people you will be dealing with on the outside, both those who come into the office and those with whom you communicate by mail and phone. They must be -- and they must appear to be -- pleasant, knowledgeable, helpful, cooperative, efficient, and motivated. They cannot be unless they are included in the project team.

4.7.3.2 Should the projet have one or more dedicated support people? The rule of thumb to which most project managers would like to adhere is that a project which will last a year and have two or more full time professional staff people should have a dedicated project secretary. This is not always possible. If the project must depend on general program support staff, it is just as important -- perhaps even more so -- to consult them in formulating the workplan, to keep them informed of progress and hence of impending work loads, and above all, to be sure they understand the substance and objectives of the work and are interested in its outcomes.

4.7.3.3. Some suggestions from OTA support staff members. Support people told the Task Force:

- Analysts should pay more attention in preparing material for typing, to spelling (especially technical terms), to the consistency of names or terms used, to writing complete sentences, and to references and footnotes.
- Use foresight and planning to hold the need for temporaries to a minimum. Usually, they are not as satisfactory as regular staff, and they require a lot of direction.
- Consult the secretary on what should be typed and what should be linolexed.
- Be clear about which work has priority, and what work can be expected in the next few days.
- Be sure that the support staff is introduced to people like advisory panel members, consultants, and contractors, whom they will be called on to assist.

4.8 Contracts and Contracting

4.8.1 OTA: Researchers or Contract Managers?

When the Technology Assessment Act of 1972 was passed, its sponsors clearly conceived of OTA as a small research-contracting organization. The Act says:

> The Office shall have the authority...to make full use of competent personnel and organizations outside the Office, public and private, and form special ad hoc task forces or make other arrangements when appropriate; enter into contracts or other arrangements as may be necessary for the conduct of the work of the Office...etc.

The Act does not say that all the assessment work is to be done by contractors, but according to Rep. Olin Teague, chairman of TAB in 1977,

> The small staff concept with major outside contracting is the basis on which Congress approved OTA...
> (Annual Report, March 15, 1977.)

The legislative history of the Act confirms this.

OTA's first Annual Report, in 1974, listed six assessments that were planned for the coming year, and said: "All of these projects will be performed by contract with outside groups." But it added immediately, "After these projects are well underway, OTA plans to further develop its in-house assessment capability."

The 1975 Annual Report said that "Assessments are carried out by panels of experts, consultants, contractors, OTA staff members, or a combination of these resources, as deemed appropriate by the OTA project management team... As the assessment or study proceeds, responsibility for its management remains solely a function of the OTA." In that year, about 68% of OTA's program money went for contractors (as compared to 95% in its first year of operation), but already the trend was strongly toward in-house studies.

Chairman Teague argued for renewed emphasis on contracting. He said in 1977:

> A large in-house staff tends eventually to become inbred and predictably biased in its views. The variable content of OTA's total task if performed in-house would require an excessive technical staff, or excessive turnover of personnel with loss of continuity, or descent to a quasi-technical superficiality. More varied and superior talent can be obtained more economically by the contract-consultant mehtod.

Within OTA, however, nearly all of the staff were disillusioned with the use of contractors by mid-1977. The contracting of large assessments in the first two years had been a painful experience. According to several project managers, nearly all of the work had to be redone in-house. Even though most of the work was competent, by the time contractor reports were delivered, they were perceived by the OTA staff as being far afield from Congressional intent and interests. A large amount of time was spent in reworking the reports.

Sometimes the topic of the assessment may have been poorly understood and poorly defined at the beginning. Sometimes the policy issues and concerns had developed in unexpected directions during the year or more spent on the study. The contractor had no way to perceive or respond to this evolution. Sometimes the contractors themselves had reinterpreted the problem to make it "more researchable."

Three factors, at least, were operating. There were no research contractors with experience in working for congressional committees. Few, if any, of the OTA staff had much experience in contracting and monitoring research. After several years of experience, OTA analysts were immersed in their program areas and increasingly convinced that they could better meet the needs of Congress by doing the work themselves.

4.8.2 To Contract or Not to Contract? Present Attitudes

By about 1977, most OTA groups were restricting contracting to relatively small, narrowly defined tasks, chiefly data gathering and specialized analytical work such as modeling. Final integration and policy analysis was always done in-house, and few large, multi-dimensional assessments tasks were contracted. That is still the general rule.

One program manager told the Task Force, "We would like to do all of the work in-house, if only we could hire more staff." The same program manager said, however, it "is hard to get the staff to tailor their work to the time available and to meet deadlines."

Program managers complain that contractors will not reserve the time necessary for thorough review and revision, are not flexible enough to shift directions as the analysis leads in unexpected directions, do not understand how Congress works and the kinds of analysis it can use, and -- as a program manager said -- tend not to like OTA's "audience-tailored" style of report writing.

There are exceptions within most programs to the policy of keeping contracted tasks small, narrowly defined, and few in number. And not all programs have adopted this policy. One program said to the task force, "We are research managers, not researchers." This group finds contracts the most cost-effective way to get work done. But even this group reported that its contracts were not large, that the work statement must be written with great care, and that "contracts have worked best when given to a university or to an individual."

Because the workload is increasing and there are, and very likely will continue to be, strict restraints against expansion of the staff, contractors may be increasingly necessary to OTA's future work.

4.8.3 Big or Small Contracts?

Most program managers argue against large contracts but disagree as to how large is large. "Large" was variously defined to the Task Force as between $50,000 and $75,000, and between $150,000 to $200,000, while one program manager said anything over $15,000 was probably too large.

Several of the program managers have said by way of advice:

- Give a large contract "only if you need a multi-disciplinary team, or if there is no way to break the work into specialized pieces." (Here, large was defined as over $15,000.)
- Large contracts give greater coherence to the work, are easier to administer, but carry greater risk -- you lose more if they fail.
- "Small ones work best, but they take about as much work to monitor" as large ones.
- "Several small contracts will take a great deal of time to integrate (into a final report)."

Perhaps the best advice comes from a program manager who says: "Be realistic about what you can get. Remember that only one-third to one-quarter of the work will be for labor, and every $1,000 is only about two or three days work."

4.8.4. Who is the Contractor?

Several program managers have been most pleased with academics and individuals as contractors. Here, the contractor can function much as another staff member. Single person efforts are easier to monitor and to integrate into the rest of the work.

Larger contracts are usually awarded to the same kinds of contract research organizations which work for the Executive agencies. OTA is not obliged to abide by the strict procurement regulations that the Executive agencies must use. Awards can be made without a formal competition ("sole sourced") when a special skill or expertise is needed. Sometimes a Request for a Statement of Qualifications is placed in the Commerce Business Daily, and on the basis of the responses, one or more potential contractors is invited to submit a proposal. (For more discussion of this process, see Section 4.8.6.)

Choosing a contractor is always risky. A secretary comments that she has observed contractors who performed badly on one project showing up later on projects for other programs, whose staff are quite unaware of the earlier failure. Others agree that OTA needs a "pool of proven contractors."

The flexibility with which OTA can award contracts, without elaborate competitive procedures, saves time (although staff members still complain about the time which must be spent on the procurement process) and allows OTA maximum control over formulation of the work statement for the contractor. The disadvantage is that OTA may miss the innovative, creative approaches to the problems which occasionally show up unexpectedly when many potential contractors submit formal proposals in answer to an RFP.

4.8.5 Contract Procedures

OTA's Administrative Services, within the Operations Division, handles contract negotiations and administration for all the programs. You should consult with them as soon as project planning begins, at the pre-proposal stage, about projected contracting needs, and work with them to set up a procurement process that can begin as soon as the proposal is approved and your workplan is formulated. Such procedures take time.

4.8.6 The RFQ and the RFP

Project managers often rely on a request for statements of qualifications (RFQ) published in the Commerce Business Daily (CBD) to bring to their attention possible contractors. the RFQ is extremely brief, but it should be designed to attract those with the experience and expertise you need, and to filter out those who would be inappropriate candidates. Try to be as clear as possible about the nature of the work to be undertaken and the skills necessary. Indicate the level of effort which will be required. An example of an OTA RFQ is shown in Exhibit 4.4.

OTA issues relatively few formal Requests for Proposals of the kind contemplated in the following excerpt (Exhibit 4.5). Many of the considerations discussed in it are nevertheless applicable to more limited proposal requests. In these, too, and in working with the potential contractor to agree on a workplan, it is important to:

- Be clear and precise about the problem to be researched, and how you expect the contractor to go about it,
- But leave room for some innovative, creative approaches. Allow for the fact that the contractor will learn as he proceeds, and may develop some bright ideas and productive insights that you have not thought of.

EXHIBIT 4.4

EXHIBIT 4.5

THE REQUEST FOR PROPOSAL (RFP)

Requests for Proposals for technology assessments do much to determine not only the quality of the proposals received but also the ultimate structure and feasibility of the work desired. In TA solicitations it is important to remember that the research results cannot be foreseen and characterized at the beginning as they can be with narrower, more bounded forms of analysis.

The RFP should make clear that a technology assessment is wanted (rather than a feasibility study) and that the sponsor is using the term "technology assessment" deliberately and with knowledge of what it entails.

The technology to be assessed should be specified as clearly as possible. To use "solar energy" as an example, it should be clear in the solicitation whether that term includes wind, ocean, and biomass source systems or not, and whether both concentrated and dispersed systems are included. The sponsor may need a comparison of the impacts of two or more alternative but closely related systems, so that it is necessary to cover an array of alternative technological configurations. This should, however, be avoided when possible. The more limited and precisely defined the set of technological configurations to be considered, the more the assessment can be directed and the more comprehensive and focused the impact analysis and policy analysis can be.

The solicitation writer must strike a precarious balance between clarity as to the client agency's expectations and needs, and breadth and flexibility as to the research approaches that will be considered responsive. A good TA solicitation will:

- clearly indicate the problem to be addressed, from the perspective of the client, and indicate salient policy issues which must be considered,

  <u>but</u>

- allow flexibility in restructuring the problem, expanding it, or tightening it, and in pointing out additional policy issues which should be addressed;

- indicate the minimum scope of analysis required for the proposal to be responsive, and suggest specific analytical tools which are considered necessary,

  <u>but</u>

- encourage innovative approaches and additional analytical techniques,

- indicate a general level of effort which is contemplated,

- allow a budget range which does not encourage padding, discourage response at a lower and possible more efficient level of effort, or encourage the promise of more product than can be delivered at that level of effort.

The program and project personnel who write RFPs for technology assessments or evaluate proposals should be thoroughly familiar with the objectives and with generic problems in performance of TA. The program officer should work closely with the contracts officers, since they otherwise may insert into contracts and work statements provisions which undesirably constrain or direct the research. Soliciting assessment capability requires more flexibility than some more traditional forms of research, where the problem can be more tightly specified and bounded at the beginning, progress is more likely to be even throughout the effort, the chronological milestones can be more precisely specified at the beginning of the effort.

Excerpt from <u>A Handbook of Technology Assessment</u> (1977) prepared by Vary T. Coates, Office of Energy Programs, School of Engineering and Applied Science, The George Washington University, for the U.S. Department of Energy, Division of Solar Energy and Energy Storage.

4.8.7 How to Get Good Work

Following are some comments by old hands at OTA about how to work with contractors:

- "Know what you want from them."
- You need to inform the contractor about the whole project, and stress the emphasis on policy options, not recommendations, especially if they are used to working with agencies.
- Use contractors as extensions of the staff.
- If you structure the contractor's task to fit the organization of your report, integrating will be easier.
- "Give them time to think." Unless you are just buying data, any task will take at least three to five months.
- Allow lots of time in the contract workplan (and budget) for revisions -- and be sure that the contractor reserves that time.
- Allow time for slippage -- it always happens.
- Specify in the contract who is to do what (that is, name key personnel who must be assigned to the work).
- Require the draft report at least one month -- preferably longer -- before the contract expires.
- Write into the contract a requirement for presentations before the advisory panel.
- Visit them frequently.

Monitoring the work is important. You will need continually to stress how this task fits into the overall assessment and the importance of policy issues. Program managers warn, "Always make a record of your guidance and the contractor's agreement during the discussions." A good suggestion: write down any "golden nuggets" you pick up from the contractor's informal presentations or discussions with you; he may not get these into his formal report.

Your visits to the contractor, or his to you, should probably be arranged for the beginning and end of tasks or subtasks, unless you are working together almost daily. Monitoring can become disruptive and overly time consuming. The hours you spend with the contractor are probably being counted as part of the work hours you contracted for.

4.9 The Project Budget

The OTA Operations Manual will give you full details about budget procedures; and OTA's Financial Services people are always ready to help. Some of the most important information is summarized here to complete our assessment process at OTA.

4.9.1 The Fiscal Year Budget Cycle

At the beginning of each fiscal year, the director allocates an amount from OTA's budget to each of the four divisions. Eash assistant Director then allocates money for each project carried over from the previous fiscal year and sets aside an amount for new activities to be started during the current year (the division reserve).

4.9.2 Establishing the Project Budget

When a proposal goes to the Technology Assessment Board and is approved, the Board also approves its proposed budget. Once the project budget is "Board-approved," it is vitally important that project costs be held to that budget. The PROMIS monitoring system - to be described later - helps the project manager keep track of costs. If it becomes clear at any time during the project that final (projected) costs will be overrun by more than $30,000 or 15% of the total budget, the assessment has to go back to the Board with an explanation and a request for modification of the budget.

As soon as the assessment has a Board-approved budget, some additional steps must be taken:

1. Financial Services must be notified of the approval, and must assign a four-digit cost-code for the project.
2. The program staff prepares an assessment data input form for the PROMIS system, which includes both the official assessment title and a "short title" which PROMIS will use; a start date and completion date; the total Board-approved budget amount; and a Staff Planning Report. The latter lists by name each person assigned to the project and the number of days per quarter they will work on the project during the current fiscal year.

3. From this information the full budget is formulated. It has seven functional categories or budget lines:
   - o In-house contractors, consultants, and detailees;
   - o Panel meetings: compensation, travel expenses, and other expenses such as meals and materials for meetings;
   - o Other contracts;
   - o Staff travel expenses;
   - o Publications (these costs are estimated on a per-page basis - the Publications Office will help;
   - o Miscellaneous costs such as computer time, temporary typing services, messenger services, etc.

Administrative Services and the other support services of OTA will help in making all of these estimates. Some of the estimates are necessarily more uncertain than others. Even line item 1, staff salaries, cannot be completely nailed down in advance; almost certainly it will be necessary to adjust assignments as time goes on. There are other traps for the unwary project planner -- you must allow for merit and promotional salary increases for staff, and an inflation rate for other costs. That makes it doubly necessary to have good advice as you formulate your first project budget.

4.9.3 Budget Execution and Monitoring

The Financial Services Office monitors project spending, comparing the spending rate with the budget and apying particular attention to those assessments which seem to be spending at a rate that will cause them to exceed their budget. Project managers receive regular financial reports from the PROMIS system, which lists all transactions and compares them to corresponding budget amounts. Funds are budgeted by quarter, but money not spent in the quarter for which it is budgeted carries over -- that is, can be used until the end of the fiscal year. (Money can also be obligated before the quarter for which it is budgeted; it is assumed that work is being completed earlier than expected.)

It is important to watch the rate at which the project money is being expended, but it is also necessary to watch how it is being spent. Be sure that one line item is not being exhausted to cover another. You may need, for example, to reallocate money from staff travel to cover an additional advisory panel meeting. Budget revisions should be made if possible in advance of the time they are necessary; don't wait until invoices come in.

4.10 Public Participation

Public participation is an important part of OTA assessments. Public interest representatives are included on OTA Advisory Panels. A more active form of public participation was pioneered by the assessment on Coastal Effects of Offshore Energy Systems in 1975-76. A broad outreach was undertaken through workshops, brochures and questionnaires distributed bhrough libraries and the news media, and meetings with many interest groups. Some of these techniques were later used in other projects. Another milestone in public participation was the priority setting exercise described above in Section 4.1, in which thousands of responses were gathered from all over the United States to assist OTA in identifying topics and problems which merited assessment.

4.10.1 The Purposes of Public Participation

Director John Gibbons points out that "OTA must take into account all parties at interest." The systematic effort to identify all of those who may be substantially affected by technologies and Federal actions and to reflect their interests and values in the assessment, is the primary reason for public participation. Other good reasons are:

- o to "keep OTA honest" -- to guard against bias, and against both the reality and the appearance of capture by powerful special interests,

- o to help OTA appraise Congress fo public reactions to policies under consideration, to be sure that political costs and benefits are factored into the assessment;
- o to widen the visibility and impact of OTA assessments;
- o to open a channel for constituency feedback to Congress about the value of OTA assessments.

4.10.2 The Right Time For Public Participation

Public participation mechanisms, ranging from informal contacts to workshops and public meetings, can be used at a number of points during a project, including:

- -- in selection and definition of assessment topics (e.g., the priority-setting exercise),
- -- in putting together advisory panels, and in service on panels,
- -- in developing a workplan,
- -- in locating and gathering information,
- -- during the analysis, particularly in identifying potential impacts,
- -- in reviewing and critiquing reports,
- -- in communicating results, and seeing that reports reach interested parties.

4.10.3 Public Participation Mechanisms

Public participation mechanisms can include:

- o the broadening of advisory panels to include a number of public interest activists and representatives;
- o outreach to organizations and institutions, citizens groups, community groups, and clubs:
  - -- information and educational materials, including an invitation to send written responses,
  - -- formal and informal talks at meetings,
  - -- questionnaires and surveys of their membership,
  - -- special workshops.
- o public workshops and seminars, with invited or volunteer participants;

- o larger public meetings and presentations;
- o brochures, questionnaires, response forms distributed to libraries, community centers, and other public places;

Real public participation must include:

(a) information actively disseminated to the public,

(b) a realistic opportunity and mechanisms for the public to respond with comments and opinions, and

(c) the intent and a process for factoring responses into the assessment process.

4.10.4 Resources for Public Participation

It takes time, effort, and money -- more than many projects have. But broadening the representation on panels, encouraging staff members to give talks at community and professional meetings, and telephone contacts with a wide variety of groups and organizations are minimum efforts which are not costly.

The Public Communications Office, within the Operations Division, can help in planning public participation activities. They are the main point of contact with the media. They also handle public inquiries on OTA and maintain a general mailing list of about 25,000 names. The Conference Center Coordinator within Administrative Services can also be helpful.

There are people within OTA staff who have developed competence in public participation activities both through project experience and through their own community-related activites. They can help you plan this part of your project.

4.11 Project Reports

Project reports are the only permanent record of your analysis. They are also OTA's main line of communication with Congress and with the public. Thus they represent the reason for OTA's existence. It is not unreasonable to say, as one program manager does, that 50% of the total effort in a project should go to writing the final report.

"The objective," says OTA's senior editor, "is to communicate effectively with educated laymen, not with the experts." That requires clarity, directness, style and -- since the readers will be busy people -- brevity. While Congressmen will for the most part be "educated laymen" in the sense of not being trained as scientists or engineers, some of them will be "experts" through long immersion in committee deliberations related to the subject. In the reports, style must enhance, not substitute for, technical quality.

4.11.1 Five kinds of reports

Final reports. The final report which embodies the distilled substance of the project usually consists of three parts: the report itself, a summary report, and technical appendices. Findings and conclusions should be highly visible, unambiguous, and memorable. The analysis which leads to those conclusions should be open to evaluation by the reader: the assumptions explicitly stated, the data displayed or referenced, and the reasoning presented logically and systematically. Detailed exposition about formal methodologies belongs in the appendices.

The summary report is a critical element. The summary is all that many (perhaps most) people will read thoroughly. It is also what the media will use. The cardinal rule in writing a summary, according to senior editor John Burns, is:

> The bottom line of the report should be the top line of the summary.

The Summary should be so written that it can appropriately stand alone and also be bound with the report. To avoid repetitiousness, it is better not to merely excerpt the critical paragraphs or sentences from the report (except for stating policy options and a few other exceptions) but to say the same thing in different, punchier, words.

Technical memoranda are briefer reports which summarize what is known about a specific subject currently being analyzed as part of a project, or related to recent projects. The technical memorandum is afterward. Writing is a specialized skill. Not all good analysts are also good writers. Teams or groups are almost never good writers. While several people may draft sections of a report, one good writer/editor is needed to rewrite all of the material so that it has consistency in flow, viewpoint, style, and tone.

Writing the report does not come at the end of the project. It should begin at least a third to a half of the way through the project (See Section 4.5). Unless one of the team members is an excellent report writer, decide at the beginning who will be responsible for writing the report, consult with the Publishing Office to select a writer/editor. This person should see all background, working papers, and drafts; attend advisory panel meetings; receive copies of comments and criticisms from the advisory panel; and attend some or all staff meetings. He or she should be familiar with the project throughout, and should begin working from rough drafts prepared by the analysts about half way through the project.

A less desirable alternative is to bring in a good editor after a draft report has been extensively reviewed. If this is necessary, however, then

-- be sure the editor gets all review comments, including marginal comments;

-- be sure the analysts are available to answer questions and discuss problems of meaning, emphasis, and nomenclature throughout the editing;

-- be prepared to have the editor rip the draft apart and restructure it if necessary.

Former senior editor John Burns warns, "The objective in writing the report is to communicate effectively with educated laymen." You are not a good judge of your own writing. Your teammates aren't either. They know what it all means, so lack of clarity may not bother them. Other analysts will attend more to the substance than to the readability (they are used to reading dull reports).

usually issued at the request of committees of Members of Congress because the subject is the focus of a legislative action which will probably be completed before the on-going assessment is completed. In some cases the subject may have been covered only peripherally or partially in earlier assessments. Because of its immediacy, a technical memroandum may have a direct and strong impact. This justifies the effort even though it may not have been contemplated in the work plan and the project budget.

Background and staff papers contain information and analysis that it is thought will be useful to various committees or other groups. The work may have been done in the course of exploring possible assessment topics or as part of the planning of a larger assessment. Some began as working papers during an assessment. Examples are "Issues and Options in Flood Hazards Management -- Background Paper," and "A Preliminary Analysis of Demographic Trends Influencing the Elementary and Secondary School Systems," both prepared by the Exploratory Group in 1980.

Other papers. The National Technical Information Service (NTIS) also sells OTA working papers or contractor reports that are not published elsewhere and are not generally in great demand, but may be useful for researchers.

Interim reports. Occasionally when a topic suddenly becomes "hot" while an assessment is still underway, an interim report is released. These are somewhat like the technical memoranda but they may preview the final report, whereas the Memoranda usually deal with only one aspect of the assessment. When Congress needs information urgently, it is better to give them partial information while they need it, than full information after the need has passed. However, interim reports carry a risk of embarassment. The continuing analysis can lead to different conclusions than those the analysts may expect.

4.11.2 Writing Good Reports

Section 6 provides several sets of evaluation criteria related to the content of the report, and its suitability for the intended users. You may want to go over these before you begin writing, as well as

Two ways to test the readability are:

- o try it on your spouse -- he or she won't want to hurt your feelings, but count the yawns,
- o try the reading test, Exhibit 4.6.

4.11.3 Review, Review, and Review

Multiple, extensive reviews are almost as important as good analysis to the quality of the final report. No one will get everything right the first time, or the second time. Review is intellectual quality control. Have the report reviewed by as many people as possible -- in rough draft, in first draft, in second draft, and as many times as it takes. Use the advisory panel, colleagues in other programs, consultants and contractors, experts and interest group representatives.

It is still hard to get intense, critical review. According to one project director, "the best review is one you pay for." It may help if you send each reviewer a review instrument like the one in Exhibit 4.7.

You should be your own toughest critic. A separate section of this report, Section 6, is provided for just this purpose.

4.11.4 Producing the Report

The project is not yet over. The writer/editor and the project director, at least, must expect to spend a great deal of time on copy proofing. This is the last opportunity to catch errors of substance and of grammar, as well as typos.

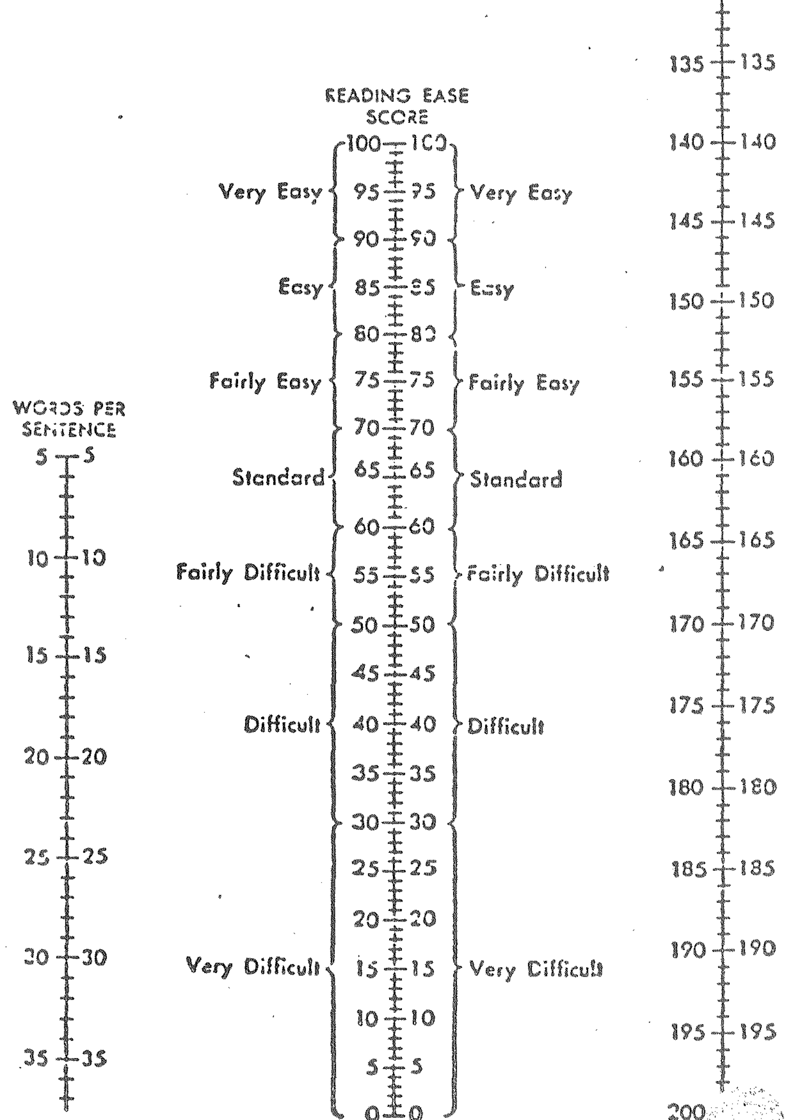
The final draft (it is still a draft until approved by TAB) should go to the Board and to the requesting committee at the same time.

After the Publishing Office sends the report to the Government Printing Office, it will be about a month before the page proofs come back. This too will take time, and the proofing should be done carefully. The project is not finished. A very important step is left: making sure the report finds its target.

Exhibit 4.6

How Easy?

HOW TO USE THIS CHART
Take a pencil or ruler and connect your "Words per Sentence" figure (left) with your "Syllables per 100 Words" figure (right). The intersection of the pencil or ruler with the center line shows your "Reading Ease" score.



How to Use the Readability Formula

To estimate the readability (reading ease and human interest) of a piece of writing, go through the following steps:

Step 1—*Pick your samples*

Pick a 100 word sample by starting with the third paragraph. Use the next 100 words to find the readability of your writing.

Step 2—*Counting the number of words*

Count contractions and hyphenated words as one word. Count numbers, dates and letters as words.

Step 3—*Figure the average sentence length*

In your sample find the sentence that ends nearest to the 100 word mark—it might be the 94th or the 109th word. Count the sentences up to that point and divide the number of words by the number of sentences. (Example: 10 sentences into 105 words equals an average sentence length of 10.5 words.) In counting sentences, follow the units of thought rather than the punctuation: usually sentences are marked off by periods; but sometimes they are marked off by colons or semicolons. (There are three 'sentences' in the preceding sentence.)

Step 4—*Count the syllables*

Count the syllables in your 100 words. Count syllables the way you pronounce the word: *asked* has one syllable, *determined* three, and *pronunciation* five.

Step 7—*Finding your reading ease score*

Using the average sentence length in words (Step 3) and the number of syllables per 100 words (Step 4), find your score on the HOW EASY chart above by drawing a line to connect your scores. The intersection on the middle line is your score.

This test is only the first clue to your writing.

Exhibit 4-6 7 cut & Photo OK

REVIEWING A REPORT*

I Structure

A Front Material

Are a preface and forward called for?
Where are authors and consultants noted?
What other acknowledgements are needed?

B Summary

Does the summary briefly and clearly state:
- what was done? why it was done?
- the principal facts?
- the principal conclusions?
- options? recommendations if any?

C Introduction

Does the introduction clearly say:
- why the document was written?
- what is intended? what is not intended?
- for whom the work was done? what other audiences are anticipated?
- how the work was done (the methodological approach)?
- something about the background?
- something about important prior work?
- what the reader can expect in terms of facts, analysis, ideas, speculation, design, advocacy, etc.?

D Body

Does it tell the reader:
- what is new in the report?
- what the results are?

Other important points:
- are methods applied consistently?
- are there errors of fact?
- are there questionable statements, conclusions, or judgements?
- is the presentation exhaustive and comprehensive?
- are there unstated assumptions which should be made explicit?
- does the paper have heuristic value? should it? what can be done to enhance it?
- what are the anticipated objections to the treatment or to the results?

E Conclusions

Are the conclusions:
- justified by the data?
- exhaustive?
- unambiguous?

F Options or Recommendations

- are they crisp?
- clear?
- ordered in priority?

G Appendices

- are they necessary?
- are they in the right form?

* Review protocol from J.F.Coates, Inc.

II Style

A Gestalt

- overall, is the readability poor? fair? good? excellent?
- is the report organized and written with various readers in mind?
- is there a secondary audience? does the report recognize it?

B Diction

- are terms appropriately defined?
- are there too many cliches or unnecessary jargon?
- are there needless repetitions of pet words or phrases?
- are there ambiguities?
- are there unnecessary or undesirable euphemisms?
- would a glossary help?

C Punctuation

- is it correct?
- is it an aid to reading and understanding?

D Spelling

- is it correct?
- is it consistent?

E Design and Layout

- are there too few, or too many, headings and designations?
- is the report attractive, appropriate, and appealing as to:
  typeface? margins and other white paper?
  quality and appearance of paper?
  color? binding?
  cover design?
- are references to tables and figures easy to follow?

F Graphics

Are the exhibits, figures, graphs, tables, and other graphics:
- clear?
- informative?
- appropriate?
- adequate in number?
- correctly placed?

G Documentation

- are references ample and complete?
- are citations easy to find?

J Secondary uses

- can exhibits (figures, etc.) be made into viewgraphs or slides?
- will text and figures reproduce?
- should the distribution list be displayed?
- should the reader be told how to get a copy?
- should there be a free-standing summary, abstract, triptych, press rele
- who is the point of contact?

III Discursive Comments on the Report

In reviewing others' reports:

- try to state at least three positive features of the report.
- abjure banalities, vague comments, gratuitously harsh comments.
- make constructive comments which can be understood easily.
- avoid causing the author to lose face.
- be as flattering or as condemnatory as effective review requires.

4.12 Follow-up and Dissemination

The final report is the beginning rather than the end of effective communication of the project's results. The dissemination and follow-up phase can greatly enhance the usefulness of what has been done. It too should be planned, rather than left to chance, especially because by this time your attention will very likely have been captured by the next project.

Follow-up work merits the allocation of about a month of time for the key personnel, probably the project manager. It is important because it:

- o delivers the message to Congress in a way that draws attention and increases its impact;
- o captures the attention of other potential users;
- o builds respect and support for OTA;
- o tends to elevate the level of public discussion of the issues;
- o contributes to professional visibility and reputation to the work;
- o delivers a pat on the back to advisory panel members; and
- o may lead to further interesting requests from committees.

4.12.1 Dissemination Begins Before the Project Ends

One of the reasons for paying a great deal of attention to the advisory panel, to public inquiries and public participation activities, and especially to continuing contacts with the requesting committee througnout the project, is to increase the interest of potential users and to build anticipation for the project report.

During the project and especially during the review phase, the support staff and the professional staff should be developing a list of those who contribute to or express interest in the study. They should receive the report. Encourage team members to attend professional meetings and conferences and talk about their work -- to the extent that they can and will squeeze in the time to do so.

In the final stages of report preparation, work with the Public Communications Service and the Publishing Office to develop the One-Pager. This has proved to be one of the single most effective ways of calling attention to OTA reports.

4.12.2 Just Before the Report is Released

Arrange a pre-release briefing for the requesting committee, and for other committees which supported the request or which are or should be interested in aspects of the report.

A pre-release press briefing should also be arranged. Work with the Public Communications Office to set it up. John Burns notes that "Press impact is Hill impact." The press is interested in the conclusions stated in a form that they can use, i.e., attention getters. But be especially careful to say exactly what you mean, and don't make it easy to be misinterpreted or taken out of context.

Don't neglect public radio and public television news people. The press briefing should be held three or four days before the release, and the press should be notified three or four days before the briefing.

4.12.3 Automatic Distribution and Sales

OTA had published 138 reports as of December 1981; and they reach a wide audience. After the initial distribution to Congress, requests are filled by the Publishing Office, and the documents are also on sale through the Government Printing Office. During March of 1980, the Publishing Office was filling requests at the rate of 17 each day for Congressional offices and 59 a day for others. At the end of 1981, the Office of the Superintendent of Documents reported that it had sold nearly 151,000 OTA reports. The Government Printing Office says,

> in comparison with other Federal agencies, OTA reports are considered good sellers. They have been selling at a higher and faster volume, they're better prepared than most agency reports, and that they appear to be more understandable to the buying public.... (OTA Annual Report, 1980, p. 60).

In 1980 the Superintendent of Documents at the request of the Peoples Republic of China for an exhibition of U.S. government documents, selected 24 of OTA's publications to be part of the display. (These are listed in the 1980 Annual Report.) Several OTA reports have been republished by commercial publishers.

4.12.4 Program Distribution

Although the Public Communications Service has a mailing list of some 25,000 people, the Program should make sure that all those who contributed to or have shown a direct interest in the report will receive it. The project director and program manager are also in the best position to identify those "potentially affected parties" who should know about the reassessment, but may not unless OTA takes the initiative.

4.12.5 Other Forms of Dissemination

Give some real attention to working up briefing packages and presentations that go beyond the printed or spoken word: slides, graphics, view graphs, movies, tape cassettes, etc., can change a ho-hum briefing to an event to be remembered and talked about. The Publications Office will help.

Encourage others who worked on the project to write papers and articles and give talks about it. These activities have a triple benefit:

- -- they call attention to the report and increase its impact,
- -- they build interest in and support for OTA,
- -- they help OTA staff members to get credit for their efforts and to build professional credentials and prestige.

The last is particularly important, in terms of staff morale and keeping good people at OTA, which has relatively few ways of giving institutional recognition to staff analysts.

Involve Congressional staff. Don't overlook the possibility of sharing the glory (and thereby the involvement in follow-up efforts) with Congressional staff who participated in initiating the study and who will be the real users. For example, if you are asked to give a presentation at a professional or industry meeting, suggest that a committee person be invited also, to comment from the Congressional point of view. Besides adding to the interest in the presentation, this recognizes his or her contribution to the committee's activities and incidentally encourages Congressional staff to think of OTA people as colleagues with a shared mission.

A reminder. Other ways in which OTA serves the Congress have already been described (Section 2.2). These also add to the time and effort which must be spent on follow-up activities; but although they are burdensome, they are highly cost-effective in increasing the usefulness of OTA projects.

The indirect, unintended, and unplanned consequences of developments in science and technology are emphasized, because this kind of social change can present us with both unforeseen opportunities and future problems. Above all, technology assessment should map for policy makers the uncertainities and unknown factors inherent in any new policy initiative. It is a way of helping decisionmakers foresee possible pitfalls in their path.

Because technology assessment is policy analysis, it is meant to be useful, rather than "correct" or "incorrect." The conclusions which it reaches should be sound, but they can rarely be "proven." Because technology assessment deals with potential consequences and feasible actions, it is anticipatory -- i.e., it is also a form of futures research.

If all of the information necessary to solve a problem or resolve an issue were available, clear, and incontrovertible, there would be little need for OTA to work on the problem. In order to be useful, OTA analysts must generally work with information that is partial and conflicting, qualitative as well as quantitative. There are no set formulae or standard procedures for doing technology assessment. There are, however, some general approaches which have been worked out by trial and error, and some methods and techniques adapted from a variety of disciplines which often prove useful.

The next section discusses the study process at OTA, as described by experienced program managers, project managers, analysts, and support staff. Later sections lay out some analytical approaches and useful techniques, and provide several sets of questions and protocols to help in planning and evaluating assessments.

5. TECHNOLOGY ASSESSMENT - CONCEPTS, METHODS, AND TECHNIQUES

From time to time, people both inside of OTA and outside have argued that its name should be changed, perhaps to something like "Office of Congressional Policy Studies." The critics outside of OTA argue that OTA does not do technology assessment because it gives too little emphasis to assessing the indirect impacts of technology, or the social impacts. The OTA analysts on the other hand understandably stress the central and primary importance of policy issues in their work, and are disgruntled at what they perceive to be attempts to force them into an "academic" model of TA.

The term Technology Assessment was coined deliberately to describe what Congress wanted from OTA. The Act says that OTA shall:

-- identify existing or probable impacts of technology or technological programs,

-- where possible, ascertain cause-and-effect relationships,

-- identify alternative technological methods of implementing specific programs,

-- identify alternative programs for achieving requisite goals,

-- make estimates and comparisons of the impacts of alternative methods and programs, etc.

This list certainly speaks of impact assessment, but it is impact assessment directed at helping Congress in its basic functions of policy formulation, legislating, budgeting, and overseeing government programs. <u>Technology assessment, then, is policy analysis directed at issues related to science, technology, and their impacts on society.</u>

5.1 Policy Analysis

"Policy issue" is a term often used but often poorly defined. A policy issue is a factor of concern in making decisions, formulating policies, and selecting among options. There are two kinds of policy issues: unresolved questions of fact, and points of controversy and conflict. Questions of fact may be unresolved because of a lack of empirical data, or because the data supplied by experts and/or interested parties is inconsistent and contradictory, or just because there are so many variables that the outcome is inherently uncertain. Points of controversy may involve competing interests and values, or conflicting judgments about choices. Most often they stem from real differences in the interests (stakes) of different groups within society.

Congress needs assistance with both kinds of policy issues, especially where they involve complex scientific and technological matters.

It is clear from the Technology Assessment Act and its legislative history that OTA was conceived as a way to provide Congress with better understanding of long-range, highly complex, interactive policy issues -- especially those which came from the unintended side effects of technological initiatives. But from the earliest days of OTA it was clear that Congressional committees also had a great need for science-technology related information on a host of short-term issues and immediate legislative activities.

The dilemma which OTA continually faces is (a) the need of maximum usefulness to Congress vs. (b) the responsibility for carrying out its basic legislative mandate. There is often a tension between the two. It is very likely that all of OTA's limited resources of staff time and money could easily be spent in responding to requests for quick turnaround, narrow, technical studies and background issue papers. Yet there is no other agency or institution which can provide the Congress with the broader, longer term, more comprehensive assessments which, as the Act recognizes, it also needs. This tension is often frustrating to OTA analysts and leads to continual criticism from the larger TA/policy analysis community.

Part of the OTA professional's responsibility, then, is interpretation, persuasion, and education -- consistently to remind and convince Congressional committees and staff of the larger context of their immediate concerns and of the need to probe and explain the underlying, structural basis of public policy issues. These structural factors, in technology-related issues, usually involve the impacts of technology on society.

The remainder of this section of the handbook suggests some conceptual frameworks and simple techniques for use in technology assessment. There are no formulae or recipes here. Technology assessment, and the larger set of policy analyses, remain an art rather than a science. Better yet, they can be thought of as "craft" -- combining the useful with the creative.

5.2 A Framework for Technology Assessments

Exhibit 5.1 suggests a framework for structuring a technology assessment. It is important to understand what this framework is, and what it is not.

- It is not a set of successive or sequential steps.
- It does suggest the elements that go into a comprehensive assessment, and the major factors that should be considered in developing a workplan and moving into the analysis.
- It suggests some, but not all, of the relationships and interactions between elements or phases of the analysis.
- It makes no attempt to indicate their relative importance.
- It does not suggest that all assessments should begin or end at the same point, that they can be broken into the same tasks by a mechanical formula, or that TA reports should display these or analogous headings.
- It does, however, provide a useful guide both to planning and to evaluating technology assessments, and
- It is used as an ordering rule for the remainder of this discussion of methodological approaches.

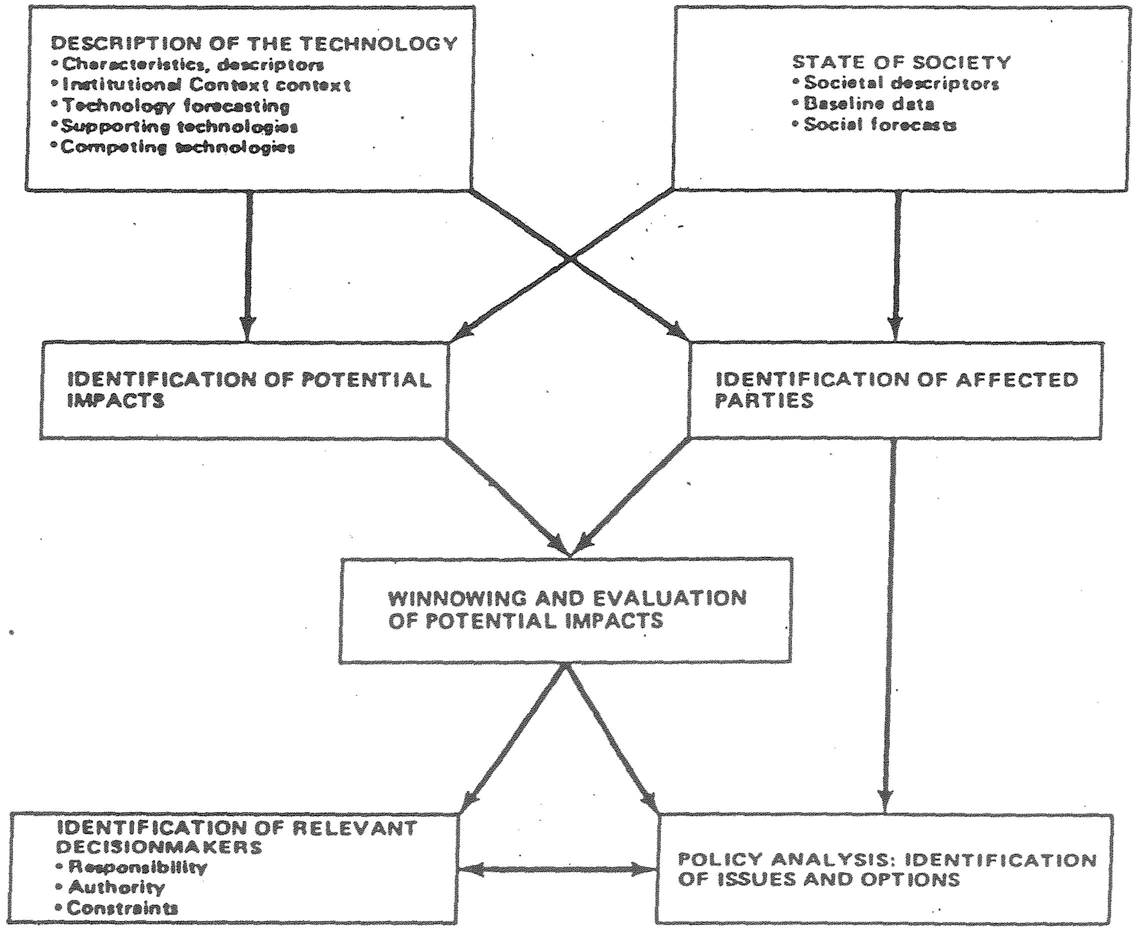
Exhibit 5.2 is a more useful way for OTA analysts to look at the same structural elements of technology assessments.

The wheel shape is meant to suggest the idea of multiple iterations -- this wheel should go through several revolutions in the course of the assessment (and you will note that progress is apt to be somewhat bumpy!).

To ride on this ferris wheel (to change the analogy slightly) please notice that you can get on at almost any point around the

EXHIBIT 5.1

SCHEME OF TECHNOLOGY ASSESSMENT



circle. OTA assessments may begin with, or focus on, an emerging technology, but they may and often do start from and be driven by consideration of troublesome policy issues, policy options soon to be debated by the Congress, or the recognition of important impacts.

This schematic also emphasizes the central role of integration and synthesis of information flowing from all elements of the analysis, and fed back and forward to other aspects of analysis. Integration is not what should occur at the end of an assessment, but what drives the assessment.

> "True interdisciplinary studies are rare, for they demand the intricate merging of insights and methods from the several contributing disciplines into a study that responds directly and thoroughly to the policy issue under examination. The threads of the several disciplines should be so tightly meshed and interwoven that they form a smooth and continuous fabric of argument. What generally passes for interdisciplinary research more nearly resembles a patchwork quilt, usually with gaping holes." *

In the next section each of the essential TA elements is discussed and some useful methodological approaches are suggested. Useful techniques are keyed to the descriptions of methds in Appendix . For the sake of clarity the discussion begins with the description of the technology, but it should be emphasized again that an assessment may well begin with consideration of policy issues.

5.2.1 Understanding the Technology

The objective is to understand the technology not as a production engineer must understand it but as a policy analyst must understand it. The analyst wants to know

-- what demands the technology makes, or may make, on the society,
-- what benefits and capabilities it will offer,
-- what problems or costs it may pose,
-- what else will happen as society adjusts to the technology,
-- how the benefits and costs will be distributed,

* Roger Levien, "Independent Public Policy Organizations -- a Major Social Invention, Rand Corp. P-4231, Nov. 1969, p. 11.

-- what policy issues will therefore arise,

-- and what we could or should do about them.

A technology can be considered:

- as a system, with inputs, processes, and outputs, and makeup of alternative configurations and materials;
- as an evolving system, for which technological forecasts, economic forecasts, and market systems are needed;
- as a social organization, with investors, owners, managers, workers, distributors, customers, end users, regulators -- and those who will misuse the technology for antisocial and criminal purposes;
- as requiring many support systems and technologies -- for example, the automobile requires fuel production and distribution, roads, parking lots, repair and maintenance, licensing, traffic laws, and a resale industry.
- as a competitor for existing technologies, or for other emerging technologies which offer similar capabilities, products, or services.

The most common mistake in technology assessment may be to spend too much time describing the technology, leaving too little time for impact assessment and policy analysis. Much of the work done in this area of the study will not or should not appear in the final report. It is intended to feed other parts of the analysis. The focus should be on links between the technology and the rest of the society and economy. Exhibit 5.3 is a chart suggesting small business concepts methods, and techniques for description of the technology.

5.2.2 State of Society Descriptors and Assumptions

The objective here is to develop baseline data to describe the societal context of the technology and to use in estimating the direction of change and the significance of social impacts. Project this forward to describe the time period covered by the assessment. Most new technologies will take from one to two decades to be fully developed and marketed or widely utilized. Most of the impacts and

EXHIBIT 5.3

DESCRIBING A TECHNOLOGY

The technology as a system. Consider the technology as a subsystem of the flow of energy and materials through society. Inputs are demands which the society must provide, outputs are contributions to the larger economy.

Questions	Techniques
Where will the inputs come from?	System diagram,
Will this mean a significant change in the supply/demand pattern?	Phased technology/demand matrix
Are any of the inputs strategic or critical materials?	Input-output analysis
What are their alternative uses and opportunity costs?	Tree techniques

Note: inputs include land, water, capital, labor, energy, materials, skills, et
Outputs include products, services, capabilities, byproducts, pollutants.
Knowledge is both input and output.

The technology in evolution . Issues may flow from the characteristics of a technology as it changes over its life-cycle or as it evolves through several generations, as it changes in scale, or as the level of utilization changes.

Questions	Techniques
How much planning, design, R&D, are necessary?	Life-cycle schematics
Is the infrastructure in place?	
What improvements and changes in the technology can be anticipated for second or later generations?	Technology forecasting
Will applications be large scale and centralized, or small scale and decentralized?	Scale effects
At what rate will it substitute for existing technologies.	
What happens to the technology when it ages or becomes obsolete? Does it create a hazard? a nuisance? How is it disposed of?	

The technology as social organization. Every technology is embedded in social institutions and accompanied by patterns of social behavior. It may casue existing institutions to change and adapt or give rise to new ones, or make it necessary to create new ones (e.g., regulatory agencies) deliberately.
Note: for further discussion see the Report to the Task Force on Management & Methodology: Todd Laporte, Technology as Social Organization.

Questions	Techniques
Is this a public sector technology (roads) or a private sector technology (cars)?	
Did public resources go into its development?	
Will anything about it drive toward a monopoly?	
Will it spawn small businesses?	
How will organizations using it tend to change?	User-change model
Is it part of a larger industrial system?	
Does it cut across established legal and regulatory categories?	

Supporting technologies: The necessary infrastructure for new technologies can be a major barrier to their economic/social feasibility. If it also involves substantial investment, the infrastructure then becomes a barrier to change in or replacement of the technology. For example the infrastructure and supporting industries which have grown up around the automobile make it difficult to replace the internal combustion engine.

Questions	Techniques
Describe the technology's suppliers, transport and communication needs, pollution control systems, energy requirements, by product utilizers, distribution and market systems, add-ons, accessories, and inter connections, secondary markets, recycling or disposal, and related advisory/consultant services.	Morphological analysis Input-output analysis

Competing technologies. An OTA analyst says, "Technology assessment is a way of structuring knowledge for choice." The choices or alternatives must be considered including the null (do without) choice, non-technological alternatives (fllod plain management rather than dams), macro-alternatives (preventive hygiene rather than medicine), and competitive older or newer technologies.

Questions	Techniques
What do we lose if this technology is not available?	Cost-benefit analysis
How does it compare with its alternatives?	Cost-effectiveness analysis
What are the opportunity costs?	Risk analysis

issues will not become urgently important for some time after that. But in the meantime, the rest of society (and possibly its values and priorities) will have changed. This social forecasting is perhaps the most difficult aspect of technology assessment. It is highly interactive with other elements. As the analysis draws attention to potential impacts and policy issues it will become necessary to generate additional background and baseline data and then to consider how the present conditions in this area are likely to change over time.

Trends to be considered are: economic conditions, political relationships, demographic patterns, social organization, resource availability, the labor force, employment, education, and values.

Questions	Techniques
What are the long-range trends?	Trend description
What has driven these trends?	Probabalistic forecasting
Can we foresee saturation points, or natural ends to these trends?	Social trend analysis
	Precursor events
Which trends will reinforce each other?	Relevance trees, decision trees
Which will tend to dampen other trends?	Scenarios
What new trends are emerging?	Cross impact analysis
What new factors may become important?	Delphi
What scientific advances could change the situation?	Nominal group techniques
	Mathematical modeling
What are some of the low-probability, high-consequence events which could happen?	Value change forecasting

5.2.3 The Identification of Potential Impacts

At the core of the concept of technology assessment is the realization that policy issues arise because technological change causes (and is caused by) social change. The use of technology has both direct impacts -- the intended benefits and the recognized costs -- and indirect or secondary consequences which may not have been foreseen or planned. These can also be either benefits or costs. These may include not only what is now called "externalities," but also opportunities to capture second order benefits and to exercise new capabilities.

Some policy issues arise from the inequitable distribution of these costs and benefits. Others arise because benefits and opportunities may be lost without government intervention, or because society demands that some of the costs be controlled or alleviated.

The attempt to anticipate secondary and indirect impacts requires not only careful analysis but an act of creative imagination. The search for subtle impacts draws on the other elements of assessment described above and below but it also causes the analyst to ask: what could happen? how will people use this technology? what might happen then? how will we adjust to new capabilities? The basic assumption is that these are no random events but chains of interconnected responses and accommodations.

This aspect of assessment then attempts to throw out a wide net; look for possibilities that can be evaluated and discarded later. There are four basic approaches:

- -- reexamine the technology description and society description and search for implications,
- -- use techniques of exhaustion (morphological analysis, etc.)
- -- use systems analysis techniques (fault trees, relevance trees)
- -- use imaginative thinking (brainstorming, simulation, etc.)

These techniques and others are described or indexed under other elements of assessment.

5.2.4 Identifying potential stakeholders and affected parties

This part of the analysis is highly interactive with the search for impacts and with the evaluation of impacts, described below. Stakeholders will also have been identified in describing the technology. An impact is an effect on someone or some institution or group. It is also necessary to discern the interests, values, concerns, demands, and policy preferences of the affected parties. Some of these groups will be aware of the technology, involved with it, and active, concerned, articulate, and perhaps organized to express their interests (whether "for" or "against" the technology or a related policy). Some will not yet be aware that they will be affected. In some cases, those who will be most affected by a technology are those who are for some reason precluded from using it yet will lose the benefit of alternatives which it renders obsolete.

Public participation is a critical element in identifying stakeholders and their interests, but it may miss some of those who are "latent" affected parties.

Questions	Techniques
Who are or will be:	Public participation
Actors: investors, producers, distributors, etc.	
Competitors	
Suppliers	
Users, customers	
Regulators	
Involuntary non-users	
Recipients of pollutants	

5.2.5 Evaluating Impacts

Not all of the potential impacts are important in terms of policy concerns and not all merit the time, effort, and money for further analysis. The objective of this part of the analysis is to winnow out those which must be considered in depth. This is necessarily an act of judgment, based on the best information available.

Some criteria which may be useful are:

- magnitude
- reversibility
- duration
- questions of equity
- regional distribution
- scale and scope
- relationship to other national objectives and priorities

Special consideration should be given to impacts which may be

- -- cumulative and slow-building,
- -- synergetic or convergent with other trends and impacts,
- -- differentially visited on already disadvantaged groups or regions,
- -- closely related to basic social support systems and institutions.

Techniques

Figures of merit	Cost-benefit analysis
Risk benefit analysis	Models
Decision analysis	Policy capture
Value analysis	

5.2.6 Identifying Relevant Decisionmakers

This calls for close political analysis in determining the leverage points related to the technology in terms of their

-- locus of responsibility,

-- jurisdictions,

-- authority,

-- power,

-- resources.

Note first that these do not always coincide. The locus of decionmaking may lie in any of several levels of government -- Federal, state, or local -- or may be shared, or it may lie outside of government (e.g. the control of the medical profession over medical technology). The decisionmaking center with the responsibility and legal authority to act, may not have the resources or political power to act. Congress will be concerned not only about the limits of its own power but with knowing who else has related powers.

5.2.7 Policy Issues and Policy Options

This is the bottom line on all OTA assessments, whether they begin with describing a new technology or plunge immediately into policy issues which are related to science and technology.

A policy issue is a factor of concern in decisionmaking. A policy issue is either an unresolved question, or a point of controversy or conflict.

Unresolved questions about the outcomes of technological initiatives or policies may be unresolved because (a) there is insufficient empirical data to allow us to foresee the outcomes, (b) the data supplied by experts and stakeholders is contradictory and inconsistent, or (c) the outcome is inherently uncertain, because of the many intervening outcomes and variables.

Points of controversy on the other hand involve basic conflicts between one or more of the following:

- o competing objectives,
- o competing interests and values (someone gains, someone loses),
- o competing priorities for the use of limited resources,
- o mutually exclusive ways of achieving an agreed upon objective.

In most public policy decisions, especially those related to science and technology, there are both inherent uncertainties and strongly conflicting sets of interests. Advocates on all sides often confuse the public policy discussion by obscuring the distinction between the two kinds of issues: hiding special interests behind an argument over data, or trying to overcome objections based on value judgments with an avalanche of expert opinions and scientific information.

Policy analysis for the Congress, then, should be designed to:

- o clearly explain the nature of the problem (or of the opportunities and problems associated with a technology) in language understandable to busy decisionmakers and the concerned publics;
- o summarize the present state of knowledge, and identify what is not known -- especially what is not knowable at the present time;
- o identify and discuss the significant policy issues, in terms of
  - -- the parties at interest, the alternative or conflicting objectives which they put forward, and their stakes in having one or the other of those objectives accepted;
  - -- what each of those objectives would mean for other parties at interest, for the general public, and for other national objectives and priorities;
- o clarify why this problem is or is not one which is the responsibility of, and within the powers of, the Federal government and the Congress;
- o set out a full range of feasible options for Congressional action, each option being presented in terms of
  - -- an objective or objectives to be accomplished,
  - -- one or more legislative and related strategies for accomplishing the objective,

-- the likely consequences of choosing this option, and

-- the uncertainties and risks attendant on this course of action.

Note, however, that an assessment may conclude that there are no actions which appear appropriate, necessary, or desirable.

5.3 Integration

Integration means relating all of the analytical conclusions into a coherent, internally consistent, balanced account.

It is worth stressing once again that analytical integration, or study synthesis, is something which should occur throughout the assessment and not at the end.

A study sponsored by NSF on "Frameworks and Factors Affecting Integration within Technology Assessments" * concluded that integration throughout an assessment is encouraged by:

- o a project leader with "a democratic/facilitating" style of management;
- o a three to five member core team covering a broad range of disciplines, and stable throughout the study;
- o study boundaries established early in the study, satisfactory to all core team members, but reexamined throughout the study;
- o explicit budgeting of time and resources, allowing for iteration of study components throughout the study;
- o "All-channel" communication and a high level of interaction within the core team (as compared to a "hub-and-spokes" style) where communication among team members usually goes through the project leader.

This study compared four strategies for integration:

- o common group learning, in which all analyses, by any team member, are criticized by all other members and then redone by a different member of the team rather than the original analyst;

* By F. Rossini, A. Porter, P. Kelly, and D. Chubin, Department of Social Sciences, Georgia Institute of Technology, 1978.

- modeling, with team members feeding data to the model;
- negotiation, in which analyses are done by one team member or outside experts and related to other analyses by "negotiation at the boundary regions and interrelations of the analyses;"
- integration by a leader.

Common group learning was found to be most likely to produce a satisfactory form of integration of assessment results.

6. THE CRITICAL EVALUATION OF TECHNOLOGY ASSESSMENTS

The Task Force on Methodology and Management arranged for four contractors to prepare White Papers on methodological approaches to improving technology assessment. As a part of their work, each of the contractors developed a systematic set of questions and benchmarks which can be used by OTA analysts in critically evaluating their own work and that of others.

This kind of self-examination might well be undertaken at three separate points during the assessment process:

- o to make sure that the project workplan is so designed that the study should produce results which are scientifically sound, rational in scope, and useful to decisionmakers,
- o at a midpoint in the study, to evaluate progress and to identify deficiencies while they can still be corrected,
- o for thorough, severe review of draft reports.

There is, as would be expected, considerable overlap in the sets of questions or evaluation criteria to be presented here. However, each set was designed by its developers to be internally consistent and comprehensive; therefore they will not be disaggregated and rearranged here. In some cases the wording or order has been slightly modified so that all criteria can be presented in the form of questions.

The four reports are available in OTA's Information Services Center.

6.1 Criteria for Evaluating Assessment Methodlogy and Management

I. Management

A. Efficiency and Effectiveness

Does the methodological approach encourage:

i. the efficient use of time and money, without unneeded work?

ii. the effective use of in-house and outside participants?

iii. the optimum use of panels, workshops, and consultants?

iv. communication across internal administrative boundaries?

v. the ability to check for convergence of the study toward completion?

vi. progress along the "organizational learning curve," including development of well-cataloged material for future studies?

vii. development of an early warning system to suggest needed studies (or interim products) in anticipation of client needs or requests?

B. Adaptability

Does the methodological approach encourage:

i. early formulation of a study workplan?

ii. early formulation of a tentative final report?

iii. monitoring techniques which facilitate redirection of work as the assessment develops?

iv. accommodation to the inevitable uncertainties in the prediction of the time and budget needed?

v. adaptability to meeting unanticipated deadlines (e.g., easy production of useful interim reports)?

vi. modularity (i.e., the ability to produce valid and useful assessments covering limited aspects of an issue with speed and modest cost?

II. The Assessment Outcome

A. Completeness, Objectivity, and Soundness

Does the report:

i. address all important issues, options, and points of view?

ii. consider the levels of uncertainty of the analysis?

iii. consider the "worst credible case" for crucial issues?

iv. separate analysis and value judgments?

v. identify any value trade-offs made within the analysis?

vi. identify any value trade-offs that Congress must consider?

vii. clearly identify remaining unresolved questions and outstanding controversies?

Will the report stand up to severely critical review?

III. The User Orientation *

Is the final report sufficiently user-oriented?

a) Does it enable the user to easily find specific information or topics within the report?

b) Does the report avoid shrouding uncertainty or controversy in vagueness?

c) Does it contain a compact and well-organized display of policy options and their anticipated consequences?

d) In dealing with technical issues, does it balance comprehensiveness with intelligibility?

e) Does it avoid presentation of excessive material with little or no use to major audiences?

f) Does it contain a bibliography of references to other material likely to be of concern?

g) Is it dull reading?

6.2 Criteria for Evaluation of Functional Completeness**

I. Will the assessment contribute to restoring or supporting public confidence in congressional policy?

and

Will it contribute to rational congressional debates and decisions?

II. In particular, does it have the following functional characteristics?

a) Does it represent a type of research not carried out by other congressional information agencies?

b) Does it provide information especially suited for use in the policy information process?

c) Is it anticipative? Does it represent an early warning system for the Congress?

d) Does it identify and describe policy options and their likely consequences?

e) Does it appraise or assess or evaluate these consequences?

f) Does it include inputs from public participation?

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* From: "A Management Overview Methodology for Technology Assessment," Review & Critique, Feb. 2, 1981.

** Taken from Lewis Gray, "A Summary of a Doctoral Dissertation: A Decision Theoretic Model of Congressional Technology Assessment; A Theoretical Examination of the Characteristics of Complete Assessment Reports with Applications," Indiana University, January 1981.

(Note: This was not one of the OTA contractor reports, but was included by the Task Force in its report along with the others.)

6.3 Criteria for Evaluation of Decision-Focused Technology Assessment *

Will the assessment be directly useful to congressional policymakers who must deal with uncertain and long-term impacts of emerging technologies?

a) Is the framework designed so that analysis can be tailored to the kind of decision to be made and to the needs of the decisionmaker?

b) Will (or does) the assessment make it possible to identify or present information on the entire range of alternatives?

c) Is the assessment comprehensive, accounting for major effects and consequences of alternative actions?

d) Are the effects quantified to the greatest extent possible?

e) Does the assessment include sensitivity analysis?

f) Does the assessment indicate the range of uncertainty and level of ignorance about key pieces of information?

g) Does the assessment make it possible to determine the value of obtaining further information?

6.4 Criteria for Evaluating Treatment of Social Impacts **

a) Has the assessment dealt with a broad range of social, economic, and institutional effects?

b) Has it covered indirect as well as direct effects?

c) Has it looked to very long-term or cumulative effects?

d) Has it considered synergistic second order impacts caused by interactions between the deployment of two or more technological systems?

e) Has it considered infrastructure changes resulting from or needed because of the deployment of technologies, such as those on regulatory or legal/institutional forms?

f) Has it considered the potential for political conflict?

g) Has it taken into account the effects of increasing scale?

* M. W. Merkhofer, "A Process for Technology Assessment Based on Decision Analysis." pp. 1-2.

** Abstracted from Todd R. La Porte, "Technology and Social Organization."

6.5. A Comprehensive Approach to The Evaluation of Assessment Methodologies

	Questions re the System of TA in General	Questions re OTA -- in General	Questions re specific OTA Studies
SYSTEM OF TECHNOLOGY ASSESSMENT	o What is the Basic Purpose of TA in the Public Decision Process? o How do the Missions of Particular TA Subsystems Differ? Why? o What are the Strengths and Weaknesses of TA Subsystems in terms of their Feed-in to the Relevant Decision Making Entities? o How might the Weaknesses/Gaps in the Capabilities of the TA Subsystems be Remedied? o What Identifiable Contributions to Societal Viability have Resulted from the System of TA?	o What Legal Mission is Prescribed for the OTA? o Is the Legal Mission Realistic in terms of Resources and Reasonable Expectations? o How does the OTA actually View its Mission? How does this Perception Duplicate or Differ from what Other TA Entities do? o Is the Congress always the Intended Primary User of OTA Reports? o Are Policy Option Outcomes the Best and Only Type Usable by the Congress? o What deficiencies, if any, are Perceived by the OTA Staff in its Normal Performance? Does it Regularly Perform up to Congressional Expectations? Why? If not, Why not?	o What, Precisely, is the Task-Objective? o What other TA Subsystems have Performed Similar Studies? o What were the Strengths or Weaknesses in such Studies? o Have Similar Studies by other TA Subsystems Contributed to Informed Decisions? Why? Why not? o To what Extent is the Assessmen Task Specified or, on the Contrary, Unspecified, thereby Leaving Discretion to OTA? o How might the Assessment Task b Reformulated so as to be of Maximum Benefit to the Congressiona Units Requesting the Study? o What Technical Assessment Desig Will Most Likely Achieve Such a Outcome?
ANALYTICAL	o To What Extent is this Mode of Assessment Utilized by Other TA Subsystems? Why? o In What Circumstances is this Mode of Assessment Prescribed by Statute or otherwise Required? o What Patterns of Assessment are Responsive to this Mode of Assessment? Why? o What Patterns of Assessment Task-Objectives have not been Responsive to this Mode of Assessment? Why? o What Resources (Funding, Analytical Skills, Information, Techniques of Inquiry, etc.) are Essential to this Mode of Assessment? o What have been Determined to be the Major Strengths and Weaknesses of this Mode of Assessment? o What Identifiable Contributions has the Analytical Mode Made to the Utility of the TA System?	o Is this Mode of Assessment Prescribed for OTA? o Has OTA Made Use of this Mode of Assessment? With Respect to What Types of Task-Objectives? Why? o Why has not this Mode of Assessment been used by OTA with Reference to Particular Assessments? o What has OTA Learned from other TA Subsystems about the Strengths and Weaknesses of this Mode of Assessment? o Does a Limit on Resources in any Way Inhibit Use of the Analytical Mode by OTA? o Does the Analytical Mode offer a Fundamental Way of Thinking About TA for the Congress in View of the Normal Policy Option Outcome of OTA Assessments?	o Does the Particular Task-Objective Pose the Assessment Task Instrumental Terms? o Are the Alternatives (Project Configurations) Specified? In General? In Highly Defined Term Or Must OTA Invent the Alternatives? o To What Extent are the other Elements and Operations (Phases of the Matrix) Specified? What doe this Indicate/Dictate in Terms Methodology and Type of Outcome o Will the Main Thrust of the Assessment be to Identify Policy Options? If so, then to what Extent Should Each of the Policy Options be Subjected to a Thorough Assessment Itself in Accor with the PPS/GWU Evaluative Framework? o What Features of the Assessment Task and Methodology Adopted Encourage an Approximate Benefit/Cost Outcome Presentation for Each Policy Option?

ect	Questions re the System of TA in General	Questions re OTA -- in General	Questions re specific OTA Studies
ERN ROACH	o What are the Major Concerns Expressed re Technologically-Based Actions? o What are the More Critical Social Value Tensions and Institutional Conflicts Arising from the Assertions of Concerns? o How have TA Subsystems Undertaken to Manage Conflict as an Element of the Technical Assessment Design? o How have TA Subsystems Adjusted Between Use of Prescribed or Posited Evaluative Criteria on the one hand and Empirical Concerns as an Evluative Reference on the other? o What Controversies (Conflicts Engendered by Concerns) have Relevant Authoritative Decision Processes been Equipped to Handle? Not Equipped to Handle? Why? o How Useful has Concern Analysis been for Responsible Decision Makers? o What Types of Task-Objectives are Particularly Amenable to the Concern Approach? o What are some of the Conceptual Implications of Using the Concern Approach?	o Has OTA made Use of the Concern Approach? o In what Types of Task-Objectives has it Proven Useful? Why? o What has OTA Learned from other TA Subsystems re the Utility of the Concern Approach? o Why or Why Not has this Assessment Approach Proven to be Useful to OTA Assessment Performance? o Are there Particular Reasons why OTA does Not Wish to Employ the Concern Approach? o Is the Treatment of Controversy re Policy Option Authorization and Implementation Simply Uncongenial to the OTA Role?	o Is the Particular Task-Object Amenable to Assessment by Conc Analysis? o How can the Concerns (Issues c Concern) Best Be Organized int Categories for Explication? o Will this Categorization be In clusive of All Issues of Conce of the Three Primary User Grou o What will be the Procedure for Determining the Significance c the Concern Categories? o How will the Impact of Alterna tive Project Configurations or Concern Categories be Determin (Alleviations and Exacerbation o Will Explication of Concerns t Determining Potential Difficul of Norm Resolution be a Servic able Outcome? If not, then ho are Concerns to be Illuminated for the Three User Groups?
L/ STITUTIONAL ALYSIS	o To What Extent has Legal/Institutional Analysis been Specifically and Explicitly Applied by Various TA Subsystems? o Has this Assessment Approach ever been Prescribed by Statute or Authoritative Rule? o What Patterns of Assessment Task-Objectives have been Most Responsive to this Approach? Why? o What Patterns of Task-Objectives are Not Amenable to this Approach? o Are Special Resources Required for this Approach? o What are the Major Strengths and Weaknesses of this Approach as Derived from Experience of Various TA Subsystems? o What Identifiable Contributions has the Legal/Institutional Approach Made to the Utility of the TA System for Informing Responsible Decisional Entities?	o Has OTA Found that Precise Specification of a Proposed Action (Alternatives) is Essential for Effective Use of this Approach? o Has OTA Found that this Approach Demands Precision in the Description of Alternative Project Configurations? o Why has - or has not - OTA Applied this Approach Explicitly in Specific Assessment Situations? o What has OTA Learned from Other TA Subsystems as to the Strengths and Weaknesses of this Approach? o What Special Resources, if any, are Required for the Application of this Approach? o Would not this Approach be Extremely Useful to those Users Who have (or accept) Responsibility for the Initiation, Authorization, Implementation, and Operation of any Given Configuration of a Proposed Action?	o Is the Particular Task-Object Amenable to a Legal/Institutic Analysis? o Are Project Configurations Spe fied in Detail or must OTA Per form this Function? o Will this Approach Address or luminate All of the Major Issu Raised by the Proposed Action? o Why might this Approach Provic a More Serviceable Outcome for the Three Primary User Groups than Alternative Methodologies

6.5 A Comprehensive Approach to The Evaluation of Assessment Methodologies
(continued)

ect	Questions re the System of TA in General	Questions re OTA -- in General	Questions re specific OTA Studies
ITERIA FOR UATING SSMENT RFORMANCE	o At What Phases of the Assessment Process Should the Performance be Evaluated? o To What Extent have Explicit Evaluative Schemes been Developed and Applied by the various TA Subsystems? o Do any Authoritative Sources Prescribe Evaluative Criteria for Policy Analysis or TA? o How Might a Scheme of Appropriate Evaluative Criteria Differ with the Patterns of Task-Objectives? o Are Special Resources Required for Effective Application of the Evaluative Function? o How does Evaluation Improve the Overall TA Function? How can this Result be Demonstrated? o What are the Strengths and Weaknesses in the PPS/GWU Evaluative Criteria of: Interpretability, Warrantability, and Serviceability?	o What Evaluative Approaches have been Established by OTA? Criteria? Advisory Boards? Peer Reviews? OTA Hierarchical Reviews? Independent OTA Unit? o Does OTA have a Standardized Approach? Or is the Evaluative Function Designed for Each Assessment Task? o What Impact has the Evaluative Function had on OTA Methodology? Type of Assessment Approach? Organization of the Assessment Project Team? Continuing Revision of Evaluation Procedures? o What Impact has the Evaluative Function had on the Quality of OTA Studies in terms of Interpretability, Warrantability, and Serviceability? o What has OTA Learned from other TA Subsystems which has Improved its Evaluative Procedures? o What Means does OTA Use to Continuously Upgrade the Evaluative Function re its Studies?	o At what Phases of this Study Should Evaluations be made? o What Internal Quality Controls should be Initiated in Order t Assure a Warrantable Report? o What Provision is made for Continuing Integration of the Contributions of the Various Memb of the Project Staff? o Has a Provisional Outline of t Final Report been Developed as Reference for Continuing Revision? o What Guidelines are Establishe for Organizing and Drafting th Report so as to make it Clearl Understandable to All Users? o What Criteria are Established Gauging the Likely Serviceabil of the Study Report for the Th User Groups?

7. TECHNOLOGY ASSESSMENT IN OTHER CONTEXTS AND COUNTRIES

7.1 The Rest of the Federal Government

During the 1970's there was a change in policymaking in Federal agencies. Administrators began to examine social as well as economic costs and benefits, and to explore the secondary or indirect impacts as well as the primary objectives of public policies. The concepts of strategic planning and technology assessment began to permeate administrative decision making.

This change was largely forced on federal agencies by a combination of congressional and judicial pressures. It was slow and uneven, but agencies dealing with science and technology and with large public works almost without exception began to pay more attention to impact assessment.

Technology assessment developed in three different political contexts and institutional settings: the Congress, the mission agencies, and the National Science Foundation. There are strong differences between TAs in the national government because of the differences in the scope of the responsibilities, powers, and authority of these institutions. NSF sponsored TAs are aimed at a wide range of decisionmakers and concerned publics. They have stressed comprehensive coverage of impacts and the use of innovative analytical techniques but have often been weak in policy analysis. TA in line agencies usually focuses on a specific project or application of technology, typically does not consider alternatives, lays out a relatively narrow range of impacts in quantitative detail, and may or may not consider policy issues. By comparison, most OTA assessments have emphasized policy options but have been weak on exploring for unexpected impacts and consequences. In all three institutional contexts, the movement to formalize technology assessment activities slowed after 1975. TA in the mission agencies remains for the most part sporadic, narrow in focus, and disjoined. The TA program of the National Science Foundation has remained active, but it, too, lost some momentum in the late 1970's. But the primary aims and concepts of technology assessment have become generalized and widely accepted, if not as widely practiced, within the national government.

The impetus for TA never came from the highest levels of the Executive branch. Presidents and their advisors generally prefer to preserve their options, unlimited by too much public information about the uncertainties and risks which accompany political initiatives. Much of the impetus came from the knowledge that Congress had established its own source of information and analysis, OTA, and the anticipation that it would be asking questions which the agencies might be unable to answer convincingly. Subtle pressure came also from social and political forces outside of government and from inherent tensions that operate between the branches of government and among federal agencies and their constituencies.

7.1.1 The National Science Foundation (NSF) Program

NSF was created in 1950 to promote the progress of science through the support of basic scientific research and education. Research grants were typically made along disciplinary lines in response to research proposals from an individual investigator, usually at a university. The two main objectives of NSF were and are: advancing the state of basic scientific knowledge, and improving the quantity and quality of scientific education.

In the 1960's, however, NSF's objectives expanded in response to congressional pressures for studies of social and environmental problems such as poverty, urban renewal, civil rights, and pollution. In the late 1960's, NSF acquired an applied research mission. New programs included a technology assessment program. Not by coincidence, NSF's congressional oversight committee was the House Science and Astronautics Committee which was then studying the proposal to establish OTA.

The TA program at NSF was never big. It received less than 3% of the applied research budget, a small part of the total budget. The TA program budget ranged from a low of less than $700,000 in 1973 to a high of under $1.5 million in 1975. In spite of this, NSF's program was largely responsible for the growing interest and capability in TA in the early 1970's. It developed a general concensus about the definition, scope, components, and techniques of technology assessment. NSF-sponsored TAs have been less policy-focused than OTA studies and have a broader and more exploratory treatment of potential impacts. They are intended to serve a more diverse group of decisionmakers, including the general public.

From 1970 through 1980 NSF funded about 52 TAs and several dozen related studies, including surveys of TA activities in Federal agencies, symposia and conferences, and stocktaking studies to evaluate NSF assessments and track their use. Since OTA did not begin to produce reports until after 1974 and mission agency assessments were few, the NSF program was the only source of TA funding during the early and mid-1970's.

NSF is not a line agency and does not make policy. It does not have responsibility for development and promotion of technology or industry, as for example, do NASA and FAA. It also does not have responsibility for controlling and regulating technologies as do regulatory agencies. Hence, a major source of institutional bias is absent at NSF. However, NSF was often accused of the political sin of intruding on the turf of other agencies. Accordingly, it adopted the strategy of concentrating on technologies which did not fall within the responsibility of any agency, or those for which several agencies had partial responsibility. In a few cases, NSF program managers persuaded other agencies to undertake assessments or to share their sponsorship. Thereby NSF avoided political conflicts and helped substantially in getting other federal agencies to accept TA.

The NSF program has covered a broad range of subjects. Some were problem-oriented: food and waste disposal, automobile pollution, energy conservation, and atmospheric freon. Technology-focused studies covered industrial, biological, medical, and social technologies. Broad public dissemination of assessment reports was encouraged, in fact, demanded. Funding for the program in 1978-1981 was, however, divided to cover a closely related program in risk analysis. There was further retrenchment during 1981.

The NSF program had many of the same problems with which OTA struggles. Research teams who perform well in interdisciplinary research are not always skilled at policy analysis. The idea of interdisciplinary research itself is elusive and ambiguous. Results of sponsored TAs were often disappointing.

NSF has had other problems as well. The primary constituency of NSF has always been scientists engaged in basic physical and biological science; even in applied research programs the primary constituents were research engineers. These groups have tended to be suspicious of interdisciplinary (or "non-disciplinary") work. They were concerned that emphasis on "useful" or "policy-oriented" research would reduce funding for traditional scientific research, and that it would violate their professional canon that scientists, not the government, should determine the direction of research. TA, therefore, frequently has not had strong supporters within NSF.

In spite of this vulnerability, NSF remains a promising environment within the federal government for technology assessment. It has the advantage of being isolated from most of the political pressures to concentrate on short-term, immediately useful issues encountered by mission agencies and by OTA.

7.1.2 Federal Executive Agencies

The social forces which brought about the introduction of technology assessment for Congress and in NSF also operated on the executive branch. Public disillusion with the benefits of technology and the increasing skepticism about governmental programs had a direct effect on agency-supported projects. For instance, the National Environmental Policy Act (NEPA), passed in 1969, gave interest groups a formidable weapon against unwelcome government projects. Since agencies increasingly had to defend their regulations in judicial arenas, they became more receptive to assessing the impact of developing technologies and of their programs and projects.

There are, however, many barriers to the development of technology assessment within the federal bureaucracy. The White House and the Office of Management of the Budget in the late 1970s repeatedly cut funds for exploratory impact studies. Legislative mandates, potential conflicts between assessment findings and agency objectives, the demands of institutional survival, and the lack of time, funds, and personnel for comprehensive studies further discourage federal agencies from undertaking technology assessments.

Some agencies have a responsibility for promoting technology or industry. For example, the Federal Aviation Administration has the responsibility of developing a domestic air transportation system. In other areas, federal responsibility for monitoring or for developing technologies is split among many agencies. Pesticides, for instance, are governed by the Department of Agriculture, EPA, FDA, the Department of Interior, and, to a lesser extent, several other agencies. Some federal agencies, on the other hand, have multiple and even conflicting responsibilities. The Department of Interior repeatedly faces internal struggles over multiple responsibilities for natural resources development, conservation and management of public lands, and trusteeship over Indian lands. The Department of Agriculture must be responsible to agribusiness, small family farms, consumers, and commodity markets. Assessments threaten to generate internal conflicts within an agency and between the agency and its various clientele. While technology assessments may inform decisionmaking, they may also invite political conflict, since they often reveal benefits for one or more constituency while indicating added costs for others.

In spite of these obstacles, federal agencies began in the late 1960's to consider the secondary impacts and policy issues surrounding developing technologies and public works programs. During the 1970's there was a marked change in the way in which decisions were made about research funds, support for technological development, civil works projects, and even to a lesser degree, technology regulation. Several large studies were done by agencies well before either the NSF technology assessment program or OTA were in operation (although none were labeled technology assessments). Federal agency decisionmaking during the late 1960's and early 1970's gave greater attention to the possible indirect, unplanned, secondary impacts of governmental programs related to science and technology, and to alternative policies and options.

Federal agencies usually do what might be appropriately called "secondary impact analysis," rather than comprehensive policy-oriented technology assessment. Responsibility for impact analysis is usually dispersed through an agency: environmental impacts are analyzed in one office, secondary economic impacts somewhere else, and social, legal, and institutional impacts in still other offices. There may be little attention to integrating available information in one study to lay out for decisionmakers the policy issues and policy options.

Between 1971 and 1977, at least five major agencies formally established technology assessment programs. The Department of Transportation (DOT) was the first cabinet-level department to institutionalize technology assessment capabilities when the decision was made in 1972 that all transportation systems would be subjected to a "comprehensive socio-economic impact assessment." The Office of the Assistant Secretary for Policy Planning and International Affairs undertook several three-to-five-year studies, such as the Bay Area Rapid Transit (BART) Study Program and the Climatic Impact Analysis Program (stratospheric aircraft). DOT also co-sponsored with NSF and

NASA assessments of intercity and large-scale aircraft transportation systems. Since the term technology assessment was new and not widely familiar in 1972, the DOT program was formally described as Systems Analysis.

The Department of Agriculture (DOA), after an exploratory technology assessment of minimum tillage in 1974, established a technology assessment program called TIFFS -- Technology Innovation in the Food and Fibre Sector. TIFFS conducted assessments of energy from biomass, automated food retailing, solar energy applications for agriculture, and large tractor technology. They were designed to support agency policy formulation, improve the allocation of R&D funds, and inform constituents about impending technological changes.

FAA established a Technology Forecasting and Assessment Group within its Office of Aviation Policy in 1975. The group first produced a forecast and exploratory assessment of minicomputers on aircraft. The office was to begin with technological forecasting and move gradually toward comprehensive impact studies, but the latter was quietly dropped from the agenda in 1978.

EPA initiated several technology assessments between 1972 and 1974. These were transferred to the new Energy Research and Development Administration (ERDA) and later to the Department of Energy. In 1974, an OMB-sponsored Interagency Task Force on Health and Environmental Effects of Energy Use issued the King-Muir Report, which called for an impact assessment of all proposed energy development projects. EPA then established an Integrated Technology Assessment Program (ITA), which initiated five multi-year, multi-million dollar contractor assessments of Western Energy Development, Ohio River Valley Energy Development, Appalachian Energy Development, electric utilities, and coal conversion.

Unlike most of the other TA programs in federal agencies, the EPA program (now in the Office of Strategic Assessments and Special

Studies) has continued to fund technology assessments, now primarily small exploratory assessments called "mini-assessments." Ten mini-assessments were completed in 1980-81, and another seven or eight were funded for 1982: studies, for example, on bromines, telematics (computers and telecommunications), increased use of wood burning, hazardous facilities, applied genetics, composite materials, alcohol fuels, and alternative chemical feedstocks. EPA also undertook a large-scale technology assessment of energy development in the Sunbelt regions.

ERDA inherited several ongoing technology assessments and some staff from EPA. Accordingly, ERDA established a technology assessment branch within its Division of Transportation Energy Conservation, which continued the EPA assessments and did assessments of the electrification of transportation systems. In 1977, ERDA also established an Integrated Technology Assessment Program within the Office of Environment and Safety. The title of both the program and the office has changed several times during DOE's troubled history, and has recently disappeared. It concentrated chiefly on studies of energy technologies and on development of a complex mathematical model, SEAS (Strategic Environmental Assessment System).

During the late 1970's, technology assessment programs and activities were established in other agencies. The Department of Health, Education, and Welfare (now the Department of Health and Human Services) began in the mid-1970's to develop capabilities and a departmental mechanism for assessing medical technologies.

Technology assessment was never fully integrated into federal agency decisionmaking processes. The DOT program was, for a time, more influential than the others. It was located in the Secretary's Office near the center of departmental decisionmaking, whereas other programs are or were in agency R&D divisions. In nearly every case in which an agency established a formal TA program, a primary objective was intradepartmental integration: for DOT, integration of the planning for several modes of transportation; for EPA, better integration of R&D activities with the work of the regulatory divisions; for DOA, integration in the sense of comparison of benefits and costs for the agency's disparate constituencies; and for DOE, integration of energy and environmental responsibilities. The other science and technology-related agencies conducted or sponsored technology assessments without establishing a continuing program or an organizational mechanism for undertaking more than ad hoc technology assessments.

The 50 or so technology assessments done by or for agencies have concentrated on areas of intense political concern and conflict -- recently, energy technologies and problems, transportation, and water projects. There is a tendency to address only the immediate concerns of the agency, to neglect broader issues and long-range, indirect impacts, and to give minimal attention to areas where no definitive answers appeared forthcoming.

Most agency technology assessments were done by contractors, although some were entirely in-house and a few relied on "blue ribbon" panels of outside experts. Contracts were preferred because agencies typically lacked interdisciplinary staff, in-house experience and familiarity with technology assessments or could not commit enough staff time to such projects. There is a tendency for assessments to be "inverted," in other words, studies of the impact of socio-economic changes on technology or an agency's clientele, rather than of the impacts of technological change on society.

7.2 Technology Assessment in the Private Sector

There have been several attempts to survey corporations to determine the extent to which technology assessment has been adapted for use in the private sector. OTA itself had hearings on this subject in 1977. The results are somewhat indeterminate in terms of how much TA is done. What is clear is that:

- o Corporate planning and corporate decisionmaking has changed considerably within the period in which technology assessment developed in public decisionmaking, and there are some similarities within the two areas.
- o But the application of the term technology assessment to modern techniques of corporate planning and market analysis is an artifact of non-industry researchers; technology assessment is not a familiar term within industry.
- o Corporate planners are increasingly interested in:
  - -- anticipating the impacts of social change on the corporation, its products, its markets, and
  - -- anticipating public policy developments, especially the regulatory constraints aimed at protecting public health, the environment, and consumer interests.
- o Even this "inverse technology assessment" (assessing the impact of society on technology and industry) often is resisted by upper management because immediate pay-off is not assured.

Some observers use the term technology assessment to describe sophisticated forms of corporate planning because these activities are designed to explore the uncertainties facing corporate decisionmakers as they develop strategies for future business development (see Exhibit 7-1). An OTA contractor comments that in both OTA and corporations

> ...there is a substantial amount of internal discussion and debate on <u>what</u> should be done, <u>how</u> it should be done, <u>when</u> it should be done, and <u>how much</u> should be spent to accomplish the particular objectives of the analysis. Consequently, many of the pressures which face people serving in the technology assessment function within the private sector are the same as those pressures faced by the OTA staff in completing their assessments. (James D. Maloney, Technology Assessment in the Private Sector, Report to the Task Force on Management and Methodology.)

EXHIBIT 7-1

COMPARISON OF PRIVATE AND OTA TECHNOLOGY ASSESSMENT

Industrial	OTA
Objectives	
. Profit maximization	. Best analysis at minimum cost
. Conflict identification and positioning	. Conflict identification
. Market diversification based on perceived consumer need	. Maximize social benefits
. Identification of consumer need	. Balancing public needs/ goods
. Corporate direction-setting/ decisionmaking	. Formulate public policy options
Structure	
. Flexible process	. Structured, yet flexible process
. Ad hoc, mission-oriented task force	. Formally organized, mission-oriented study group, panels, contractors
. Mostly internal effort, some use of external resources	. Mostly external analysis, internal staff focuses on policy issues
. Private oral report	. Public written, published reports
Time Frames	
. Short to mid-term view	. Short, mid, long-term views
. Study takes 1 year to complete	. Study takes 6, 12, 18, 24 months to complete
Other Perceptions	
. Complete thinking on business development	. Complete thinking on options to achieve social good
. Accountable to stockholders	. Accountable to Congress
. Survival of firm	. Impact on decisionmaking/ awareness
. Competitive environment	. Resource allocation among equal "goods"

Other observers stress the essential differences between public sector technology assessment and these corporate activities:

> The term 'technology assessment'...should be reserved to describe a form of policy analysis that is designed to support public-sector decisionmaking and the judicious allocation of public resources through the analysis of potential impacts and consequences to society. The use of the term...for comparable analyses designed to assist private-sector decisionmaking is...undesirable and counterproductive...(because) it tends to cast into a negative perspective some very useful and progressive developments in corporate planning and the exercise of corporate responsibility...by implying unrealistic expectations...(This) tends to evoke in industry management resentment and resistance, both of which become barriers to the development of desirable management support activities...(and) may prevent industry from appreciating and making use of the findings of public-sector technology assessments and from politically supporting this public-sector activity.
>
> (Vary T. Coates, Technology Assessment in Industry: A Counterproductive Myth? Report to the Task Force on Management and Methodology.)

Maloney urges that OTA might learn from industry by cultivating a greater degree of flexibility in study procedures, in stressing "market or consumer thinking" in the generation of policy options, and in recognizing the "incremental reversibility of decisions." Coates argues that

> ...the function of industry is to generate the stream of goods and services that responds to...demands created by public policy objectives and...by the exercise of individual freedom and choice. So long as industry respects and complies with the constraints imposed by constitutionally sound government authority on behalf of the public, it is at least debatable whether industry has a responsibility, a right, or a capability to make subtle determinations as to what constitutes the long-range public interest.

Whether or not one calls some aspects of modern corporate planning "technology assessment," the observers agree that "technology assessment in a private sector is best considered to be a full strategic analysis of business opportunity of interest to the firm" (Maloney).

Even this kind of "full strategic analysis" is probably not widespread except in the largest corporations. A few instances are known of corporations experimenting with a public technology assessment of one of its products; Monsanto conducted an open evaluation of its "Lo-pak" plastic soft-drink bottles before they were marketed, modeling this exercise on public-sector assessments. The Lo-pak assessment emphasized evaluation of the product in terms of compliance with existing public policies and regulations. In nearly all other cases, however, corporate "technology assessment," to the extent that it exists, differs from public sector assessment in fundamental ways:

- o it is concerned primarily with possible effects on the firm and, at best, secondarily with effects on the larger community,
- o it is concerned with compliance with existing or clearly predictable public policy rather than with generating public policy,
- o its outcomes are private and proprietary, not public.

7.3 TA in Other Countries

7.3.1 A Parliamentary Office of Technology Assessment?

There have been repeated attempts to establish something like the OTA in Sweden, the Netherlands, the Federal Republic of Germany, the United Kingdom, France, and Japan. All have failed. In a parliamentary government there is no division of power between the legislature and the executive. The majority party (or coalition) controls both, and party discipline is usually strong. The majority party has, at least in theory, no reason to be suspicious of information from the ministries, which it controls. The opposition party (or parties) can make little contribution to policy or decisions, but has the constitutional and traditional role of offering alternatives to the policies of the majority. The usual pattern has been, therefore, for opposition parties to favor the establishment of an OTA, which would allow them to share information which the government agencies generate, and also perhaps to influence policy formulation. The majority party, for the same reasons, usually is opposed to the proposal.

7.3.2 Technology Assessment Outside of the Legislative Context

Many of these countries, however, have used technology assessment within ministries or through special task forces. In Germany the Ministry of Research and Technology and the Ministry of Inner Affairs have sponsored technology assessments by universities and independent research groups, such as Battelle - Frankfurt. These have been criticised for giving too little attention to non-quantifiable social impacts. But active interest in TA in Germany is increasing, and France is again actively interested.

Sweden's National Board for Technology Development and the Secretariat for Futures Studies within the Prime Minister's office conduct impact assessment studies. In Great Britain a special group, the Programmes Analysis Unit, shared by the Department of Industry and the Atomic Energy Authority, had a technology assessment program from 1967 until the PAU was abolished in 1979.

West Germany's Committee for Economic and Social Change did a great deal of research on the impact of technological and social innovations such as telecommunications and changing work time patterns from 1971 to 1976, when the Committee's legislated lifetime expired.

7.3.3 Ad Hoc Assessments

Several outstanding assessments have been done by commissions or task forces set up only for the duration of the study. The Swedish Nuclear Referendum is one example. In the Netherlands, the Klaassesz Royal Commission, working with the Rand Corporation, assessed the impacts of a proposed dam on the Rhine Estuary and suggested an alternative (a half-dam with cosable caissons), which was accepted by Parliament.

7.3.4 Non-Government Technology Assessment Centers, etc.

In most European countries, there are TA activities or programs in universities, professional organizations, research institutes, industries, or industrial groups. In Britain, for example, active centers include the Science Policy Research Unit at the University of Manchester, and the Technology Policy Unit at the University of Aston (Manchester). At Germany's University of Cologne, the Institute for Organization and Automation (BIFOA) is active, and in Japan, Saitama University's Policy Studies Division. Such groups are eager to have contacts with U.S. government and non-government TA programs. Comparison of their work with U.S. assessments of comparable technologies can often provide insights into the effects of differing institutional or economic frameworks for technological development.

7.3.5 TA in Canada

In Canada, decisions concerning large technological projects are made by the Ministers in Cabinet, drawing on information and analysis provided by the Ministries. As in other parliamentary systems, there is in theory at least more congruance between legislative policy and executive programs than in the U.S.. Other problems are the same. No ministry may have clear responsibility for an area of critical technological development; a number of ministries may have overlapping responsibilities; a ministry may have responsibility for promoting a technology or an industry but give little attention to its social consequences; or a technology may be so pervasive that neither federal nor provincial governments understand or control its effects on the environment or institutions.

Canadian technology assessments have depended heavily on the science advisory structure, consisting of the National Research Council, the Ministry of Science and Technology, and the Science Council. The first is like a combination of the U.S. National Academy of Sciences and National Science Foundation. It is a channel for the movement of technical data between government and industry. The Ministry of Science and Technology is somewhat analogous to the Presidential Office of Science and Technology Policy, but unlike OSTP, has a Technology Assessment Division and a Secretariat for Futures Studies. It sponsored, for example, The Conserver Society, an assessment of alternative futures for Canada.

The Science Council might be compared to the Ford Foundation or other large private foundations in the U.S., but it is funded entirely by the Canadian government, to provide advice, assessment, and criticism on matters of science and technology policy. It does this with a degree of independence which is sometimes uncomfortable for the government. It has played an active role in technology assessment and was instrumental in initiating one of the most outstanding technology assessments yet undertaken, Northern Frontier, Northern Homeland.

That assessment of development in the Canadian Arctic was done by a Royal Commission (usually known as the Berger Commission after its chairman, a Judge) and combined a massive public participation program with a broad range of scientific analysis and testimony. It brought into public focus the conflict between development and the interests of the Canadian native peoples, and has been a powerful factor in subsequent development policy decisions.

7.3.6 TA in Japan*

When Rep. Daddario proposed the creation of OTA in 1966, there was immediate and strong interest within Japan. Pollution and technology-

* This section draws on two reports to the Task Force on Management & Methodology: R. Randolph and B. Koppel, Technology Assessment in Asia: Pitfalls and Potential; and V. Coates, Technology Assessment in Europe and Japan.

induced hazards were then severe and the subject of vigorous public concern and agitation. Well before the Congress acted on the Daddario proposal, at least two high-level delegations from Japan toured the U.S. to talk with those who were active in developing technology assessment. The Ministry of Technology and Industry's Science and Technology Agency (STA) sent a group of officials and university professors in the late 1960's. The Japan Techno-Economic Society (JATES, comparable to the U.S. National Association of Manufacturers) sent another delegation in 1969.

STA and JATES then combined forces in 1971 to create an Institute for Future Technology to develop methodology and to do technology assessments. Other study groups and think tanks were established by industrial and professional groups with encouragement from the Ministry of Technology and Industry (MITI). During the 1970's, at least 35 case studies or experimental technology assessments were done. Some of the topics were skyscrapers, pesticides, medical instruments, new towns, off shore nuclear plants, energy storage, solar energy devices, the wired city, and waste disposal pipelines. The pesticides TA directly affected policy decisions. Little is known about the other TAs, largely because most were not translated into English.

JATES continued to be a strong supporter of TA for several years, and many Japanese corporations had active technology assessment divisions. Again, not much is known about these activities in the U.S. In 1974, JATES joined with the International Society for Technology Assessment,* a professional society based in the U.S., to sponsor a large conference on TA in Tokyo.

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* ISTA has since been superseded by IAIA, the International Association for Impact Assessment, c/o Technology & Science Policy Program, Georgia Institute of Technology, Atlanta, Georgia 30332

Other factors which have contributed to some decline in interest in TA in Japan are said to be

- o the failure to develop strong ties with "explicit science and technology policy" and with the real decisionmakers,
- o concentration on "implicit" science and technology policy, that is, on side effects and problems rather than innovation and opportunity,
- o the inability to tie technology assessment directly to the DIET, the problem already pointed out in attempts to establish parliamentary OTAs in Europe,
- o Japanese frustration at being unable to develop rigorous, formal methodology which would "prove" the conclusion of TAs,
- o Strong public suspicion of assessments sponsored by MITI, which is considered strongly pro-industry.

The primary factor in the lessened activity in Japan, however, is clearly that the worst problems of pollution and risks have been somewhat ameliorated, and the government, industry, and the public have become more concerned about enhancing Japan's position in international markets by early adoption of new technology. Thus, the perceived failure of Japanese technology assessment groups to identify TA with positive/promotional aspects of technology policy as well as with control/regulatory aspects has led to its declining support.

7.3.7 Other TA Activities

In Israel, as in most of the developing countries, there has generally been on the one hand a preoccupation with the urgent and pressing problems of economic development and national security, and on the other hand, a general public attitude of uncritical approbation for technology. But Israel has recently been experimenting with technology assessment within the Ministry of the Interior and the National Council for Research and Development. In Egypt, the Academy of Scientific Research and Technology and the National Research Centre have small groups beginning to develop a technology assessment capability. Several universities in India have conducted technology assessments -- for example, of the Green Revolution -- and continue to have active programs. Brazil has attempted to utilize technology assessment in its National Alcohol (fuel) Study.

It is difficult to evaluate the sparse available information about technology assessment in Eastern European and other Communist countries. Government officials and scientists from these countries usually explain that thorough and systematic analysis of the impacts of technology is done in the central planning structures of the government, and significant detrimental impacts and problems are minimized before the technology is adopted. They admit, however, that there is growing concern about industrial pollution of air and water, especially in East Germany. Occasional participation of faculty and graduate students from Eastern European and Russian universities in conferences around the world reveals an active interest in impact forecasting and assessment in these countries; for example, in the Forecasting Research Center of the Technical University of Wroclaw, Poland. In the fall of 1980, the Polish Academy of Sciences convened a Conference on Technology and Society to which a number of technology assessment specialists from the U.S. National Science Foundation and American universities were invited as speakers. Several government-invited visitors to China have recently been specifically requested to discuss technology assessment and to bring with them examples of TA reports. A strong impression emerges that the problems of factoring scientific information into political decisionmaking, are very much the same in all countries in spite of differences in ideology, economic institutions, and governmental structures.

8. SHARED EXPERIENCE: SOME COMMON PROBLEMS AT OTA, AND WAYS TO HANDLE THEM

The Task Force on Management and Methodology spent many hours talking with analysts and program managers about their work, their concerns, their problems, and the ways in which they tried to cope with them. All of the programs put together memoranda for the Task Force which also were rich in helpful observations, criticisms, and suggestions. Many of the quotes sprinkled through this handbook were drawn from these discussions and memos. A number of Task Force recommendations based on these shared experiences have been implemented -- this Handbook is one of them -- and others are still being worked on.

Some of the problems which OTA staffers highlighted are common to all research organizations and indeed to all offices and workplaces. Others arise from the special nature of OTA, as a research/analysis/science-oriented institution working in an environment which is highly decision directed, politically sensitive, and continually pressured by fast moving events. Some of the problems require -- or at least could be partially alleviated by -- changes in administrative and management procedures or by formal actions. Others, however, can only be solved by the informal, cooperative, sensitive efforts of all of the people at OTA, working together with a heightened awareness of the problems and needs of each other.

The problems and issues which were most often mentioned are noted below, in some cases with suggestions which were offered for getting around them.

Internal communication is poor. This was by far the most commonly heard complaint and the one which is most serious. It is certainly not unique to OTA, and is usually much worse in larger, more bureaucratic organizations. But it may be particularly frustrating at OTA because of the nature of the work, which is not or should not be fragmented into isolated compartments but interrelated, interdisciplinary, and overlapping. The work environment should encourage each person to learn from each other, each project to build on the results of others, and each program to contribute to the growing capabilities of the office as a whole. In particular, there were observations that:

- o There is little communication between programs or projects with overlapping interests, or related projects;
- o Project managers often do not know about people in other programs who have expertise or information which they need;
- o Support staff are not informed about the status of projects and what they can expect as far as work, travel, panels, consultants, etc.;
- o Analysts put in requests for information and documents, but do not know about data others in the office already have;
- o There is no advance information about the number of projects that can be done at what level within the next year's budget, which makes planning difficult;
- o Administrative regulations and procedures are not well communicated;
- o The staff does not understand the role and function of support offices;
- o The staff does not understand accounting and budgeting procedures;
- o Most of the staff cannot give people who ask a coherent description of what OTA is and what it does;
- o People in other programs (or projects) are not informed about advisory panel meetings, even when they are working on closely related subjects;
- o Projects sometimes engage consultants or contractors, or appoint advisory panel members, who have performed unsatisfactorily in the past, and no one warns them.

Steps have been taken or are now being taken to solve some of these problems. The Operations Division is preparing a Manual of Procedures and Services which will explain office procedures, accounting and budgeting practices, and reporting requirements. That manual and this handbook will make the support offices and their services more familiar to the staff. This handbook should also help people get a better overview of the flow of work at OTA and how it fits into the legislative branch.

These things in themselves will not make people better informed, unless people make an effort to learn. Most of the problems, moreover, cannot be solved by any formal procedures or printed information. They can only be overcome by people talking to each other, and going out of their way to pass on information and to keep themselves informed about who is doing what and who is interested in what.

There are some simple steps that can be taken to encourage informal communication. Some of the things frequently suggested to the Task Force were:

- Have brown bag lunches to which people from other projects or programs are especially invited;
- Use these lunches and other informal meetings for briefing on work progress, for brainstorming, or to work out basic assumptions, workplans, or report outlines;
- Get in the habit of preparing and circulating memoranda about lessons learned, techniques used, and productive information sources or consulting service;
- Ask people from other programs or projects to play the role of advisory panel or committee staff, for dry runs of briefings;
- Request project support staff to attend staff meetings.

Some other comments suggested more innovative or more structured solutions. For example:

- Preparation of a consultant/contractor register, with project managers who use outside help required to make a record of their performance, noting special strong points and weak points;
- A staff book, which would provide resumes of all staff and mention particular expertise, experience, and interest, with cross-indexing;
- Circulation of brief, chatty biographies and vignettes of new people, or of the existing staff members, a few at a time;
- A reference volume of projections, extrapolations, and assumptions (demographic, economic, social) used in projects -- or a standard set to be used, within limits, in all projects;
- Project close-out reports with a full record of lessons learned.

To be edited

6.4 Thirty-One Useful Techniques

Technology assessment uses techniques and methods developed for the physical and biological sciences, the social sciences and economics; and engineering. It relies equally heavily on techniques derived from the newer disciplines of systems analysis, operations research, and futures research and forecasting. In this section thirty-one techniques particularly useful for assessment and policy analysis are briefly described. Most of them have been mentioned in the preceding two sections.

Some of these techniques are simple, paper and pencil aids to systematic thinking and structured analysis. Others are more formal, well developed methods, some of which require the use of a computer. Some can also be used effectively to summarize and display in a final report the reasoning and analytical steps which underly study conclusions.

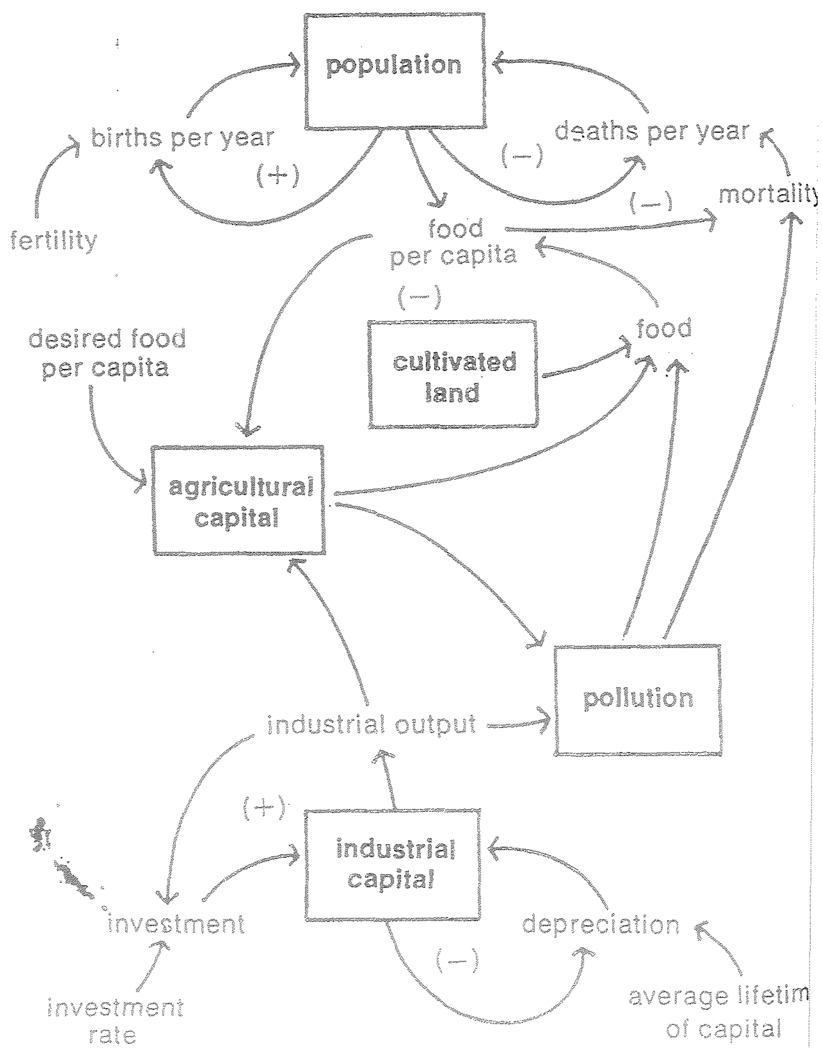
T.1. Signed digraph. A signed digraph generated by the assessment team is useful for blocking out a problem, and checking that all structural components have been considered. In (a) below, there is a simple signed digraph. All components of a problem are mapped, connected by arrows showing the direction of interactions. These arrows are signed with a plus if the relationship is ~~positive~~ reinforcing - i.e., as the number of births goes up population increases, if population increases the number of births goes up. This is a positive feedback loop. As the population increases the number of deaths per year increases (+) but if the number of deaths per year increases, population tends to decrease (-) An odd number of minus signs creates a negative feedback loop.

Positive feedback loops strengthen a trend, negative feedback loops dampen it. Exhibit (b) illustrates how signed digraphs can be used to structure a policy-related problem.

Ex. T.1a Signed digraph.

from: Meadows, Limits to Growth, p.117.

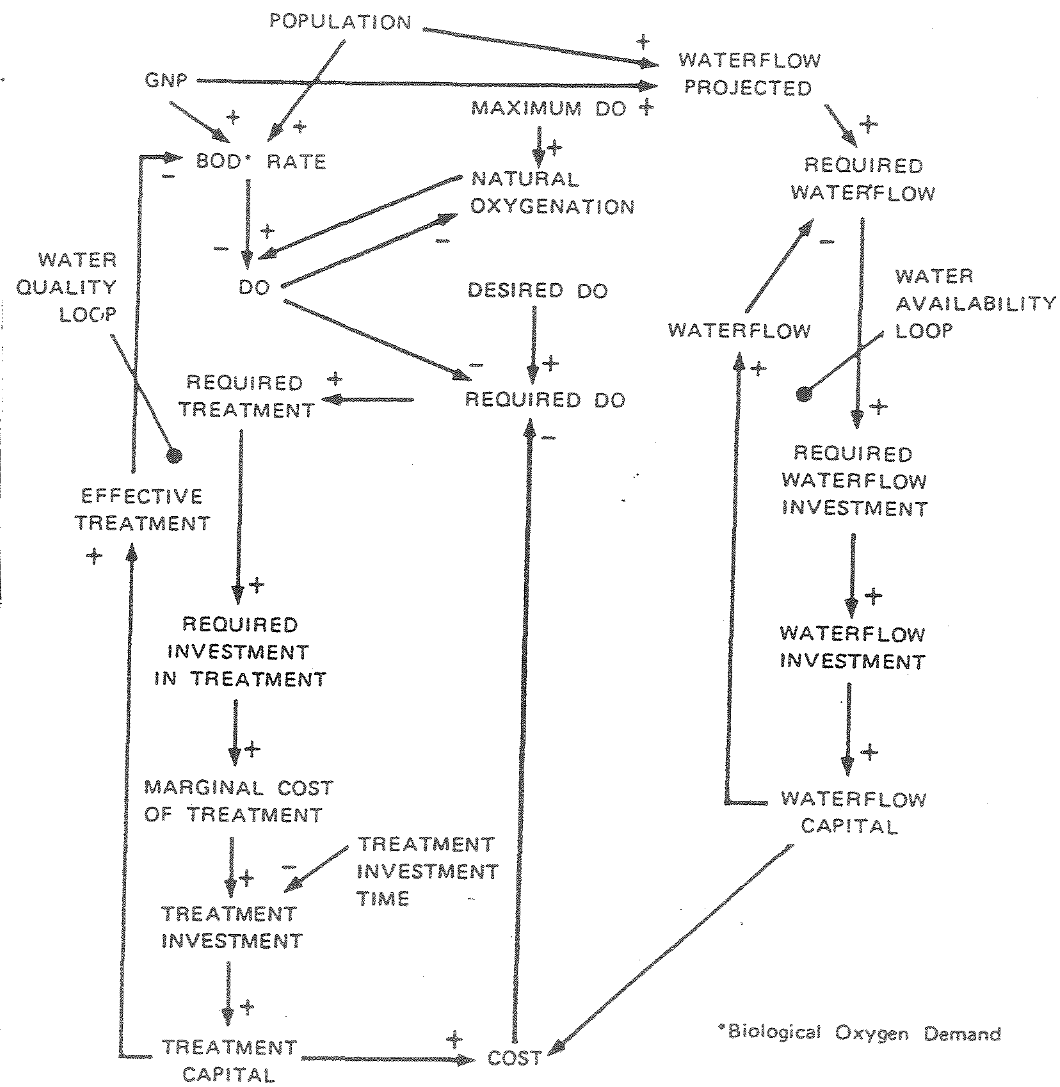
~~Figure 21~~ FEEDBACK LOOPS OF POPULATION, CAPITAL, AGRICULTURE, AND POLLUTION



Some of the interconnections between population and industrial capit operate through agricultural capital, cultivated land, and pollution. Ea arrow indicates a causal relationship, which may be immediate or delaye large or small, positive or negative, depending on the assumptions includ in each model run.

Ex T.1 (b)

Water quality and water availability.
from: ~~Kruzic~~ SRL*, p.105



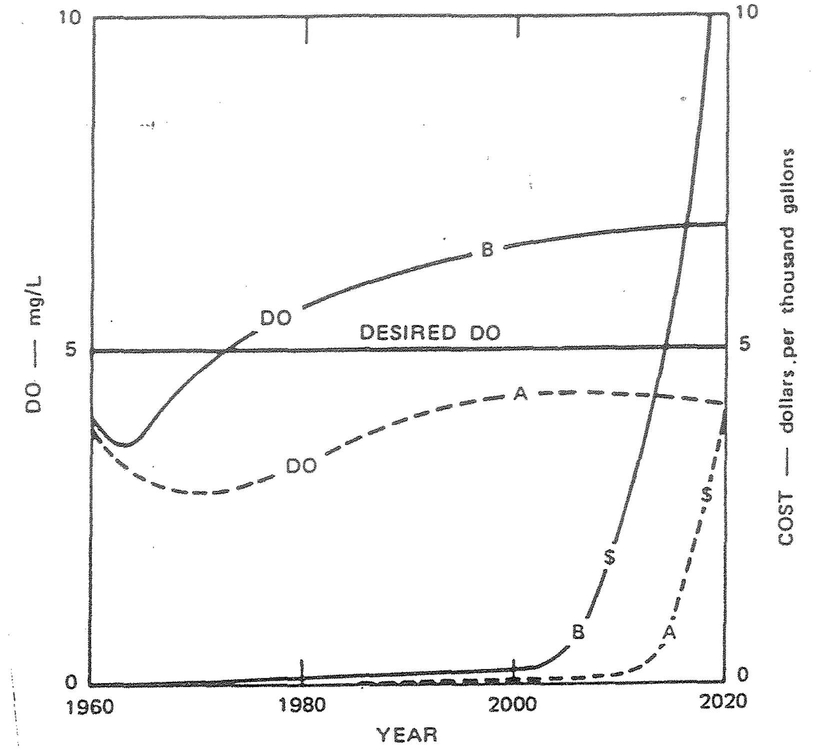
FEEDBACK LOOP DIAGRAM FOR WATER QUALITY AND WATER AVAILABILITY

T.2. Dynamic modeling. Dynamic modeling is too complex and expensive for most OTA projects, unless there are models already developed and running which could provide insights for the project. The world model of Limits to Growth is one example of dynamic modeling. Such models begin with a signed digraph, but quantitative estimates are associated with each (+) or (-) and the resulting interactions, which are carried out by a computer, reveal the evolution of systems over time as the variables interact under the specified feedback conditions. By changing the feedback equations or adding interacting trends a number of possible futures can be explored. See EPA: A Guide to Models.*

* Full citations in Sec. 6.5

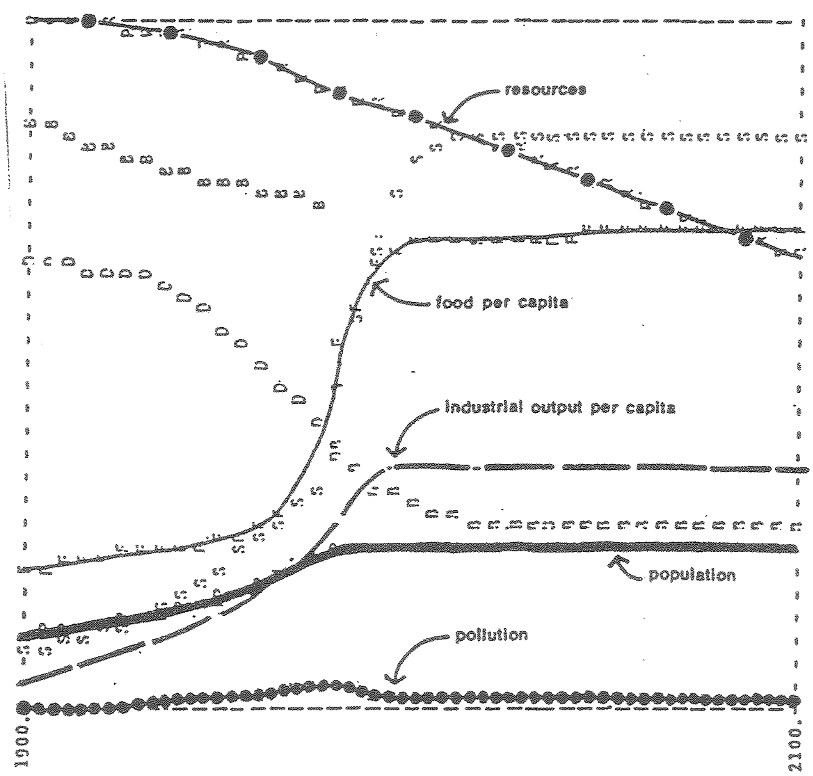
Exhibit T.2(a).
Model results,
see Ex.T.1(b)

from: ~~Kruzic~~ SRI,
p.17.



SIMULATION OF TREATMENT AND DEVELOPMENT COSTS OF WATER IN THE UNITED STATES AND DISSOLVED OXYGEN FROM 1960 TO 2020

Figure 46 STABILIZED WORLD MODEL I



Technological policies are added to the growth-regulating policies of the previous run to produce an equilibrium state sustainable far into the future. Technological policies include resource recycling, pollution control devices, increased lifetime of all forms of capital, and methods to restore eroded and infertile soil. Value changes include increased emphasis on food and services rather than on industrial production. As in figure 45, births are set equal to deaths and industrial capital investment equal to capital depreciation. Equilibrium value of industrial output per capita is three times the 1970 world average.

Ex. T.2 (b) A run of world
model showing
effects of selected
policies.
Limits to Growth, p

IV. 1.3

T.3. Cross-Support Matrices.

This technique waa developed to study interactions and interrelationships between series of developments and events. The assumption is that a change in technology, social behavior, values, economic conditions, etc., may,

(a) change the probability of occurrence of interconnected events,
(b) change the timing of interconnected events, or
(c) affect the mode of impact of interconnected events.

The assessment team sets up a matrix of events, developments, or policy interventions, and then assigns numbers to the nodes to represent the effect that each event, if it occurred, would have on the liklihood (or strength) of each other event. They also estimate the possibility of each event happening, if considered in isolation.

Finally they consider each pair of events and assign new probabilities; viz., if event A occurs, the probability of B occurring increases to X%.

The computer, using a Monte Carlo or other probabilistic technique, generates a series of scenarios showing the complex interrelationships of various combinations of events.

The matrix can be used to test the sensitivity of the schenarios to various trends or various policy interventions or to likely and unlikely events in the larger world. The value of the techniques is that it helps, through a reiterative process, to determine which factors should be emphasized in the assessment as having the strongest bearing on outcomes. See ~~Kruzic,~~ p. 122-1238, and Fowles, pp.348-355.

If This Event Occurs:	Initial Probability by 1985	The Probability of This Event Becomes: 1	2	3	4	5	6	7
1. Electricity Price Increases by 50 percent	0.25		0.60	0.40	0.30	0.08	0.85	0.50
2. Conservation Reduces Average Load 4 percent and Peak Load 1 percent	0.30	0.35		0.50	0.20	0.10	0.90	0.25
3. Strict Environmental Standards Established for Western Coal	0.50	0.40	0.30		0.20	0.05	0.75	0.50
4. Energy Storage and Load Control Reduce Industrial Peak by 10 Percent	0.20	0.15	0.15	0.50		0.10	0.60	0.75
5. A Moratorium on New Nuclear Plants Is Passed by 10 States	0.10	0.50	0.30	0.20	0.20		0.75	0.50
6. Peak and Seasonal Pricing Is Adopted	0.75	0.25	0.20	0.50	0.75	0.10		0.65
7. Average Load Factor Increases by 15 Percent	0.50	0.10	0.30	0.50	0.20	0.10	0.65	

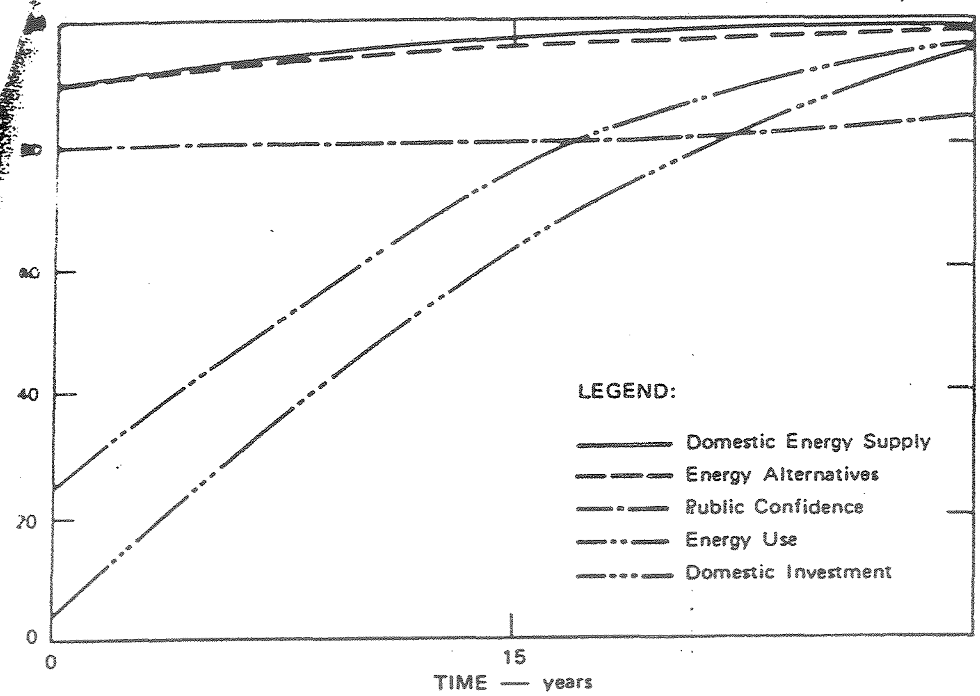
Initial Estimates of Event Occurrence Impacts

If This Event Occurs:	Initial Probability by 1985	The Probability of This Event Becomes: 1	2	3	4	5	6	7
1. Electricity Price Increases by 50 Percent	0.25		0.60	0.40	0.45	0.08	0.85	0.50
2. Conservation Reduces Average Load 4 Percent and Peak Load 1 Percent	0.30	0.35		0.50	0.40	0.10	0.90	0.25
3. Strict Environmental Standards Established for Western Coal	0.50	0.40	0.30		0.40	0.05	0.75	0.50
4. Energy Storage and Load Control Reduce Industrial Peak by 10 Percent	0.40	0.15	0.15	0.50		0.10	0.60	0.75
5. A Moratorium on New Nuclear Plants Is Passed by 10 States	0.10	0.50	0.30	0.20	0.40		0.75	0.50
6. Peak and Seasonal Pricing Is Adopted	0.75	0.25	0.20	0.50	0.50	0.10		0.65
7. Average Load Factor Increases by 15 Percent	0.50	0.10	0.30	0.50	0.40	0.10	0.65	

Final Estimates of Event Occurrence Impacts

T.4. KSIM (Kane Simulation) is a form of dynamic model (see T.2) and also a form of cross-impact analysis (T.3) which provides a tool to interface broad planning or policy issues stated qualitatively with quantified data. KSIM begins with a small group workshop procedure to define variables and their relationships and then uses a computer program to display changes over time in the variables under changing policy interventions. See ~~Kruzic~~ SRI, pp.139-54.

CONSIDER Initial Projected Variable Interactions of the National Deep Water Port System



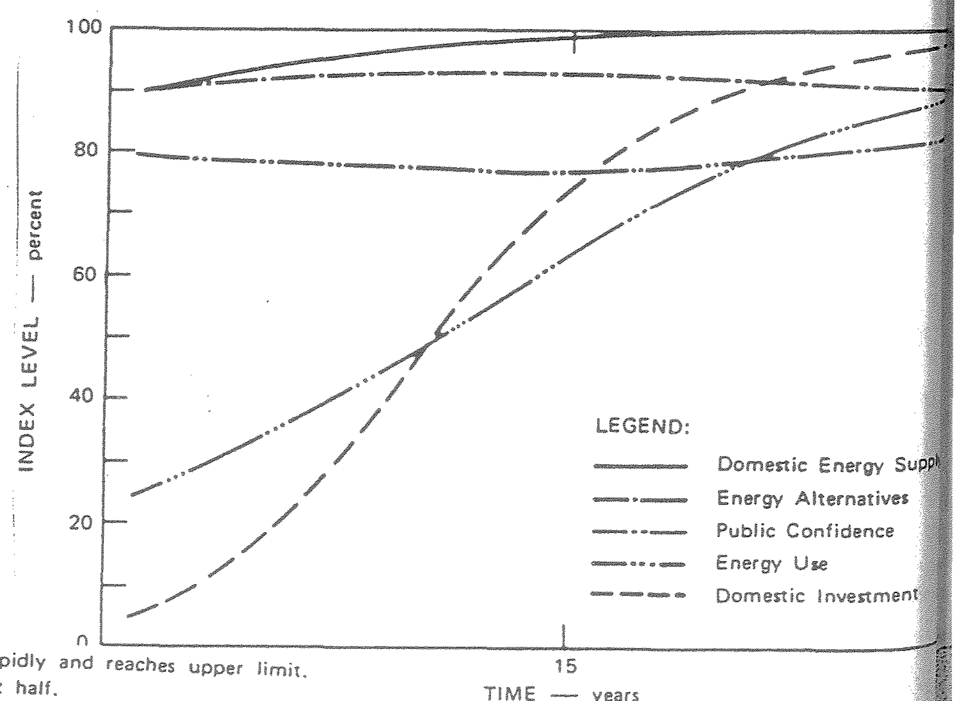
← Ex. T.4(a)

BASE CASE

Domestic investment increases steadily to near
Energy use increases steadily to near maximum
Public confidence is stable.
Domestic energy supply increases to maximum
Energy alternatives increase to maximum.

CONSIDER: Crude Oil Imports not Available.
Impact of Outside World on Domestic Investment is Positive.

Ex. T.4(b) →



IMPLICATIONS:

Domestic investment lags then increases rapidly and reaches upper limit. Over 70 percent of increase occurs in first half.

Energy use increases at slower rate.

Public confidence dips in first half and then recovers.

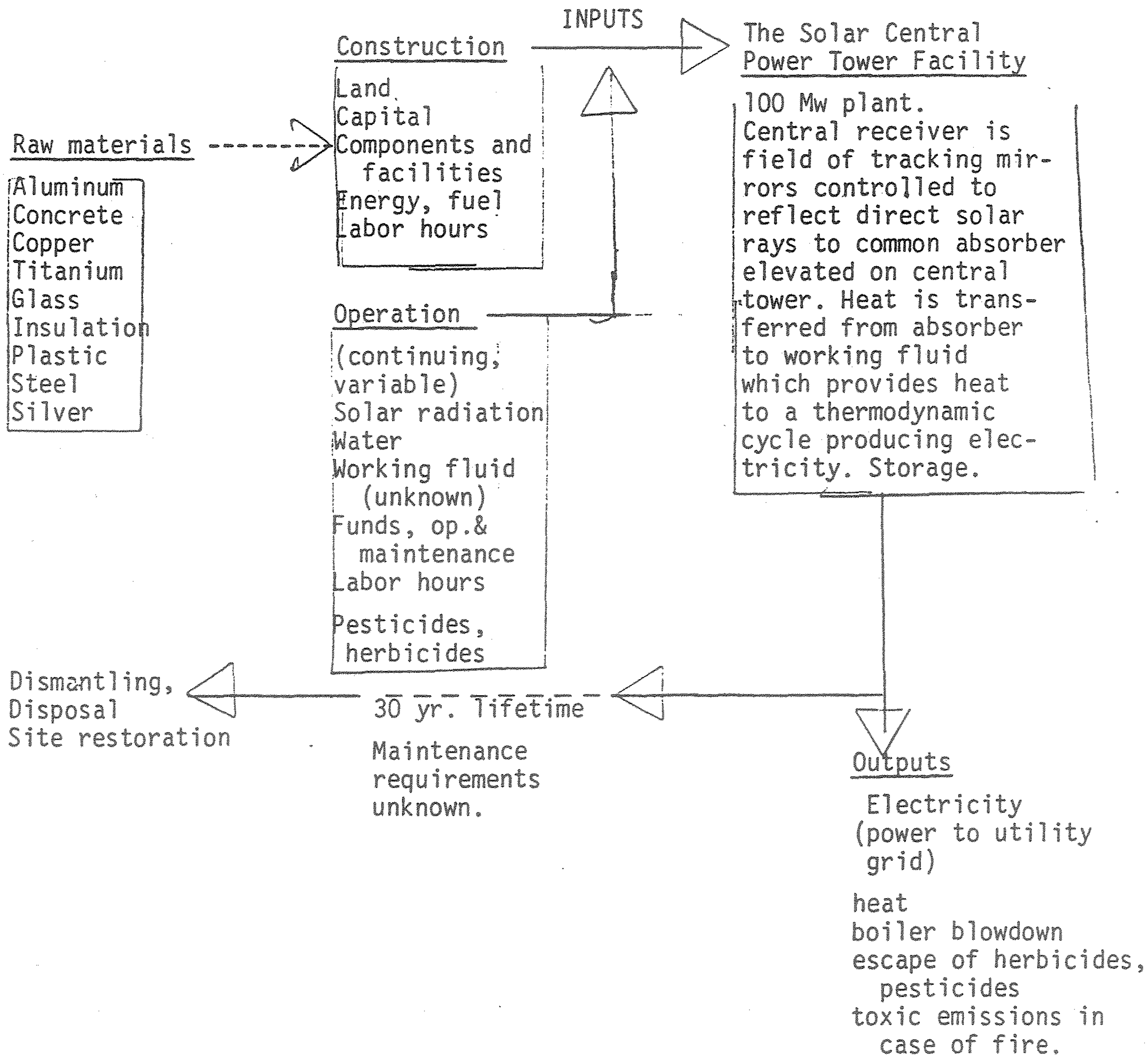
Domestic energy supplies rise to maximum in first half

Energy alternatives rise in f...

T.5. System diagram of a technology . This is a paper and pencil exercise for use in the technology characterization tasks of assessment. It becomes a scaffolding for other analytical tasks throughout the assessment, for example, estimating inputs for a phased technology/demand matrix (T.6) or laying out the social organizations and institutions associated with the technology. The system diagram lays out all of the inputs to the technology, both for its manufacture or construction, and those consumed during its operations, and also identifies outputs (products, byproducts, pollutants, etc.)

Ex, T.5

System diagram, example.



T.6. Phased Technology/Demand Matrix (PTDM) This is another pencil and paper exercise designed to help in deriving potential impacts associated with the resource requirements of a technology.

~~PHASED TECHNOLOGY / DEMAND MATRIX -- EXPLANATION AND NOTES~~

See Exhibit T.6, following page

~~The Phased Technology / Demand Matrix is intended as an analytical aid in the identification of potential impacts or consequences of technological innovation.~~

The user first describes the technology in detail (vertical axis). The PT/DM requires and will allow considerable modification or variation depending on whether the technology to be assessed is the most advanced application of an existing technology (e.g., a new coal mine or a manufacturing plant) in a known location, or a technology which exists only in concept. In the latter case, many iterations of the matrix will be required to investigate alternative configurations of the "final" technology, alternative strategies for development and/or commercialization, and all possible uses and misuses of the technology.

Each phase of the technology as described is then assessed in terms of its requirements, or demands -- these may be treated on a local, regional, national, or global scale. They may be described quantitatively or qualitatively.

The estimation of these requirements then guides the search for possible impacts and at the same time gives some indication of their magnitude. Both "benefits" and "disbenefits," internalized costs and "externalities," must be identified, and it is particularly important to flag uncertainties and unknowns.

NOTES

(a) The solution of technical, management, legal, political, or social problems at the initiation (R&D or planning) stage of a technological enterprise can carry over into other enerprises and thus create significant impacts whether or not the original enterprise is successful. Consider possible spin-offs.

(b) Consider: ownership and institutional (industry) context of the technology, changes in landuse and impact on local plans, environmental impacts of construction including noise and congestion, temporary employment and income impacts.

(c) Note that transportation/distribution occurs at both input and output ends of the operation. Consider health and safety of workers and the community, disposal or recycling of byproducts.

(d) Consider: employment, costs, institutional, political impacts of regulatory mechanisms.

(e) Consider: new or enhanced capabilities created by the products or services, criminal and antisocial abuses of the products, disposal or recycling of product.

(f) This phase is usually overlooked. Consider both closedown of specific facilities, obsolescence of the technology itself, possibility of continuing innovation and improvement, effect of heavy capitalization in blocking alternative innovations.

(g) Consider: opportunity costs, availability of risk capital, insurance, inflation.

(h) Consider: management, skilled and unskilled labor needs; number, location, and duration of employment opportunities, effect on minorities, etc.

(i) Consider: amount, location, quality, ownership, present and future uses of land, mineral and water rights.

(j) Consider alternative sources and types of energy, location and transmission, net energy accounting, alternative uses, security of supply.

(k) Consider location, sources, grades, criticality and security of supply, substitutability, recycling or recovery.

(l) Consider: air, water, land, noise, aesthetics, ecology, natural disasters, climate.

(m) Consider: new skills, training and retraining systems; advances in knowledge from R&D (basic and applied).

(n) Consider: adequacy of existing institutions or need for new ones, changes in function of existing institutions -- economic, political, social. Consider: family, community systems and governmental institutions. Consider: interest group formation.

Appendix 1

PHASED TECHNOLOGY / DEMAND MATRIX - FOR IDENTIFYING POTENTIAL IMPACTS OF TECHNOLOGY

TECHNOLOGY	.CAPITAL (g)	.LABOR (h)	.LAND (i)	.ENERGY (j)	.MATERIALS (k)	.ENVIRONMENT (l)	.KNOWLEDGE (m)	.INSTITUTIONS (n
Initiation (a) Basic research Development Demonstration or Pilot Design, Planning								
Implementation (b) Ownership Siting Construction Procurement, Contracting								
Operation (c) Inputs Processes Outputs Products Services Byproducts Transportation, distrib.								
Regulation (d)								
Utilization (e) Use & misuse Product disposal								
Closedown or Obsolescence (f)								

Developed by: Vary T. Coates, Ph.D.
Associate Director, Program of Policy Studies
in Science and Technology
The George Washington University, Washington, D.C

change

T.7. Input-Out Analysis. An input-output transactions table shows the relationships, in dollars, between the inputs and outputs of each industrial sector in an economy (national, regional, or local), and the relationships between the sectors. For example, the highly simplified matrix below, *from* which shows only three highly aggregated sectors for some small region or for a Lilliputian country, says that annual agricultural output (sales) amounted to $70,000. Of this, $10,000 worth of products or services were sold within the agricultural sector (e.g., farmers sold feed to livestock raisers). $5,000 worth was sold to the manufacturing sector (perhaps cotton to textile mills) and $5,000 to services industries (perhaps restaurants). $50,000 worth was sold to households ("Final Demand").

During the same year, the agricultural sector purchased $20,000 worth of goods and services from manufacturers (tractors), $5,000 from the services sector (vetinarian care), $5,000 in imported goods; and also paid out $30,000 in wages, rents, interests, and profits to owners. Note that the gross output column and the gross outlay column always balance. A somewhat more complex transactions table appears on the next page, Exhibit T.7b.

The transactions table would be accompanied by (or integrated with) a table of direct requirements, or coefficients, which translates these dollar amounts into percentages of gross outlay or output. The second vertical column of the Lilliputian coefficients table would, for example, read:

	Manufacturing
Agriculture	.05
Manufacturing	.30
Services	.10
Imports	.15
Value Added	.40
Gross Outlay	1.00

This tells us that for every dollar spent by manufacturers, 5¢ goes to agricultural sector, etc.

If then a Lilliputian manufacturer invents a better mousetrap, and demand for Lilliputian manufactured products rises by $10,000 as a result, we can anticipate that agricultural sales will also rise by $500 as a result of increased purchasing by the manufacturing sector. To produce this additional $500 worth of products, the agricultural sector will buy $145 dollars worth of additional tractors or tools, and to produce them, the manufacturing sector will buy an additional $7.24 worth of goods from the agricultural sector -- in other words, each change in one sector sets off a round of changes in other sectors, which in turn set off still another round of changes throughout the economy.

Input-output models work through all of these changes by computer, thus producing a final table of direct plus indirect requirements per dollar of delivery to final demands.

Ex. T.7a

I/O

Transactions Table ($1000)

		Purchasers: Agri-culture	Purchasers: Manufac-turing	Purchasers: Services	Final Demand	Gross Output
Sellers	Agriculture	10	5	5	50	70
Sellers	Manufacturing	20	30	25	25	100
Sellers	Services	5	10	10	55	80
Imports		5	15	5		
Value added		30	40	35		
Gross outlay		70	100	80		

E4 T.7 b7

Hypothetical Input-Output Transactions Table

Sector Purchasing (in Billions $)

Sector Producing	Inputs[2] ↓ / Outputs[1] →	Processing Sector (1) A	(2) B	(3) C	(4) D	(5) E	(6) F	Final Demand (7) Gross inventory accumulation (+)	(8) Exports to foreign countries	(9) Government purchases	(10) Gross private capital formation	(11) Households	(12) Total Gross Output
Processing Sector	(1) Industry A	10	15	1	2	5	6	2	5	1	3	14	64
	(2) Industry B	5	4	7	1	3	8	1	6	3	4	17	59
	(3) Industry C	7	2	8	1	5	3	2	3	1	3	5	40
	(4) Industry D	11	1	2	8	6	4	0	0	1	2	4	39
	(5) Industry E	4	0	1	14	3	2	1	2	1	3	9	40
	(6) Industry F	2	6	7	6	2	6	2	4	2	1	8	46
Payments Sector	(7) Gross inventory depletion (−)	1	2	1	0	2	1	0	1	0	0	0	8
	(8) Imports	2	1	3	0	3	2	0	0	0	0	2	13
	(9) Payments to government	2	3	2	2	1	2	3	2	1	2	12	32
	(10) Depreciation allowances	1	2	1	0	1	0	0	0	0	0	0	5
	(11) Households	19	23	7	5	9	12	1	0	8	0	1	85
	(12) Total Gross Outlays	64	59	40	39	40	46	12	23	18	18	72	431

[1] Sales to industries and sectors along the top of the table from the industry listed in each row at the left of the table.
[2] Purchases from industries and sectors at the left of the table by the industry listed at the top of each column.

* From Miernyk, Wm. H., *Input-Output Analysis*, Random House (5th printing 1967).

Input-output tables have been computed for national, regional, and even a few metropolitan economies. They are almost always from several years to a decade old, but the assumption is that the sectoral relationships remain fairly stable. While most OTA assessments would neither require nor support extensive I/O modeling, simple inspection of an I/O table and some gross calculations can provide valuable insights into some of the potential impacts of technologies which might have a significant effect on the output or outlay of a large industry.

For additional discussion of the use of I/O analysis in forecasting and technology assessment, see ~~Kruzic~~ SRI, pp.155-172, or ~~Government~~ EPA Models, pp.

T.8. Life-cycle schematics. Another paper and pencil exercise which is helpful both in identifying impacts and in working out state of society assumptions involves working out a timeline for the technology or for a project (e.g., a pipeline or power plant). For a new energy technology, such as synfuel development, a life-cycle schematic might include:

Stage	Time	Changes to Be Investigated
R&D		
Pilot plant	—	Inflation, escalation of price of alternative fuels, changes in availability of materials, significant advance in technology.
Design/plan.	—	
total	10 yrs.	
Siting	9 mon.	
Construction	—	Escalation in costs of construction, changes in surrounding land values, secondary economic development, boom towns, etc.
Operation	30 yrs.	Decreasing efficiency from aging. Increasing stringency of regulation. Development of new competing technologies (solar?). Increased demand (rising population). Increased taxes.
Obsolescence, close-down,		High unemployment in surrounding area. Accumulated pollution on site. Costs of clean up and site restoration.

In some cases it is also necessary to deal with the anticipated life cycle of technologies and industries. See Technology Forecasting, T.~~10~~. 9.

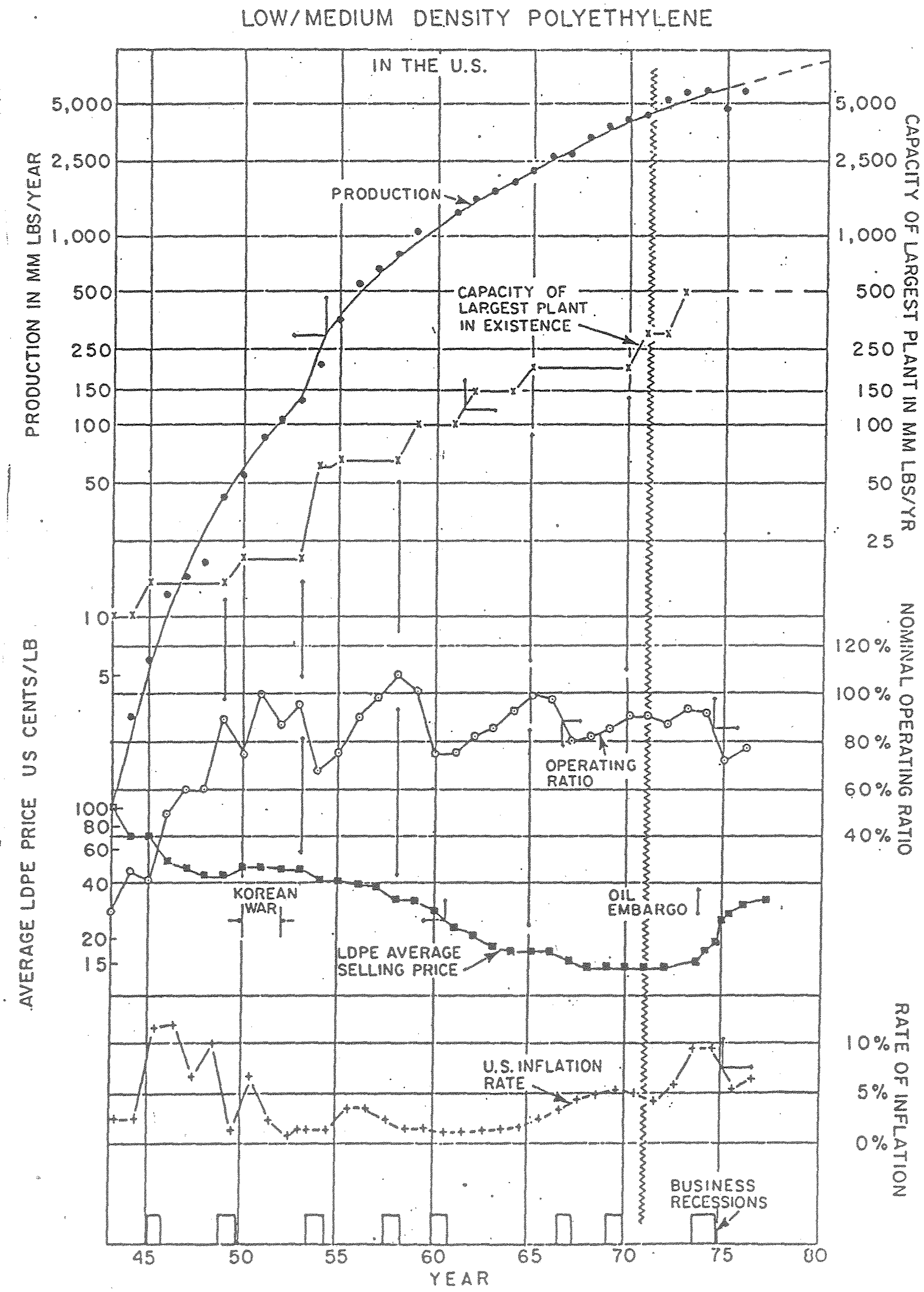
One attempt to deal with life-cycle effects of industries using new technologies is shown in ~~the~~ exhibit ~~below~~. T.8. It embodies the following assumptions:

-- rapid progress in a scientific or technological field,
-- a large market available through substitution or displacement of existing goods or services,
-- a relatively high cost of design,
-- rising demand which necessitates new capacity,
-- technological progress which reduces the unit cost of the product (at the same scale of manufacture) but also permits larger plants (or larger units, such as aircraft),
-- which leads to reductions in unit cost.
-- High design costs tend to delay redesign, leading to
-- characteristic stepwise increase in the size of the largest plant (or unit).
-- Larger units produce overcapacity, and
-- prices drop. These lead to
-- further market penetration and growth in demand.

The argument is that these ripple effects can be discerned in many technologies such as aircraft, computers, petrochemicals, space vehicles, tankers, etc., and by historical analogy can be applied to other new technologies.

See: Simmonds, W.H.C., "The Analysis of Industrial Behavior and its Use in Forecasting," Technology Forecasting and Social Change 3, 1972, 205-224, and "Aggregating Technology into Economics," paper presented at the First Global Conference on the Future, World Future Society, Toronto, July 20-24, 1980. Simmonds is on the staff of the National Research Council of Canada.

Exhibit T.8. Modeling lifecycle behavior of technology.
(from "Deflationary Growth," by W.H.C. Simmonds, National Research Council of Canada, ms., n.d.)



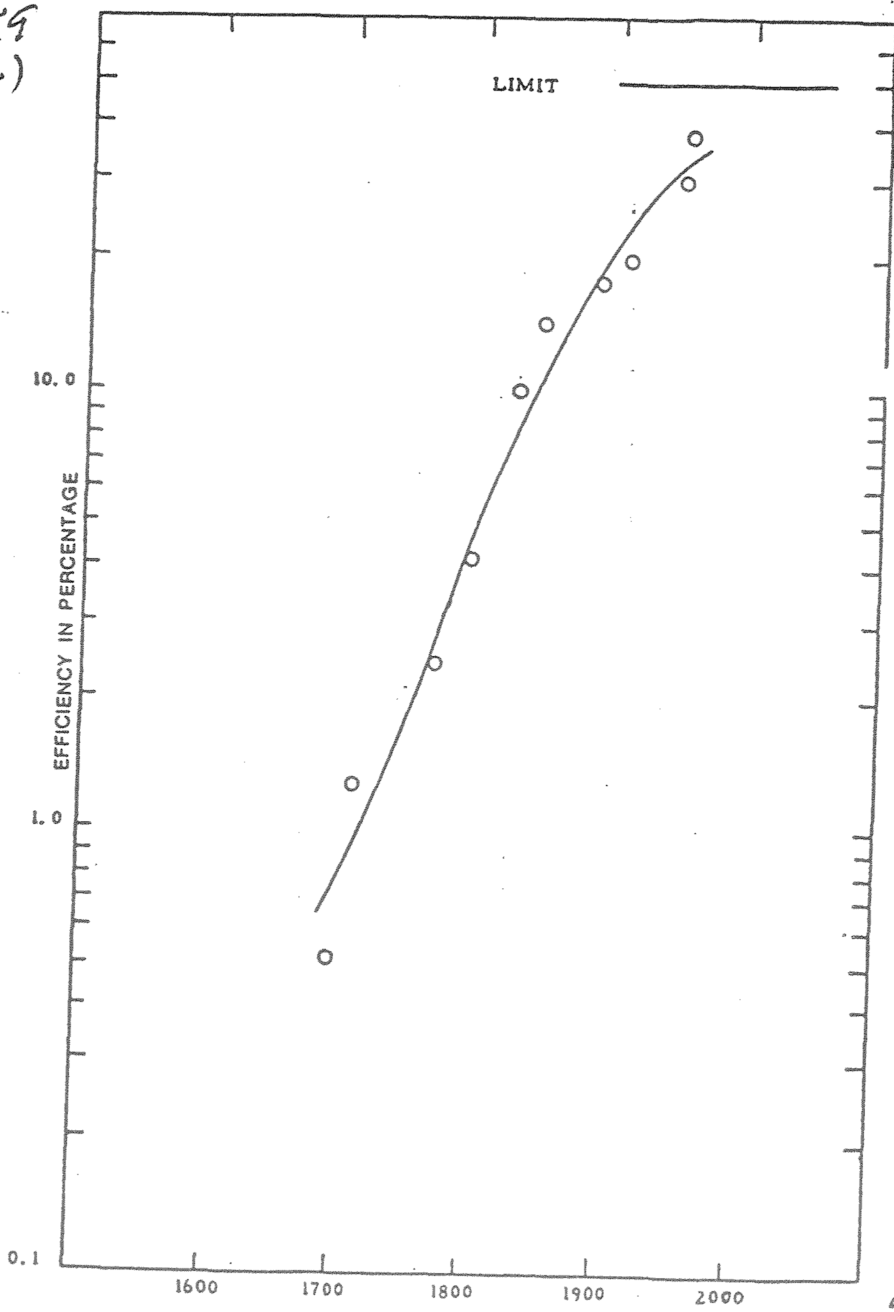
T.9 Technology Forecasting. Technology forecasting is useful in anticipating the future direction and pace of technological development, and also the rate or pace at which a new technoloty may replace an older technology or reach a significant level of utilization ~~(see Substitution forecasting, T.11)~~.

Technology forecasting is not difficult or expensive, but it is one part of an assessment which can readily be contracted out if no one on the assessment team is experienced with it, as it is a fairly self-contained undertaking.

The two most commonly used techniques are growth curves and trend curves, both simple extrapolation techniques. Growth curves are appropriate for forecasting the future behavior of a single new technology (such as EFT) or a technological characteristic which unites several generations of technology (e.g., aircraft passenger miles per hour, or aircraft noise).

Technology forecastors often assume that a new technology usually progresses slowly at first, until basic problems are solved; then progress becomes rapid for a time because of competition and a high level of investment; at a later stage progress slow again as some technical limit is approached and it is harder to squeeze out each new increment of improvement.

Ex. T.9 (a)



It is expected therefore that technical progress can usually be described with a "lazy S" curve.

See exhibit T.9 (a) for an historical example.

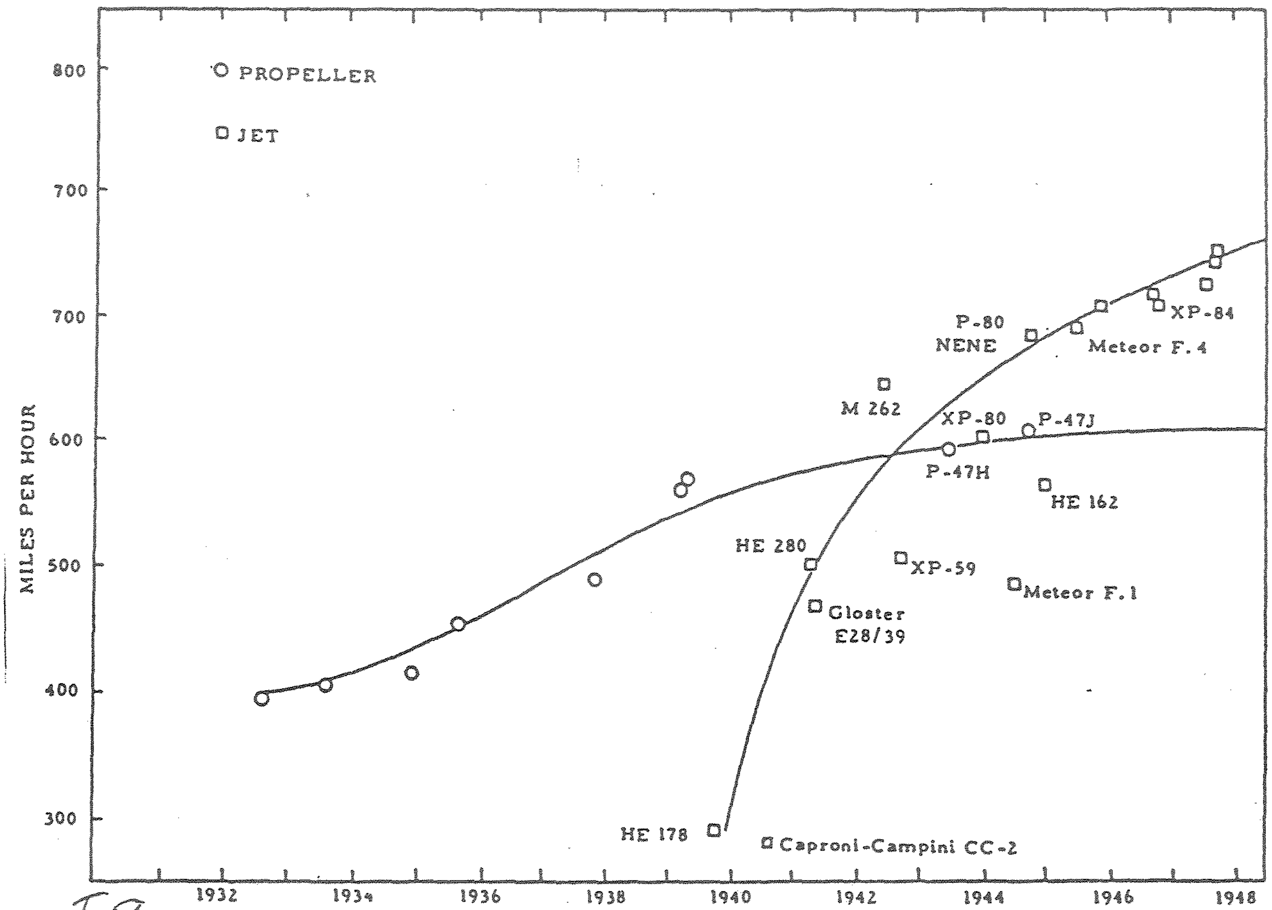
If the technical limit is overcome, with a new generation of technology o an entirely new technical approach, progress begins again. See exhibit (b) and (

Forecasts for a technology which has already had a relatively long period of development and for which there is considerable empirical data are considerably more credibl than those for technologies which have a current substitution of 25% or less. In the latter case, historical analogies, to similar technologies, can be suggestive.

Some technologies, especia those which deliver a new cap ity or a large quantum increa in capability, do not exhibit lazy S curve. See exhibit (c) for one example.

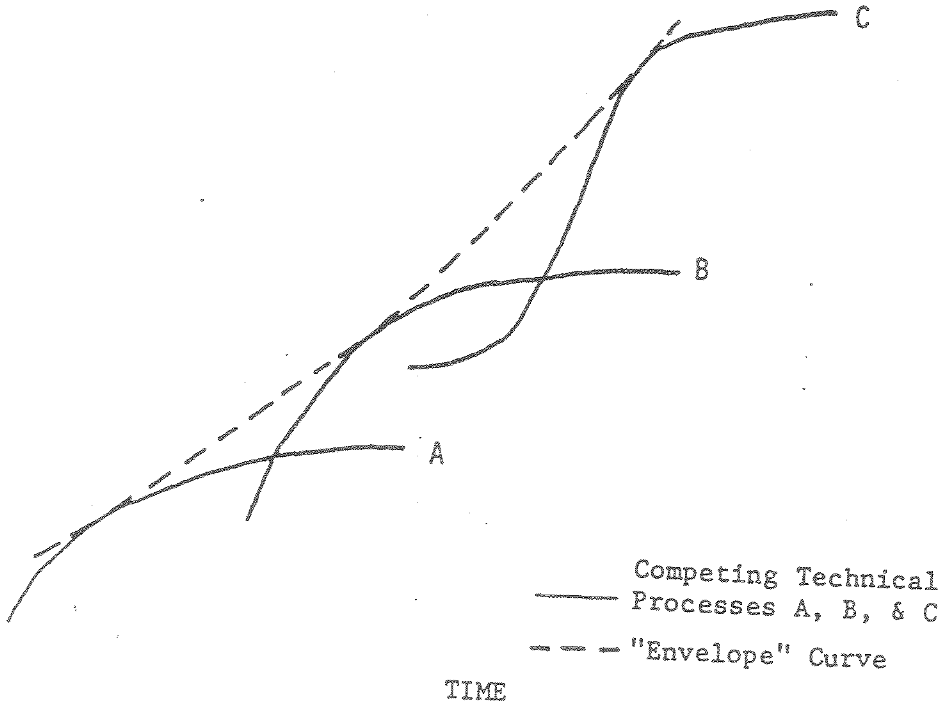
T.9 (a)

Growth in Efficiency of Steam Engines



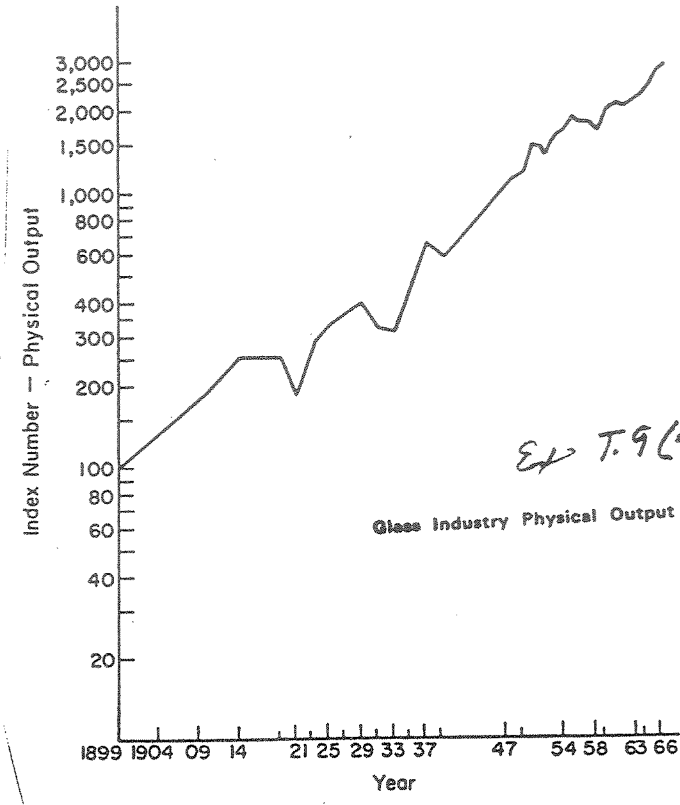
T.9 (b)

~~Figure 2~~. Intersection of Growth Curves for Speed of Propeller-Driven and Jet-Propelled Aircraft



Level of Technological Progress, Efficiency, or Productivity

T. 9 (C)



Ex T.9 (4)

A major problem is forecasting when technological breakthroughs will occur and technical limits be overcome. Some forecasters choose a measure of performance which has steadily progressed (such as aircraft passenger miles per hour) and extrapol this trend without attempting to specify how advances will come about -- for example, whether through new propulsion technologies or increases in cabin size.

An alternative is to use one or another correlation techniques. One example is the leader-follower approac combat aircraft development has consis-tently led and prefigured commercial aircraft development, with a rather consistently increasing time lag. This can be extrapolated. Another alterna-tive is to look for "precurson events" (see T.20). For example, it is sometim assumed that an increase in the number of professional/scientific papers related to a technological area indicates increased interest and funding, and therefore the liklihood of a technological breakthrough will increase.

For detailed discussion of technology forecasting see: Fowles, pp. 369-396, also: Bright, ~~Ayres~~ p. ...

<u>T.10. Scale effects.</u> An important consideration in evaluation of the potential consequences of a new technology are effects of increasing scale -- that is, the typical size of unit operations and facilities, or the degree of centraliza-tion or dispersion of applications of the technology.

In regard to such technologies as power generation, telecommunications, computers, banking, etc., it is generally recognized that the social, economic, and environmental impacts are quite different for

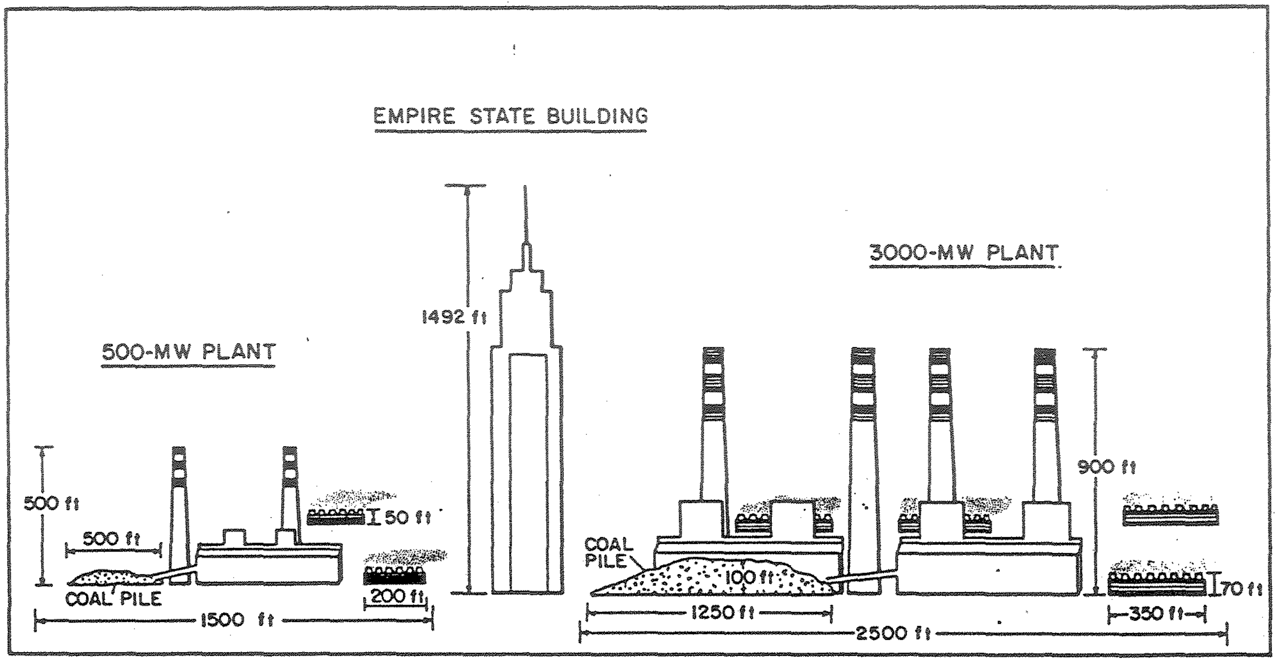
-- small scale, dispersed applications (e.g., small scale hydropower)
-- large scale, centralized applications (e.g., very large dams)
-- highly integrated national and regional networks (e.g., a regional power grid).

The degree of dependence of a community, region, or nation on one central technological resource or network, and hence the vulnerability to its disruption, is also important.

Engineering studies of theoretical efficiencies of systems, and statistica econometric studies or models of economies of scale (or diseconomies of scale) are usually industry-specific or firm-specific. The literature on social and environmental effects of scale is voluminous but tends to be ideological, advocacy-oriented, and theoretical, or very highly site specific. Thus there are few wide used or generally adaptable techniques for getting at scale effects other than informed judgement.

A paper by Kenneth Jameson on "Economies of scale in the Electric Power Industry," in Sayre, op.cit., will provide suggestive analogies. See also "A New Look at Small Power Plants," Los Alamos Scientific Laboratory, LASL 78-101, Jan. 1979, from which the following example is taken. It illustrate a way to display scale differences graphically, to aid in team discussion.

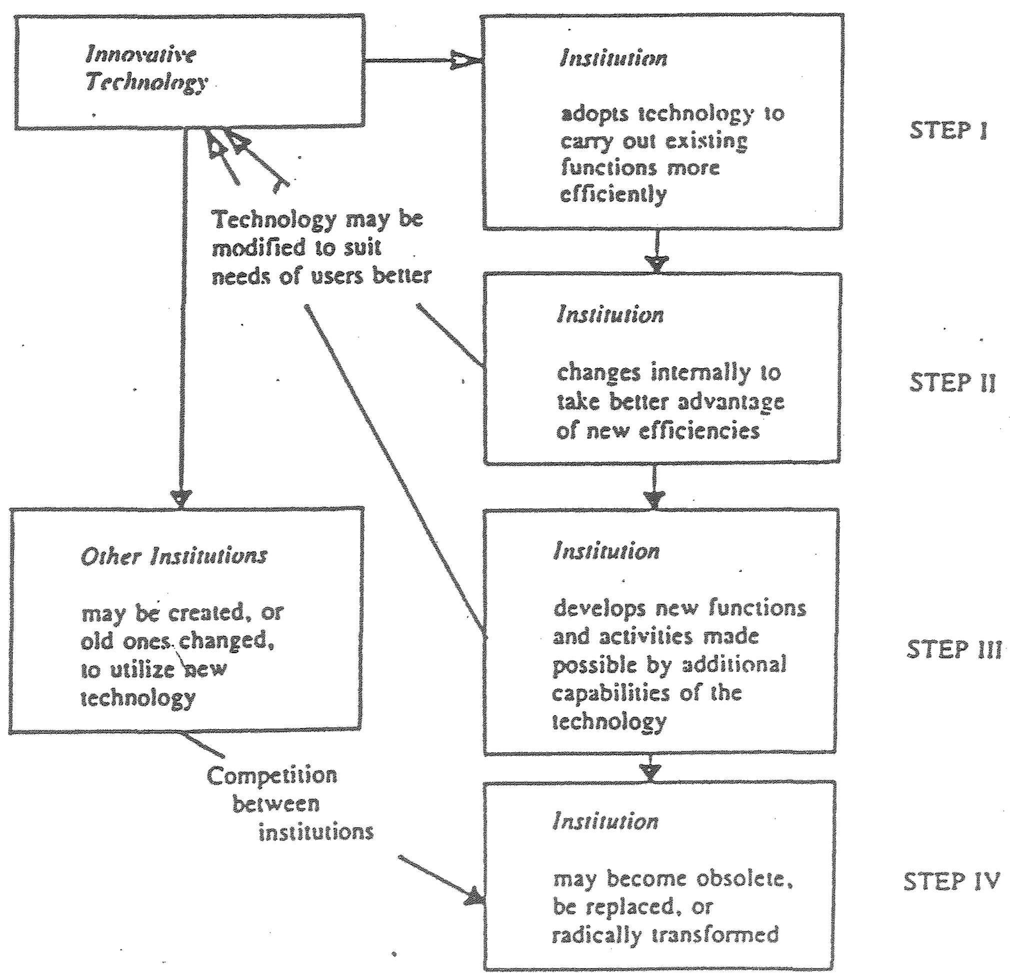
T.10 Scale Effects



T.11. User Institution model. This conceptual approach facilitates identification of technology's impacts on public and private institutions which adopt and use it. It suggests that:

- o the user institution adopts the new technology to replace an existing technology and carry out accustomed functions more efficiently
  - -- a retail merchant replaces an established bookkeeping system, and calculating machines with computers,
  - -- a manufacturer replaces assembly line operators with industrial robots,
- o the user institution changes internally in order to take full advantag[e] of the new technology's capabilities
  - -- the merchant reorganizes accounting procedures, and then moves to continuous inventory control,
  - -- the manufacturer reorganizes the factory floor to use flexible manufacturing systems incorporating robots;
- o the user institution exploits additional technological capabilities to initiate new activities
  - -- the merchant installs point-of-sale terminals and offers banking services to customers,
  - -- the manufacturer begins the manufacture of some products in space, or in other environments where human workers could not function;
- o entirely new institutions may evolve, or older institutions be transformed.

This framework is an example of a class of "search protocols" which do not prov[ide] answers, but suggest questions to aid the assessment team in thinking about a problem.



Ex. T.V

~~FIG. 6-1~~.—Impact of technology innovation on user institutions (after Joseph Coates, *Telecommunications Policy* 1:196–206, 1977).

T.12 Cost-Benefit Analysis is now the principal analytical framework for evaluating public expenditure decisions. In theory, cost-benefit calculations compare all costs and all benefits (tangible and intangible) of a proposed project, program, or regulatory activity, to be sure that public resources are put to their most valuable use. How, then, is it different from technology assessment?

First, cost-benefit analysis is a closed algorythm for evaluating ways of achieving a clear-cut, already evaluated objective. Secondly, in practice it is chiefly useful for evaluating alternatives which can be tightly specified in terms of dollars. Costs are usually defined as investment costs plus annual operating costs, modified or adjusted by a discount rate. The costs are taken at present market values, the discount rate is either the prevailing cost of capital for investment or a social discount rate taken to represent that which is necessary to achieve some desired distribution of expenditure over time; in other words, a statement of the present value of some future dollar ($1 invested at 9% for 10 years is worth $2.37 at the end of that time; thus a dollar's worth of benefits in 1992 is worth 42¢ in 1982).

Evaluating social and environmental costs and translating them into dollars for comparison is obviously difficult and controversial; there is a voluminous body of literature on techniques for making the translation, such as "willingness to pay," "willingness to be compensated," etc., which will not be discussed here.

Cost-benefit analysis is nevertheless a highly useful tool within technology assessment, appropriate for comparing economic (monetary) costs and benefits in four kinds of situations:

(1) evaluating a single project or action: in the simplest case, if the dollar benefits exceed dollar costs, the evaluation is positive.

(2) choosing one of a number of discrete alternatives as preferable: for example, choosing between eight sites and/or designs for an agency headquarters, eight congifurations for a power plants, etc. The one with the largest net benefit would be the best choice, if only direct economic costs and benefits are relevant. See exhibit T.12 (a).

(3) Choosing the best scale for a project, i.e., choosing between non-discrete, or continuous, alternatives. Here the selection rule is, the best alternative (or scale) is that with the highest net benefit, or the lowest positive marginal net benefit. See Exhibit T.12 (b).

(4) evaluating projects or activities which are subject to a resource constraint: for example, out of eight projects judged to merit funding, how many and which ones should be funded if there is not enough money to go around? Here, one calculates the net benefits per dollar of cost for each project, ranks them in order accordingly, calculates cumulative cost from the top down (that is, from the project with highest net benefit per unit cost to that with the lowest) and funds projects in that order until the money runs out. See exhibit T.12 (c) -- if the funding limit is $500,000, the first four projects would be funded.

It is important to note that cost-benefit analysis does not imply evaluation based on a benefit/cost ratio as sometimes carelessly stated. In the example below, project II is the best choice between alternatives because it delivers the highest net benefits -- if the $25,000 is available -- even though the less costly project has a higher benefit/cost ratio.

Project	Benefits	Costs	Net benefits	Benefit/cost ratio
I	$10,000	$1,000	$9,000	10
II	100,000	25,000	75,000	4.0

Exhibit T.12 (a)
(example 2)

Headquarters	Initial cost	Benefit: Savings on energy costs	Savings on maintenance costs	Total benefit	Net benefit
A	100	100	500	600	500
B	500	400	850	1250	750
C	200	200	600	800	600
D	75	25	150	175	100
E	150	50	325	375	225
F	200	150	250	400	200
G	50	75	100	175	125
H	150	175	275	450	300

(All figures are in thousands of dollars.)

Exhibit T.12 (b)
(example 3)

Suppose that the forest manager for our conservation area wants to make an informed decision on how much fertilizer to use on the area's nursery of tree seedlings. Fortunately, the experts at the state Forestry Experiment Station have extensive data on the benefits of fertilizer and also on what these benefits are worth in dollars for a tract of this type. The information provided may be expressed in the form of a graph, as shown in Figure 9–1. The forest manager's estimates of the cost of fertilization, including the cost of the fertilizer itself, are also shown in Figure 9–1.[3] In

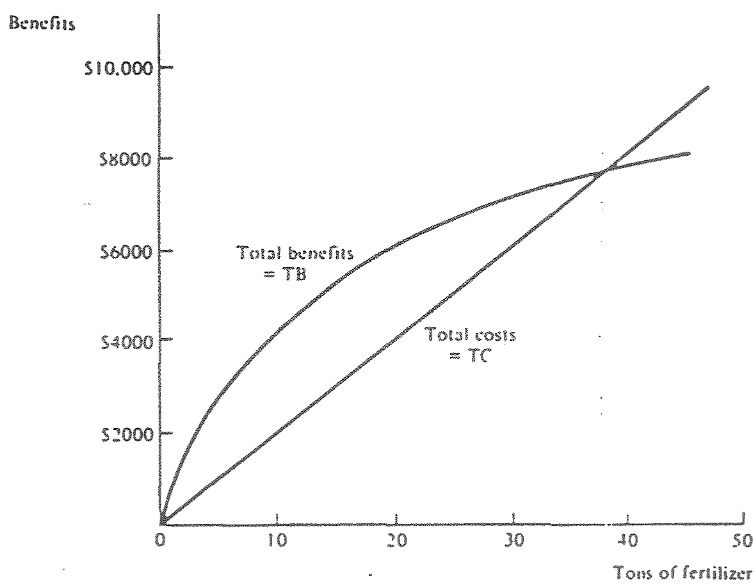
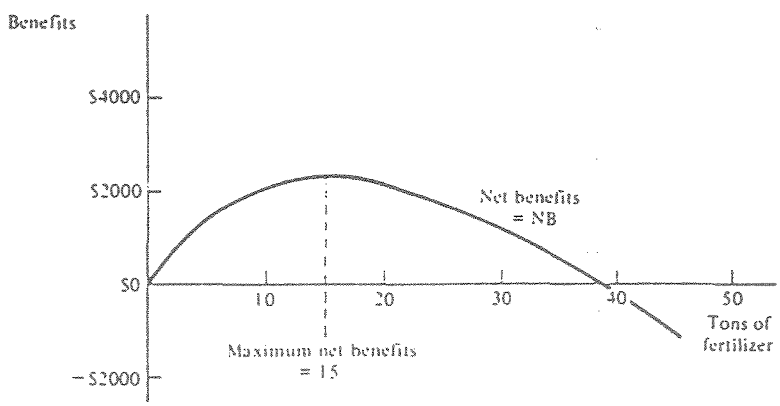


Fig. 9–1

~~Figure 9–2,~~ net benefit = (total benefit − total cost) is shown. Net benefit reaches a maximum at about 15 tons. Hence 15 tons of fertilizer should be applied to the seedling forest.



~~Fig. 9–2~~

[3] In actually solving a problem such as this, an analyst would ordinarily not rely on a graphical solution. Rather he would attempt to describe the relationships by equations, which would permit a more precise answer to be determined. Graphs are superior for expository purposes

Exhibit T.12 b continued

(1) Tons	(2) TB	(3) TC	(4) NB	(5) MB_F	(6) MC_F	(7) MNB_F	(8) $MNB_\$$
5	2.5	1.0	1.5	.50	.2	.30	1.50
10	4.1	2.0	2.1	.32	.2	.12	0.60
15*	5.3	3.0	2.3	.24	.2	.04	0.20
20	6.1	4.0	2.1	.16	.2	−.04	−0.20
25	6.7	5.0	1.7	.12	.2	−.08	−0.40
30	7.2	6.0	1.2	.10	.2	−.10	−0.50
35	7.5	7.0	0.5	.06	.2	−.14	−0.70
40	7.8	8.0	−0.2	.06	.2	−.14	−0.20
45	8.0	9.0	−1.0	.04	.2	−.16	−1.00

** The optimal choice*
TB, TC, and NB are in thousands of dollars.
MB_F, MC_F, and MNB_F are in thousands of dollars per ton of fertilizer.
$MNB_\$$ is in dollars per dollar of expenditure.

Headquarters	Initial cost	Net benefit	Net benefit/ initial cost	Cumulative initial cost, all projects
A	100	500	5.0	100
C	200	600	3.0	300
G	50	125	2.5	350
H	150	300	2.0	500
E	150	225	1.5	650
B	500	750	1.5	1150
D	75	100	1.3	1225
F	200	200	1.0	1425

(All figures are in thousands of dollars.)

Exhibit T.12 c
(example 4)

In section T.12 above , explanation and examples are abstracted and/or adapted and modified from: E. Stokey and R. Zeckhauser, A Primer for Policy Analysis (N.Y.: W.W. North & Co.), Chap.9.

There are many texts on cost-benefit analysis, as well as innumerable articles and professional papers on alternative ways of placing a dollar value on benefits and costs, especially environmental benefits and costs. Ways of evaluating human life and/or health are highly controversial and there are scores of books and articles on this subject.
The Aldine Publishing Co., in Chicago, publishes a yearly selection of the most important professional articles on the subject, called the Aldine Annual: Benefit-Cost and Policy Analysis.

T.13 Cost-effectiveness analysis (CEA) is a form of cost-benefit analysis which can be used to compare alternatives where:

- o the costs are the same (or the total expenditure is fixed) and only the benefits need be compared;

or o the benefits are similar (or the mission directive is fixed) and only the costs need be compared.

Cost-effectiveness analysis does not require that everything be translated into the dollar metric, so long as the variables to be compared can be expressed in similar units.

For example,* a city agency is given $40,000 to be spent on rat control. Method A costs $400 per housing unit and is 90% successful.
Method B costs $160 per housing unit but is only 50% successful.
Method A would cover 100 housing units for $40,000 and exterminate the rats in 90% or 90 units; its cost-effectiveness is .0022.*Method B would cover 250 houses and succeed in 125 of them; its cost-effectiveness is .0031. It is therefore the better alternative.

Suppose however there is a Method C which can be used only in certain areas or in certain conditions (e.g., it can only be used in dirt-floored basements). Unfortunately, only 50 housing units meet this condition; it would cost $12,000 treat them, and the method is 80% successful. Therefore Method C has a cost-effectiveness of (.80x50) / $12,000 = .0033. Since it has the highest CE it should be used to the maximum ($12,000 worth) and the remaining $28,000 should be spent on Method B. In this way, 127 houses will be successfully treated (CE = .0033).

T.14 Multi-attribute Utility Analysis - this technique is similar to cost-benefit analysis, but it describes the consequences of alternatives not in terms of dollars but as intervals along a continuum of utility or value. It is described as an aid to a decisionmaker in understanding the implications of his own preferences in making decisions. Multi-attribute utility calculations use an abstract unit of value called "utils." Instead of trying to arrive at a market-value or a quaisi- or proxy-market value for all costs and benefits, this technique uses one or more direct inquiry methods of valuing consequences. A person - perhaps the decisionmaker, or a group - perhaps of potentially affected parties, may be asked to rank a set of alternative outcomes (or problem-solutions) and to make paired comparisons between adjacent items (would you prefer B or C, C or D, etc.) Or alternatives may be indicated on a scale, for example, from 1 to 10. There are also fairly complex and cumbersome mathmatical techniques for incorporating uncertainty or risk aversion and intertemporal comparisons into the valuing process.

A comparison of cost-benefit analysis and multi-attribute utility analysis can be found in Pacific Northwest Laboratory monograph PNL-RAP-24, UC-11 "Usefulness of Alternative Integrative Assessment Methodologies in Public Decision Making,"July 1978.

T.15 Risk Analysis . Risk Analysis is concerned with (a) determining or estimating the probability of undesired consequences. (b) estimating the costs and benefits of reducing that probability, and (c) the implications of this for decisionmaking. Risk analysis is particularly useful in anticipatory assessment of new technologies, planning for coping with natural hazards, and formulation of policies and standards related to environmental pollution and occupational safety and health.While risk analysis can be applied to any undesirable consequences, the current intense interest and the voluminous methodological literature now being generated tend to focus on evaluating risks to human life and health, especially in relation to justification of environmental regulation and to questions of liability and compensation.

Risks probabilities are usually estimated in terms of morbidity and mortality rates or accident rates, especially Fatal Accident Frequency Rates (FAFR). Sometimes these are translated into statistical reductions in life expectancy, expressed in days or minutes. See exhibits 4.15a. Problems obviously arise when there is no historical data to draw on; for example, in risk analysis related to nuclear power (no record of fatalities from accidents in commercial plants, but a high public perception of risk) and in anticipatory assessment of emerging technologies.

In this case, two useful techniques are event trees and fault trees. (See Tree Techniques, T.20). Event trees are sequence dependent. A symbolic mathmatical map of the technological system is prepared, an hypothetical "initiating event" for an accident or disaster is developed, and statistical procedures are used to estimate the failure probabilies of system components, safeguards, and redundancy components under the conditions of the initiating event and subsequent events. The fault tree is similar but more complex. Each component, interface, and process within the system is investigated, a failure probability is estimated, and all alternative paths for resulting consequences to other components and processes are traced and the second and higher order probabilities calculated. (These can of course be modeled on a computer.)

It has become clear that public or consumer perceptions of risk as well as statistical risk are important to decision making, and that actual and perceived risk are in many cases quite different. A number of studies have documented the difference for particular technologies or scenarios, generally agreeing that several factors such as the voluntary-involuntary nature of the risk, the degree of perceived control over the risk, familiarity with the source of the risk, frequency of contact, trust in control institutions, off-setting benefits, and dispersion/concentration of risk,are important in influencing perception of risk and the level of risk which will be tolerated. Understanding of these factors has not progressed to a point where public perception or acceptance of new risks can be reliably predicted. Surveys, questionnaires, and active public participation procedures are used to measure perception of risk; but even self-reporting of perceptions may not be a good indicator of subsequent risk-related behavior.

Estimation of the costs of reducing risk probabilities, while it may be complex, is usually do-able with straightforward engineering/economics techniques. Estimation of the benefits of reduced risk is however difficult and almost always controversial because (except where it concerns chiefly property damage, as in some natural hazards) it is likely to involve valuing human life or health effects. Some of the techniques or approaches which are used or have been advocated include

-- lifetime earnings lost or foregone,
-- willingness to pay (to avoid risk)
-- willingness to be paid (compensation for accepting risk)

-- probable compensation
-- health status indicators
-- social/public benefits (e.g., reduction in demand for or increased efficiency in use of, medical services and facilities)

These techniques for valuing the benefits of risk reduction are described and discussed in OTA Background Paper ______________________ and will therefore not be described here in detail. Unresolved methodological problems include: questions of equity (most techniques undervalue life and health of the poor, aged, women, minorities, etc., with low lifetime earnings expectations); problems of identifying and characterizing the likely victims, inadequacy or complete lack of data on less-than-fatal, cumulative, and multiple health effects; difficulties in comparing or aggregating data; etc.

Recent sources of information about risk analysis:

Exhibit (a) Illustrative Methods for Stating Risk Probabilities
from: E.Titterton, "Risk, Safety, Costs, and Common Sense," Interdisciplinary Science Reviews 6, No.4, 1981, 325.

Accident Statistics for the USA: Risk of Fatality by Various Causes as Given in the Rasmussen Report[2]

Accident type	Total number (per year)	Individual chance (per year)
Motor car	55 791	1 in 4 000
Falls	17 827	1 in 10 000
Fires and hot substances	7 451	1 in 24 000
Drowning	6 181	1 in 30 000
Firearms	2 309	1 in 100 000
Air travel	1 778	1 in 100 000
Falling object	1 271	1 in 160 000
Electrocution	1 148	1 in 160 000
Lightning	160	1 in 2 000 000
Hurricanes	93	1 in 2 500 000
Tornadoes	91	1 in 2 500 000
All accidents	111 992	1 in 1 600
100 nuclear power plants	0	1 in 500 000 000

Risks in Individual Action,[3] USA

Individual action	Minutes of life expectancy lost
Smoking a cigarette	10
Calorie-rich dessert	50
Non-diet soft drink	15
Diet soft drink	0.15
Crossing a street	0.4
Extra driving	0.4/mile
Not fastening seat belt	0.1/mile
1 mrem of radiation	1.5
Coast to coast drive	1 000
Coast to coast flight	100
Skipping annual PAP test	6 000
Moving to an unfavourable State	800 000
Buying a small car	8 000
Vietnam army duty	600 000

Death Rates per Thousand Employees From 1967–1976 in UK for Various Fuel Industries

Offshore oil and gas	1.65
Deep-mined coal	0.26
Gas	0.09
Oil refining	0.06
Nuclear	0.014

Risk in Man-Days Lost per Megawatt–Year Energy Output[4]

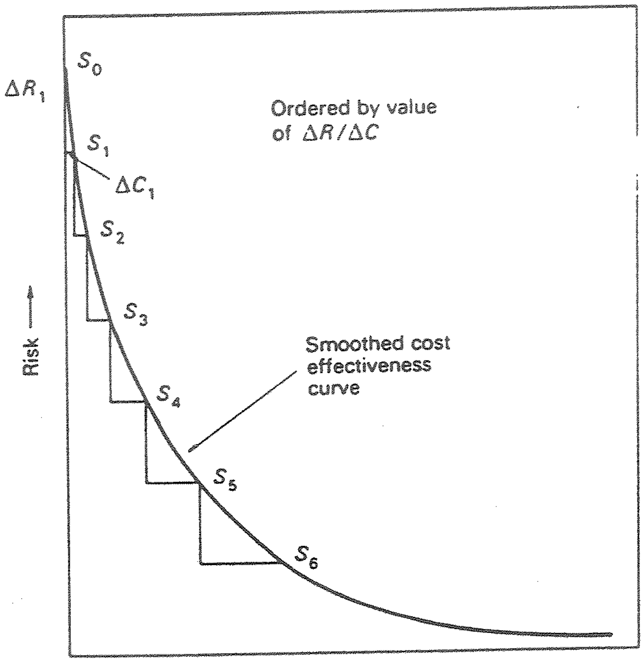
	Occupational	Public
Natural gas	5.9	—
Nuclear	8.7	1.4
Oil	18	1 920
Ocean thermal	30	1.4
Coal	73	2 010
Solar		
space heating	103	9.5
thermal	101	510
photovoltaic	188	511
Wind	282	539
Methanol	1 270	0.4

Estimated Deaths for a Specified Energy Output 10 GW yr[4]

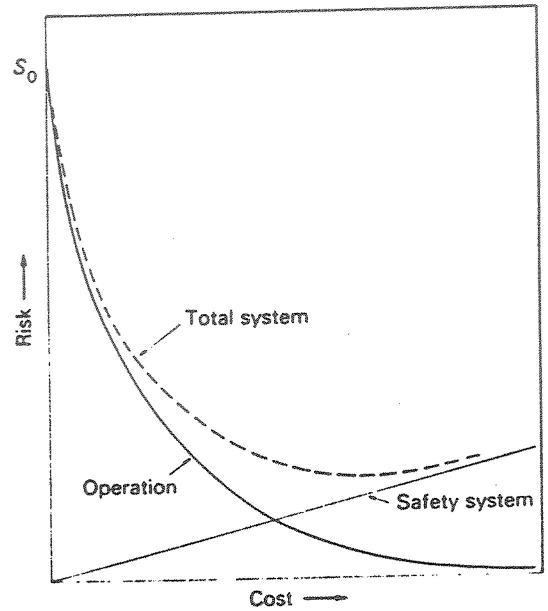
Natural gas	1–4
Uranium	$2\frac{1}{2}$–15
Solar, space heating	90–100
Wind	230–700
Oil	20–1400
Coal	50–1600

Exhibit T.15 b. Cost-effectiveness in Risk Reduction

See T.13.



Cost effectiveness of risk reduction (after W. D. Rowe[6]).



Cost-effectiveness of risk reduction considering the total economic system including adding affects of safety systems installed (after S. C. Black and F. Niehaus[9]).

T.16 Trends and Trend Extrapolation. A trend is a perceived pattern, perceived on the basis of time-series data or observation, which can be used to explain present conditions and situations and extrapolated or extended to provide some indication about, or forecast, a likely or possible condition or situation in the future. The extrapolation or projections may be simple curve fitting, or may forecast continuing cycles or fluctuations within a range indicated by past performance. What counts is that trend projection should be a rational/judgemental, and not a mechanical, exercise. Bear in mind that patterns are mental constructs only. The questions to be asked are:

- o what are the factors or forces which have been driving this trend?
- o are they continuing? will they continue?
- o what factors or forces have been dampening or limiting this trend?
- o will they continue to do so?
- o what are the inherent or natural limitations on this trend? is there a foreseeable saturation point?
- o is there any "threshold" associated with this trend? i.e., a point beyond which the effects of the trend are not sustainable? a straw that will break the camel's back?
- o are there trends which are convergent in effect, or mutually supportive or re=inforcing? (See cross-support and cross-impact matrix, T. 3.)
- o what new forces and factors may affect this trend?
- o what exogenous events -- unforeseeable occurances, extraneous or random changes -- would disrupt the trend?

The mathmatical procedures for simple trend extrapolation are laid out in ~~Kruzic~~, pp. 42-64 (as well as in most statistics text books and forecasting manuals); ~~Kruzic~~ also describes procedures for some related but less frequently used techniques:

SRI

- o the Box-Jenkins technique is a quantitative technique for deriving patterns (trends) from complex time-series data when no obvious pattern is apparent, through multiple iterations of the data through procedures which lie somewhere between multiple regression analysis and computer simulation. It can deal with only one variable. (~~Kruzic~~ SRI, pp.65-84).
- o Normex forecasting is another form of pattern recognition which requires large amounts of data and attempts to combine change patterns of several different kinds to define a joint outcome. It is still undergoing development and there is little in the literature about its use. (~~Krusic~~ SRI, pp. 65-84)
- o Proxy data for small areas is a simple technique for scaling down a body of data collected over a large (geographical) area and fitting it to a smaller sub-area by identifying localized influences over trends affecting the larger area. (~~Kruzic~~ SRI, pp.60-62).

T.17 Probabilistic forecasting. In developing future-state-of-society assumptions, generating scenarios, or studying the sensitivity to unexpected events of trends, it is sometimes useful to use probabilistic forecasting. Many phenomena appear to change randomly (i.e., we cannot discern cause-and-effect relationships driving the pattern of change) and yet to remain within some limits. Probabilistic forecasting can help the assessment team get a feel for the differences between "likely" and "unlikely" events and situations related to the interactions of technology and the social environment. Some probabilistic techniques are:

- o Monte Carlo simulation --
  - define a process as a set of possible events,
  - by a process like roulette, or generating random numbers, go through many rounds in which these events occur in various combinations or sequences,
  - by keeping track of the occurrences, and summing them, estimate relative probabilities of the cluster of events in which you are interested, or identify the clusters which occur most frequently.
- o Markov processes -- this technique assumes that (a) events are ordered in chains or connected sequences, (b) that there is some probability which can be estimated, that a given event will be followed by another given event, (c) that the amount of time necessary for one event to be followed by another event will vary, and that (d) the probabilities of this transition time can also be estimated. When these estimates are assigned, one can compute the combined probability that the process will be in any given state, as defined by events, in any given time.

Related techniques, usually derived from operations research, include inventory theory, parametric sensitivity analysis, queueing theory, and optimization techniques.

T.18 Social Indicators and Social Trend Analysis. It is clearly necessary, in doing technology assessment, to consider social as well as technological and economic change. Social forecasting is more difficult because there are more variables and a broader range of variations and interactions, and because people and institutions are adaptive and goal-seeking. However, it is important to remember that if no explicit social forecast is made, there is an implicit social forecast inherent in the assessment: of a future exactly like the present. Of all possible futures, that is assuredly the most unlikely; in fact, that is not a possible future. The credibility of such an assessment is therefore limited to the immediate present.

There is a plethora of techniques for social forecasting, relatively few of which are fully developed and codified or widely accepted and used. Most of the techniques described in this section, and many more, may be used for or adapted to social forecasting. They could be arrayed along an axis from empirical or data driven to imaginative or image-driven approaches, with trend extrapolation close to one pole and science fiction near the other; and along a perpendicular axis from normative forecasting to Monte Carlo simulations.

This section however is concerned narrowly with the use of social indicators in trend forecasting. This is a technique for using empirical data as surrogate measures or proxie representations of social variables which are intangible, incommensurate, difficult or impossible to quantify, etc. So for example, public health status can be represented by a number of indicators aspect of that social quality or condition, such as infant mortality rates, incidence of certain diseases, life expectancy, hospital admissions, etc. Quality of life work might be represented by a combination of labor turnover, tenure, strikes and work stoppages. Frequently perceptions and attitudes, as measured by opinion polls, is combined with such statistical data. Using time-series data, trends can be detected and extrapolated (see T.16) which are assumed to represent trends in the quality for which the indicators are proxie.

The Center for Demographic Studies within the Bureau of the Census issued in Dec.1980 Social Indicators III, a handsome compendium of social statistical trends (displayed in both tables and graphics) for use as social indicators. (Social Indicators I and II were issued in 1973 and 1976.) Exhibit T.17a suggests the breadth of the social indicators volume by displaying the table of contents for the summary overview section only (the full listing of contents consumes 14 such pages).Exhibit (b) is a representati

Science Indicators, published yearly by the National Science Board (NSF) provides, again both in statistical tables and in graphic displays, indicators which can be used in several different aspects of technology assessment. Exhibit (c) shows representative displays from this document.

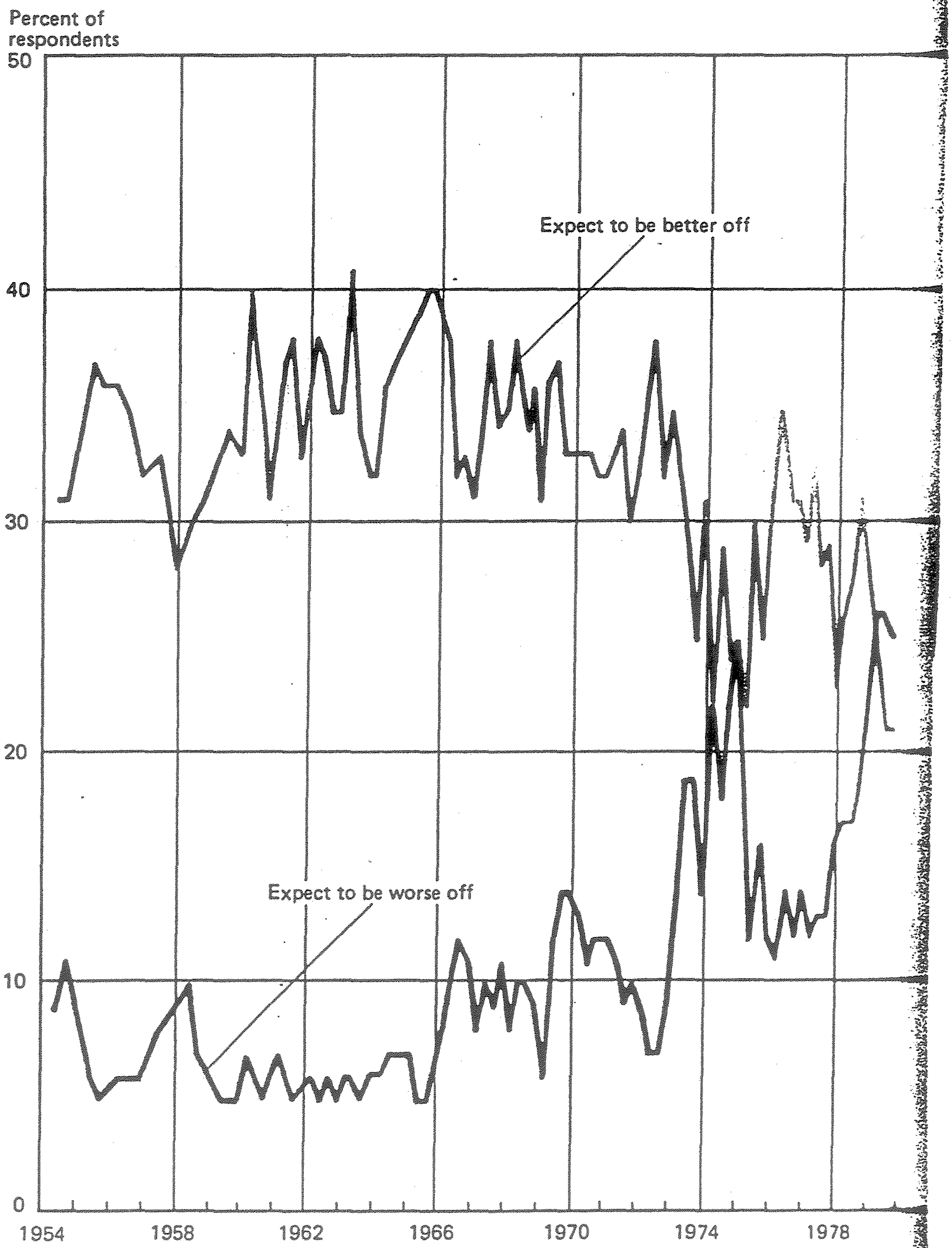
Ex. T.18 (a)

QUALITY OF LIFE IN THE UNITED STATES: AN OVERVIEW

SELECTED MAPS

54 - T-18b Social Indicators III

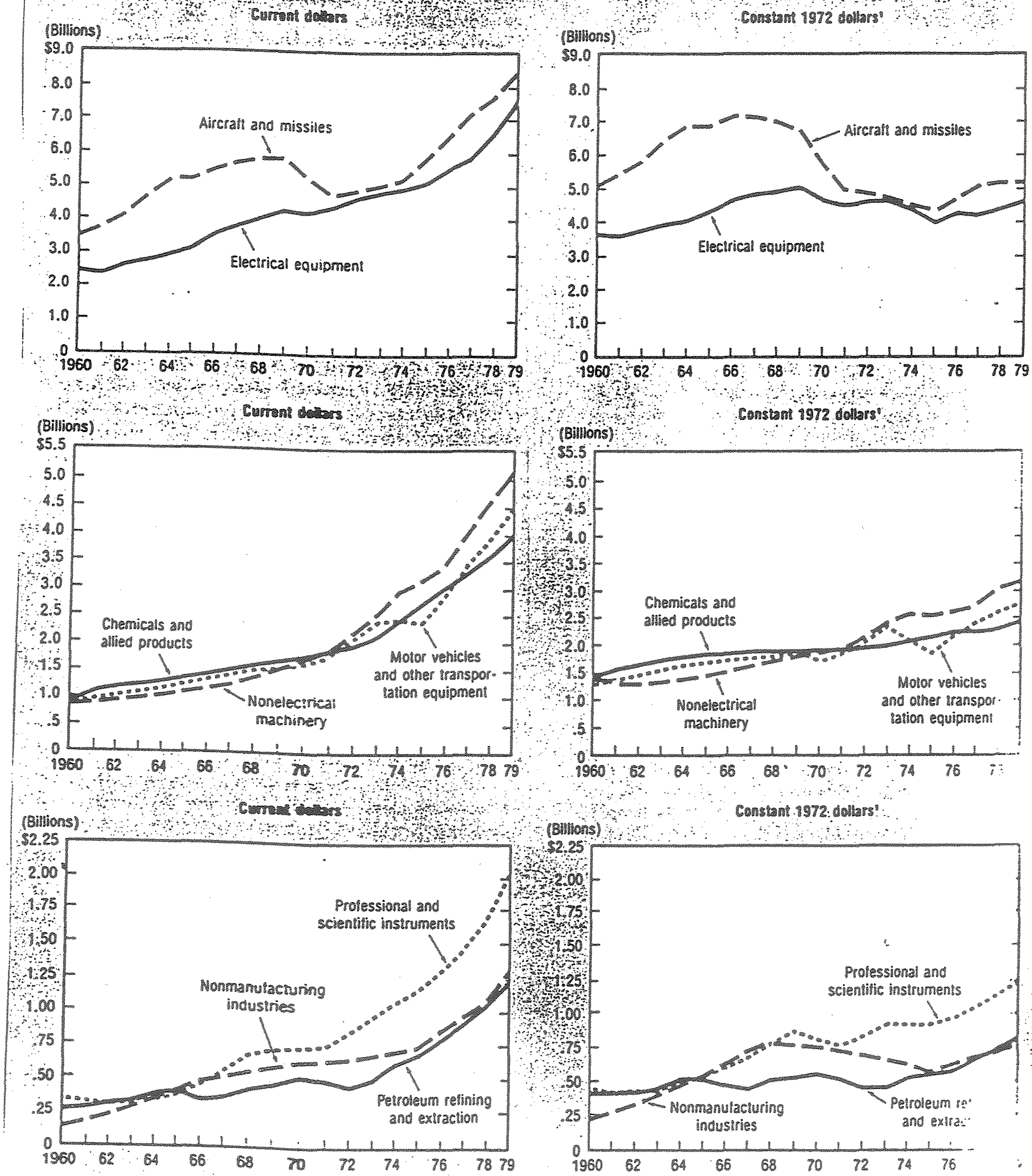
Chart 9/2. **Expected Personal Financial Situation: 1954-1979**



Source: See table 9/2.

Ex T, 18C   Science Indicators

Figure 4-5
R&D expenditures by selected industries



[1]GNP implicit price deflator used to convert current dollars to constant 1972 dollars.
NOTE: Preliminary data are shown for 1978 and 1979.
REFERENCE: Appendix table 4-5.

T.19 Precursor Events. Economists sometimes use "leading indicators" to rorecast market behavior or other economic trends -- e.g., housing starts and commodity prices. Technology forecasters also may look for precursors with some established relationship to the topic of their forecast; an increase in the number of published papers in a field, for example, has been considered a precursor of significant scientific or technological breakthroughs. A causal factor may or may not be obvious; if one is discerned then the argument from correlation is strengthened. Exhibit (a) shows a precursor relationship taken from technology forecasting. Finding a pattern of precursor events however must generally be considered only a clue to future behavior, or a suggestions to be investigated further.

Precursor events forecasting has also been applied to social behavior. (Observers have claimed that when women's hemlines drop, the economy takes a downturn; when shirts get shorter, economic conditions improve.) Having observed that "Sweden was among the leaders in the introduction of (social) innovation and that there were numerous instances in which the United States followed suit some years later, with an average time lag of 6-10 years," one forecastor at least has used this observed precursor pattern to forecast consumer protection regulation and related events in the U.S* See Exhibit T.19b.

*Marvin Cetron, Forecasting International, Arlington, Va.

T.19 (a)

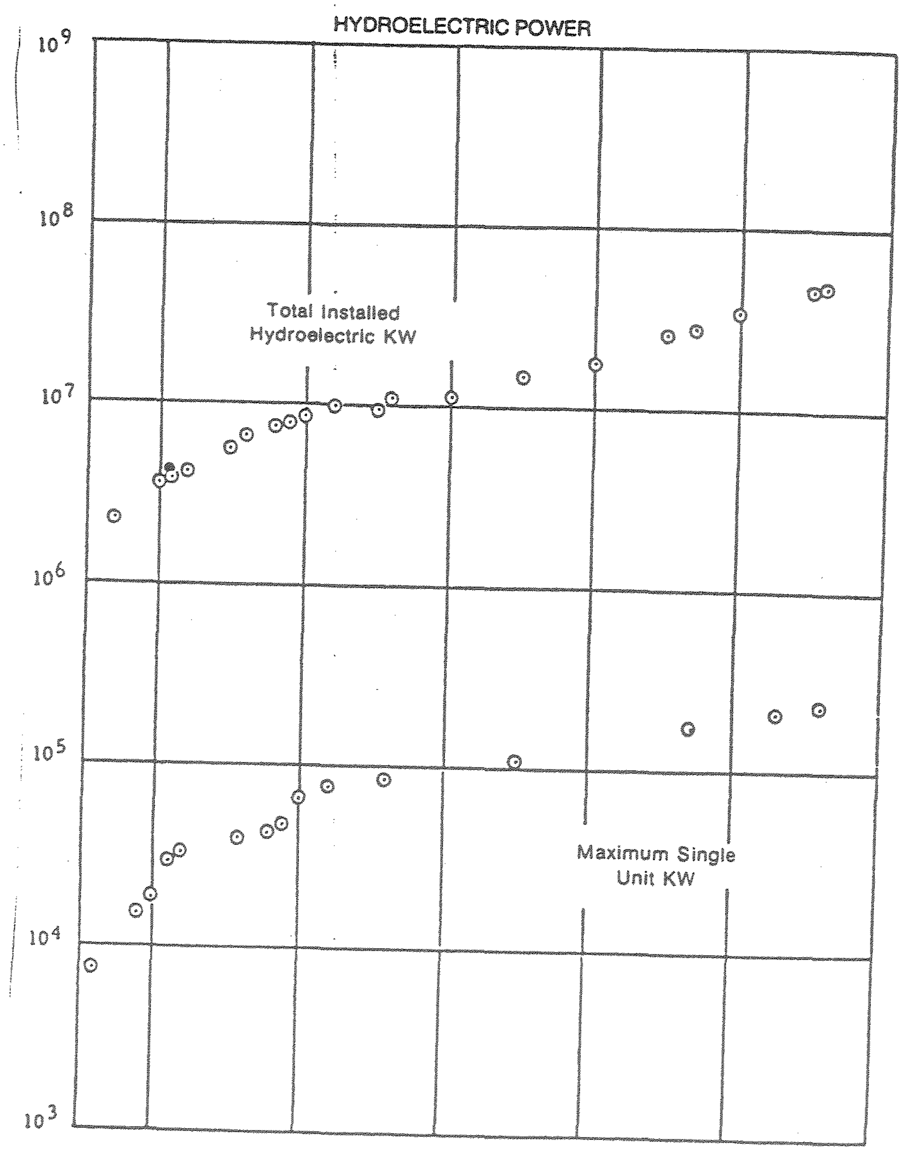


Figure 5. Parallel Growth in Total Hydroelectric Power and Maximum Hydroelectric Turbine Size

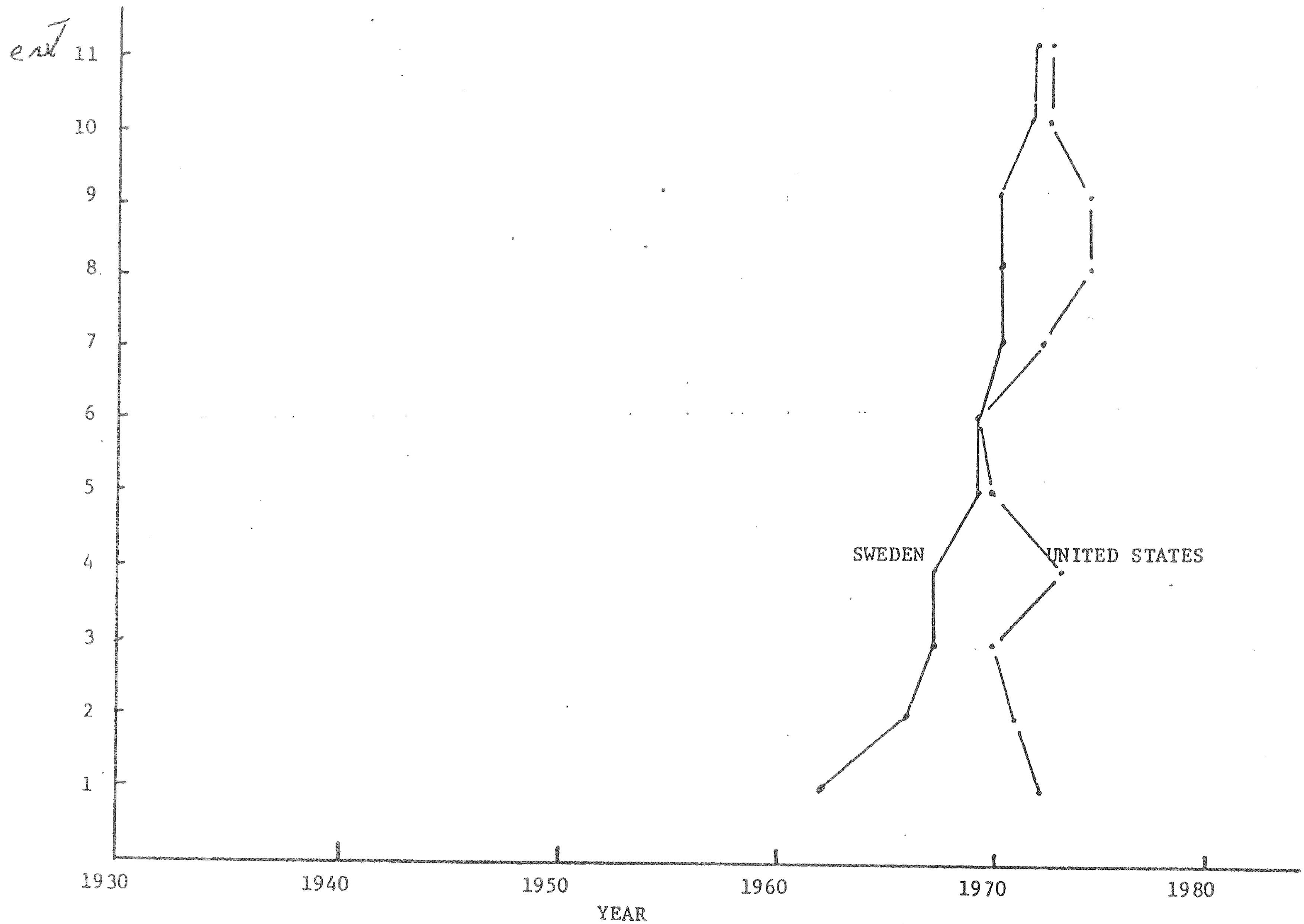
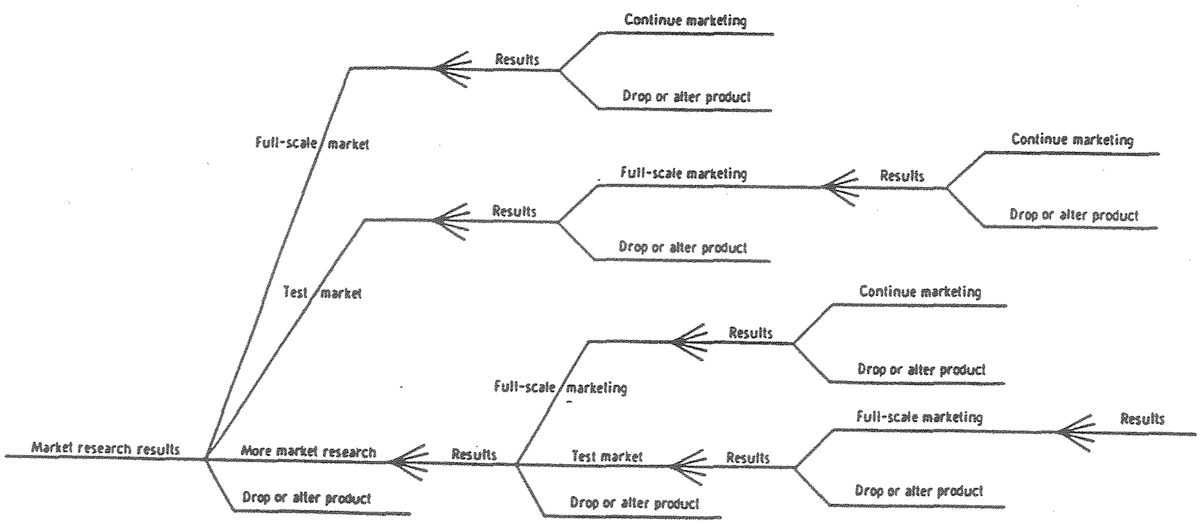


EXHIBIT ~~4.11~~ J.19 b

T.20 Tree techniques. A "tree" is one of several "methods of exhaustion" ("exhaustion" is meant to apply to the subject matter, not the analyst) derived from systems analysis. The technique is a combination of morphalogical analysis (see T.28) and networking theory. There are a number of different forms of tree analysis which may be designated as decision trees, relevance trees, fault trees, and topic trees. Each assumes that most intellectual constructs or concepts, and the subject matter they represent, can be progressively broken down or subdivided into less-inclusive components such that the subdivisions at any level, taken together, subsume all of the logical components or concepts represented in one component at the next level of aggregation. (A tree may be graphically displayed either vertically or horizonally). Since one may work either backwards or forwards (up or down) along the tree, it represents a thought-discipline which can be used for analysis, synthesis, or planning purposes. Construction of a tree is often the first step in developing a mathmatical model.

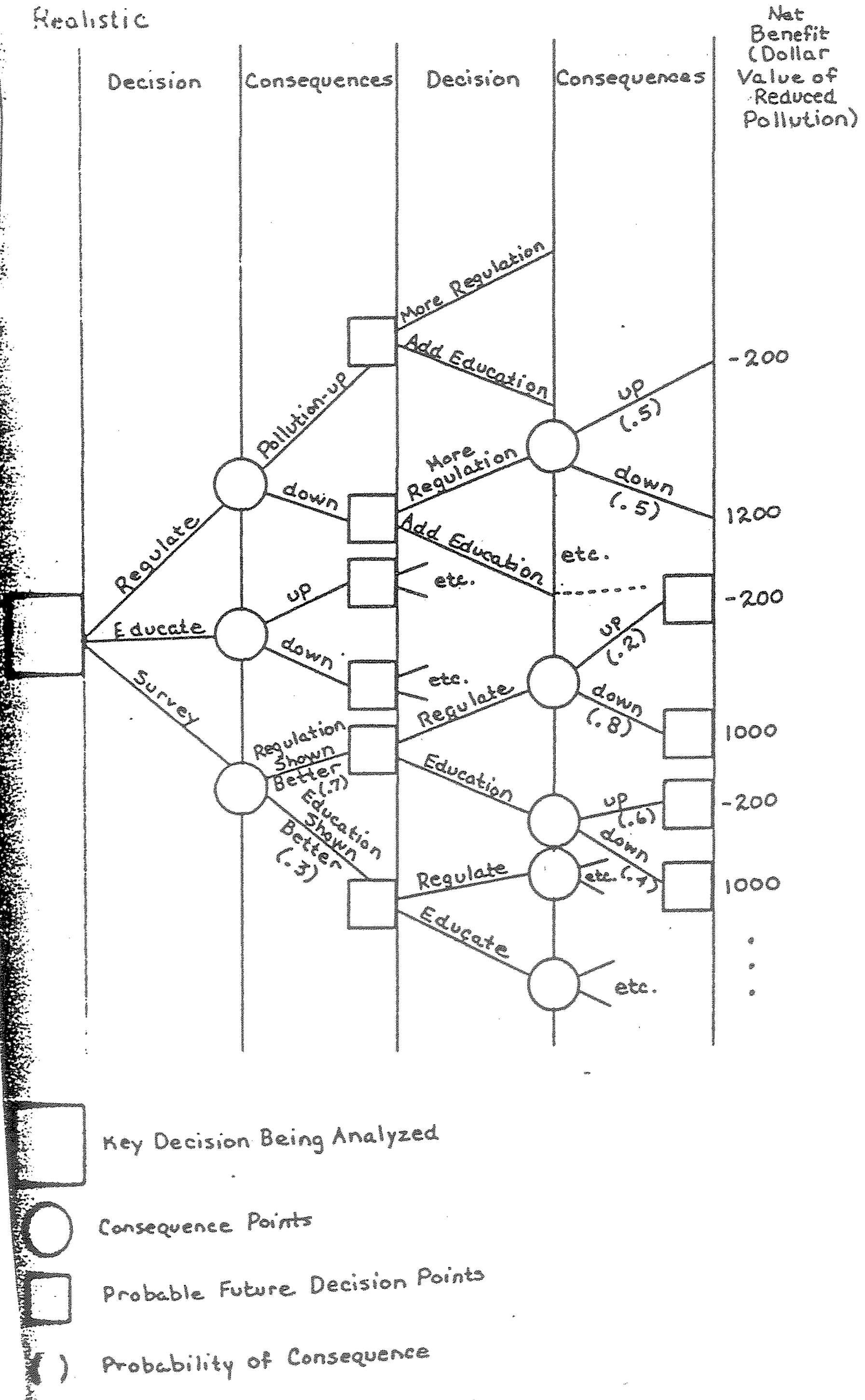
Decision trees represent a process, such as development of a technology or management of a project, as a series of decisions, each preceded by an activity (or situation) with one or more possible outcomes each of which requires a decision as to which path to follow to reach the next goal or branch point. Exhibit T.20(a)for example is a decision tree for new product develpment (from NASA, p.15).



Ex, T-20a A decision theory diagram for new product introduction.

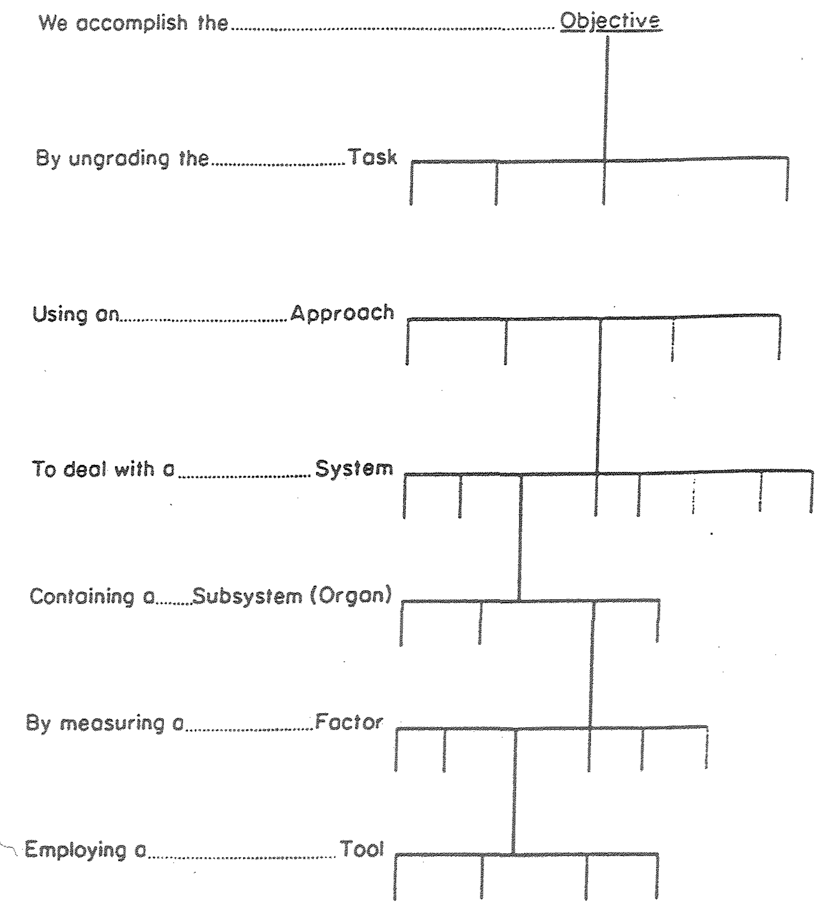
Exhibit T.20 (b) indicates how a decision tree may be carried further by specifying the probability of each outcome, and the net benefit of alternative outcomes (the costs of each decision could also be specified on the diagram, especially if resources are limited and insufficient for some courses of action). (from EPA Guide to Models, p. 27).

Ex.
T.20
(R)


Realistic
Decision
Consequences
Decision
Consequences
Net Benefit (Dollar Value of Reduced Pollution)
Regulate
Educate
Survey
Pollution-up
down
up
down
Regulation Shown Better (.7)
Education Shown Better (.3)
More Regulation
Add Education
More Regulation
Add Education
etc.
etc.
Regulate
Education
Regulate
Educate
up (.5)
down (.5)
etc.
up (.2)
down (.8)
up (.6)
down (.4)
etc.
etc.
-200
1200
-200
1000
-200
1000
Key Decision Being Analyzed
Consequence Points
Probable Future Decision Points
( ) Probability of Consequence

When a decision tree is to be used for planning purposes (or for formulating policy options aimed at accomplishing a technological objective) one might begin to construct the tree by following the outline in Exhibit T.20 (c), from M.Esch, in Bright, p.162.):

Exhibit T.20 (c)



Relevance trees. Exhibit T.20 (d) is a relevance tree constructed to dissect the intellectual content of a question taken from basic science. (This tree was constructed for purposes of basic research planning through the definition of long range goals. See Gordon, in Bright, p. 139.)
Note that for the same of simplicity of presentation, only one branch of the tree is shown at each level, with the dark boxes and lines tracing the path represented here.

A relevance tree tries to lay out all factors and trends significantly influencing a topic (often, an objective) and assign to them numbers which represent the magnitude of their potential influence, contribution, or relevance to the topic at interest. As practised by one industry forecasting/planning staff* the process is as follows."At each node of the tree, a team of experts, using matrices, decision criteria, and subjective probability(estimates) assign quantitative values relating to the relative importance of upgrading that item in terms of its meeting the overall national objectives for the next decade"(or, in other situations, its relevance to the topic or subobjective at the next level). Exhibit T.20 (e) represents "the basic structure for a relevance tree" as described

* Honeywell, which uses an approach which they call PATTERN, or planning assistance through technical evaluation of relevance numbers. See Esch, in Bright.)

Ex. T.20 (d)

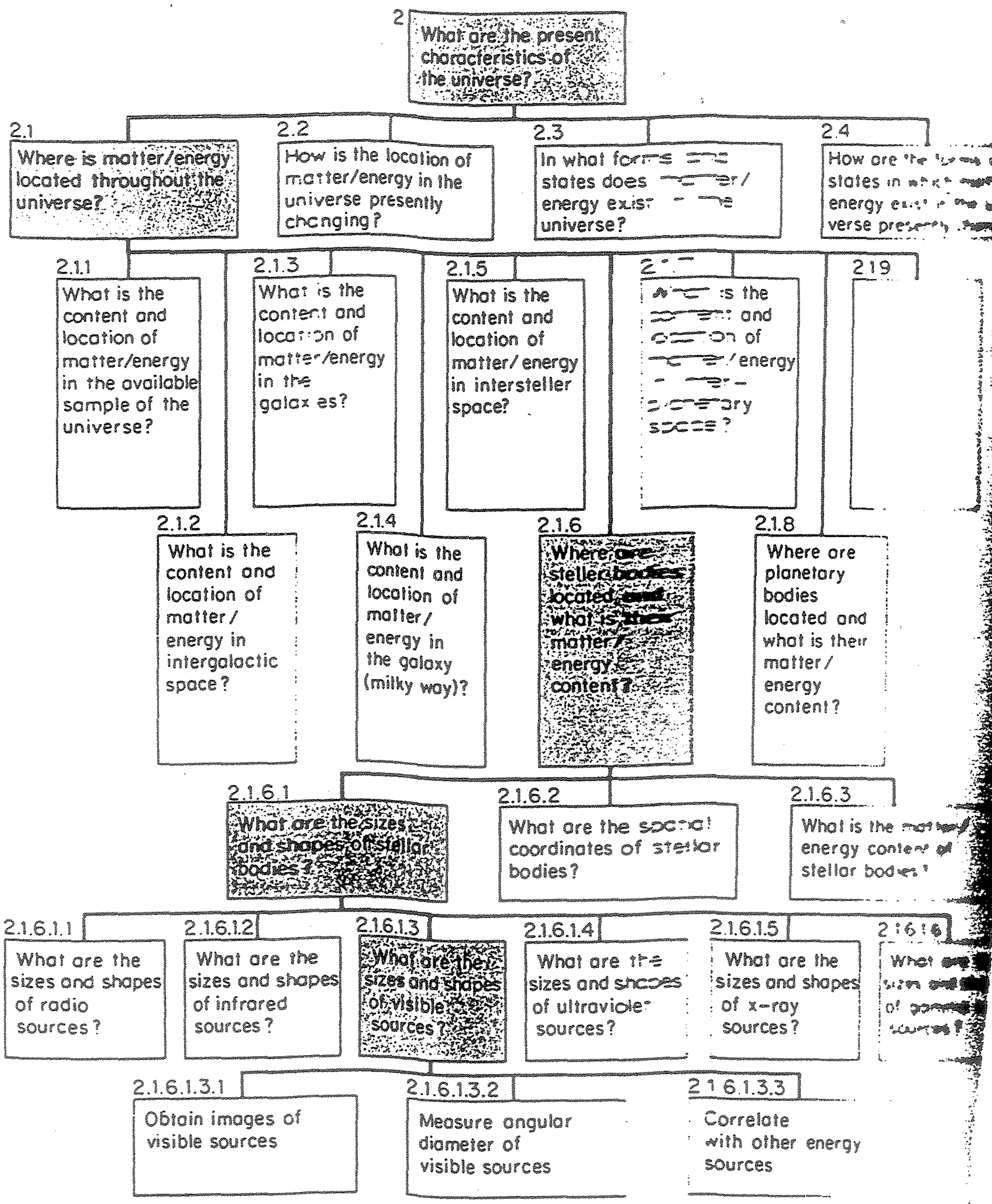
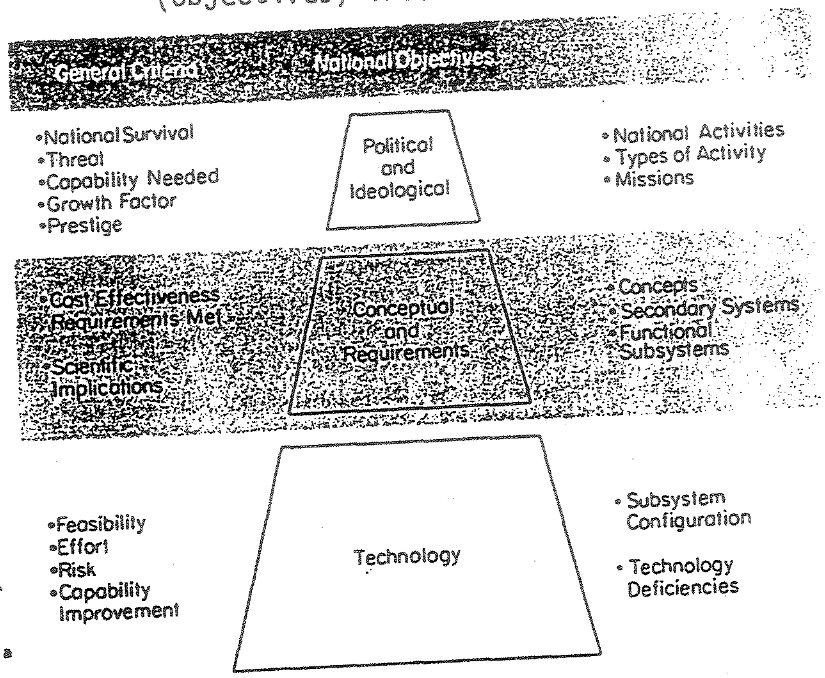


Exhibit 8. Selected Subobjectives, Including Present Characteristics of Universe Categories.

Exhibit T.20(e) Basic Structure for Relevance (Objectives) Tree.



by the industry team.

In the relevance tree shown in Exhibit T.20(f) below, for example, this structure was then subdivided into seven levels. In order to make value judgements at each horizontal level and in order to be sure all subtopics are identified (i.e., that the tree is exhaustive) criteria, or ground rules were specified for subdividing each level further. (only the first four levels are shown in (f).) The individual relevance numbers within any branch of the tree total one (each branch is to form a complete set of alternatives.) The criteria for assigning values (relevance numbers) at the third evel (technological objectives) for example were: liklihood of technical challenge, capability needed to counter, contribution to international posture. Each alternative was rated on each criteria, but the criteria themselves had different weights in the final calculatio (In this case the final calculations were done by computer.)

Ex. T.20 (f)

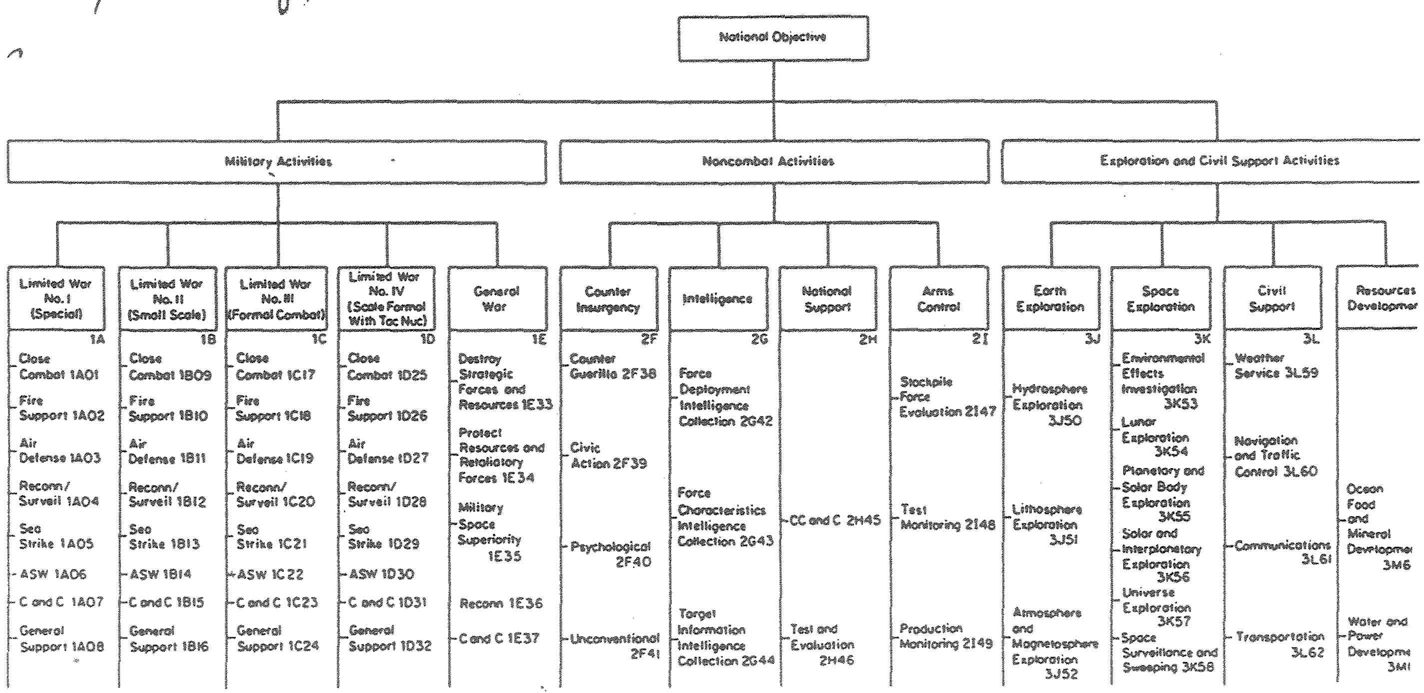


Exhibit 4. Relevance Tree Structure to the Mission Level.

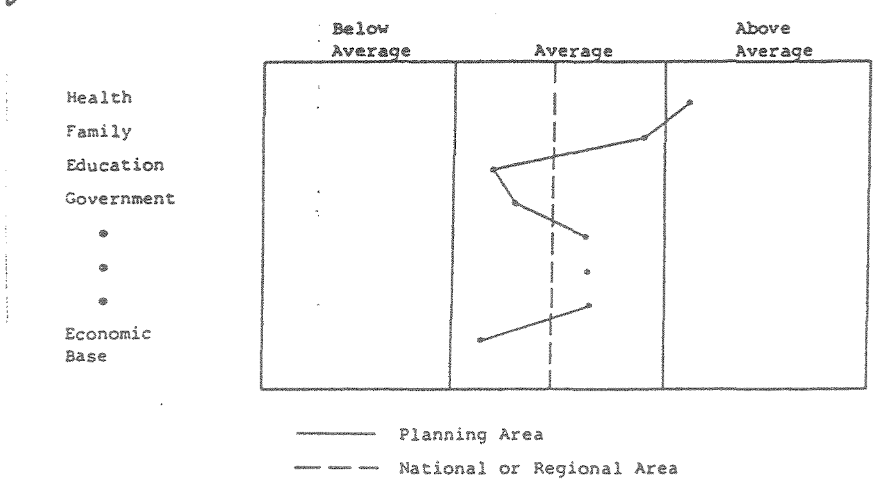
<u>Other kinds of trees.</u> Fault trees, for identifying and estimating the probabilities of system failures, have been described under risk analysis (T.   ). Many other kinds of trees have been or could be constructed. In a Technology Assessment of Geothermal Energy, the Futures Group used a complex tree to lay out all of the systems and process alternatives that could be used in geothermal energy production; the tree display took 70 close packed pages in the report.

<u>T.21 Social profiling.</u> A social profile integrates and presents baseline information about a community as it exists before a new technology is introduced or a plan is implemented. This helps later in valuing and demonstrating potential impacts. Data for social profiles tends to be cross-sectional or trend data. Exhibit T.21(a) shows only a part of the data which might be collected and a format for analyzing it. (from Fitzsimmons, et al., pp.108-9) Other data categories include population and population characteristics, economic base, employment, social services, recreation, transportation, communications, housing, religion. See: Social Indicators, T.18, and Proxy data for small communities, T.16(Trend Extrapolation).

The community is rated Above Average, Average, or Below Av. as compared to regional and national norms (or some other criteria) and profiled as shown in Exhibit (b), for later comparison. Social profiles can of course be made more complex and fine grained than the one shown.

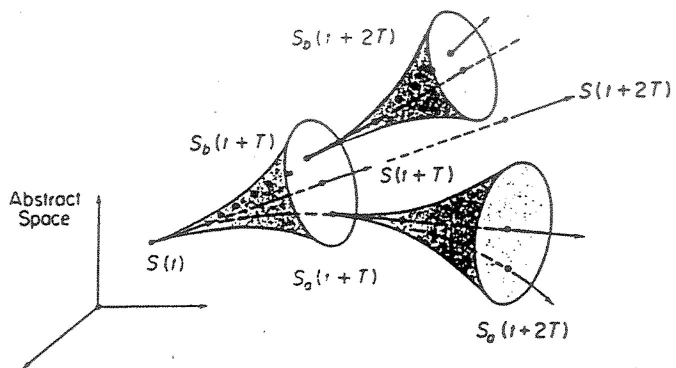
Exhibit T.21 (a) Topics and Items	Measure		Rating AA/A/BA
	Planning Area	Regional or National Norm	
INCOME (cont'd.)			
≥ $ 3,000 ≤ $ 9,999			
≥ $10,000 ≤ $24,999			
≥ $25,000 ≤ $49,999			
≥ $50,000			
EDUCATION			
Average Education Level for Adults 25 Years or More			
% High School Dropout Rate			
% H.S. Seniors Going to College			
Average H.S. Senior Achievement Test Performance			
WELFARE			
% Population Receiving Welfare Payments			
% Population Receiving Welfare Services			

Ex T.21(b)



T.22 Scenario writing. A basic assumption in futures research and technology assessment is that the future is not determined; there are always alternative futures within a range of possibilities influenced by past and present conditions. The further into the future one tries to look the wider that range will be. Specifically, each event in a specified time (the present) has a range of possible outcomes, and every present situation or continuing trend will evolve in directions which are affected by many forces. When we take into account the timelines from all or any significant number of events and trends, the number c possible combinations of possible consequences quickly becomes staggering.

T.22 a



But there is also a great deal of convergence and overlapping between these combinations. It is therefore both feasible and useful - by limiting out consideration to a relatively few events and trends - to select and describe clusters of future outcomes (i.e., alternative futures) to represent either (a) the more likely among alternative futures, or (b) those which delimit the range -- the most divergent pair and one or two in the midrange along some spectrum.

These alternative futures, or scenarios, can be described in a variety of ways, from the most impressionistic prose descriptions (science fiction) to graphic representation of a system of quantified parameters. The latter version is of course very close to a structural or dynamic model. Science fiction, while it can be the most forceful, holistic, and persuasive way to convey an image of a possible future (as witness the novel 1984) requires more talent than technology assessment teams ordinarily have at their disposal.

A good middle ground in scenario writing calls for the following steps:

(1) Having prepared a signed digraph (T. 1) of the problem, technology, or topic of interest, consider what perspective on the society of the future is of interest to you: you may for example be most interested in a quality of life scenario, in one which describes a system of social-economic transactional relationships, or in society described as a demographer/geographer might view it.

(2) Through reiteration and refinement of the signed digraph, define a small set of variables which appear to explain most of the relationships and interactions which affect your topic.

(3) For each of these variables (forces, factors) describe a small number of states or conditions which, while not exhaustive, appear to span the range of possible states for that variable:for example, government - totalitarian dictatorship
- constitutional/democratic
- minimum/anarchistic

ec..ideol. - unfettered free enterprise
- mixed economy, substantial regulation
- state socialism, communism

Alternative end-states for the same variable should be stated along the same dimension ... represent non overlapping segments of the continuum. Give them

a simple title or designator for purposes of manipulation, but back this up with a one-ten page discursive description of what is meant. The variables, the end-states, and the descriptions should be thoroughly discussed and reiterated by the team as a whole until there is complete understanding and agreement on what they are intended to mean.
(4) In theory, each state of each variable is combined with each state of all other variables (if 4 variables, 3 states each, then 64 scenarios). In fact, many of these will be inconsistent or contradictory -- for example, see (3) above, a minimum/anarchic state of government and a mixed economy with substantial regulation would not tend to go together -- these can be discarded immediately. Exhibit T.22(b) shows the process of matching.

Exhibit T.22b

ALTERNATIVE SCENARIOS: 1973-1985

POLITICAL ALIGNMENT	SOCIAL VALUES	INSTITUTIONAL STABILITY	ECONOMIC STRUCTURE	WORK ATTITUDES	TECHNOLOGY VS. ECOLOGY
Neopopulism	Counterculture	Radical Change (Violence)	State Capitalism	Alienation/ Dropping Out	Antimaterialism
Independent Voter/New Federalism	Individualism/ Pluralism/ Humanism	Sporadic Violence	Business-Government Partnership	New Motivation	Accelerated Environmental Protection
Traditional Democratic (Centralized Government)	Modified Traditional Values	Evolutionary Change (Concentration)	Mixed Economy	Increasing Leisure-Orientation	Evolutionary Environmental Protection
Conservative Revival	Counter-Reformation (Traditional Values)	Law and Order (Stability)	Reprivatization	Protestant Work Ethic	Backlash vs. Ecology

Format for Mini-Scenarios on Social Change (used by General Electric Company)

(from Bright, p.241)
(4) With the number of scenario outlines reduced to a manageable number, a pen-and-paper cross-support matrix exercise (see T. 3) will let the group probe the interrelationships between variables (for each scenario) and may lead to some other scenarios being discarded. For example, you may find that some of the variables would dampen or suppress others, making that scenario unfeasible. If time and know-how are available, a KSIM (see T.4) would show these variables in a dynamic relationship over time, improving your understanding of the process of change, of which the scenario is only a snap-shot.
(5) At this point a small number of scenarios can be selected, to give a balanced representation of the span of possible futures. (Some may be so similar that they can be coalesced). From 3-5 scenarios are about the right number for most purposes.
(6) Using the state descriptions written earlier (3. above), signed digraphs, etc., the team can flesh out the scenarios, writing brief descriptions of future states-of-society, which might be from 1-5 pages long. These will be useful in all phases of an assessment, particularly in evaluating potential impacts and in framing policy options. A brief summarized version of the scenarios may appear in the final report if it is desirable to provide the reader with an explicit context, but their chief usefulness is as a common point of reference for the team throughout their analysis.
Exhibit T.22c gives examples of scenarios.

Ex. T.22(c)

Exhibit T.22c. Scenarios. from Fowles, p.236-7

TWO SCENARIOS ON THE FUTURE OF BUSINESS

On the theory that future outcomes can, to some extent, be shaped by constructive, anticipatory action, this pair of scenarios was developed in 1973 (as part of a set of four) to illustrate the differences that might flow from divergent business responses to the emerging "qualitative expectations" of the post-WW II generation in the United States.

SCENARIO OF A REACTIVE BUSINESS RESPONSE

"Beset by inflation, recession, shortages and a profit squeeze, and confronted by the recent spate of newly-legislative requirements (e.g., EEO, OSHA, product safety, pollution control), business opts for a policy of 'minimum feasible compliance.' Having no realistic option but to comply with the law, companies attempt to deal with the 'revolution of qualitative expectations' simply by adhering to the minimum requirements of new statutes. They challenge administrative interpretations of the law whenever possible, and resist pressures for new legislation wherever they develop.

"For a while the public, distracted by concern over rising prices, unemployment, and declining incomes, and disillusioned and distrustful in the post-Watergate climate, is content to see the assimilation and enforcement of 1970–1973 legislation. Meanwhile, however, the basic forces working toward a further shift in societal values continue to work their way through society, and a 'business-as-usual' attitude on the part of companies does little or nothing to deal with the developing challenge.

"The advent of the political year 1976, and the emergence of a younger, better educated and more aggressive work force and electorate set the stage for a new round of anti-business legislation. In particular, the perceived failure of business to deal adequately with the conflicting claims of the energy crisis and a clean environment leads to the introduction of bills, and the writing of planks in party platforms, to control business growth and investment, and to restructure major industries. A change of Administration and continued business 'heel-dragging' ensure passage of many of these bills by 1978.

"At the same time, a basic inability to deal with the 'quality of work' expectations of the new work force leads to progressively declining morale and productivity, increasing unionization, alienation and 'whistle-blowing.' Business, suffering a crisis of confidence and failure of nerve, is by now in a virtual state of siege, harassed by government regulation, beset by boycotts and class-action suits, 'betrayed' by its employees, and obsessed with a 'fortress mentality.' All that remains is the final step of public control and take-over of major corporations."

SCENARIO OF A PRO-ACTIVE BUSINESS RESPONSE

"Compliance with both the letter and the spirit of current laws, and the sponsorship of new legislation and public information programs, are only starting points in this strategy. These efforts are buttressed by the establishment and enforcement of standards and self-policing activities on such matters as advertising, consumer rights and product safety.

"The major emphasis, however, is not on the legislative/educative aspects, but rather on innovative approaches to corporate marketing, production and management policies that, over the next decade, lead to a sweeping reform of business relations with customers, employees, government and the public. The need for thorough-going revisions of many conventional methods and policies flows from an awareness that, in many instances (such as pollution abatement, conservation of energy/materials, product servicing, job re-structuring), a 'tinkering' or 'additive' approach is not only less effective, but also more costly in the long run.

"Progress, inevitably, is slow because of institutional inertia, costs and conflicting claims on management attention. But it is sufficiently noticeable that the gap between expectations and performance is kept manageable and tension does not reach the breaking-point. Although corporate mistakes occur, and are well publicized, the public attitude toward them is marked by a greater degree of tolerance than in other scenarios. Penalties are imposed more selectively, and Congress is less apt to reach for 'shotgun' legislation. Such laws as are passed tend to embody and codify the best of current business practices.

"The value of a pro-active response becomes apparent, too, in the work force area. As the changing composition and wants/needs of the labor force reach critical levels in the latter half of the decade, the early experiments in job enlargement/flexible scheduling/participation start to pay rich dividends in enabling companies to attract and retain a committed and productive work force.

"Pressure from consumer, environmental and other interest groups continues to be a major factor, but a great openness in corporate communications (including more voluntary disclosure of corporate information) keeps this pressure at a low level of acrimony. In general, while there may be greater 'publicization' of the corporation than there was in 1970, there is markedly less 'politicization' of economic decision-making than in the other scenarios."

T.23 Delphi. Delphi is one of a class of "consensual" techniques used for integrating the judgements of a number of people (experts, decision makers, or affected parties) about a question which cannot be answered with empirical data. For example, " in what year will human regeneration of a limb first be demonstrated?" Answers may range from "never" to "next year."

It can be demonstrated experimentally that the collegial response of a group tends to be more accurate that the average response of individuals, presumably because of the sharing of information and insights. However, when a group (especially a group of recognized experts) attempts to respond to questions in a conference situation, i.e. face to face, the group judgement tend to be dominated by individuals who (a) have the greatest prestige, or (b) are most articulate and persuasive. Delphi was invented to mitigate this problem.

As orginally formulated, the Delphi technique consists of (a) posing a quiery in written form (usually a lengthy questionnaire) to a selected group of participants, (b) receiving and collating their responses and arranging them along some continuum (e.g., from "never" to "tomorrow "); (c) determining those who fall into the first and fourth quartiles, i.e., those whose answers fall toward either extreme of the continuum; (d) having those persons state the reasoning or evidence for their extreme judgements, and feeding this rationnale (anonymously) back to all participants; (e) having all participants provide a revised response, and (f) repeating this process for a second or third round. The Delphi thus combines the advantages of group judgement, with interactive sharing of information, with anonymity and presumably increased objectivity. The usual result is that responses tend to converge, over the course of several rounds, toward a consensual judgement. Sometimes, however, they diverge in a bi-polar fashion, which can be equally informative as it indicates a real, demonstrable uncertainty or division in values.

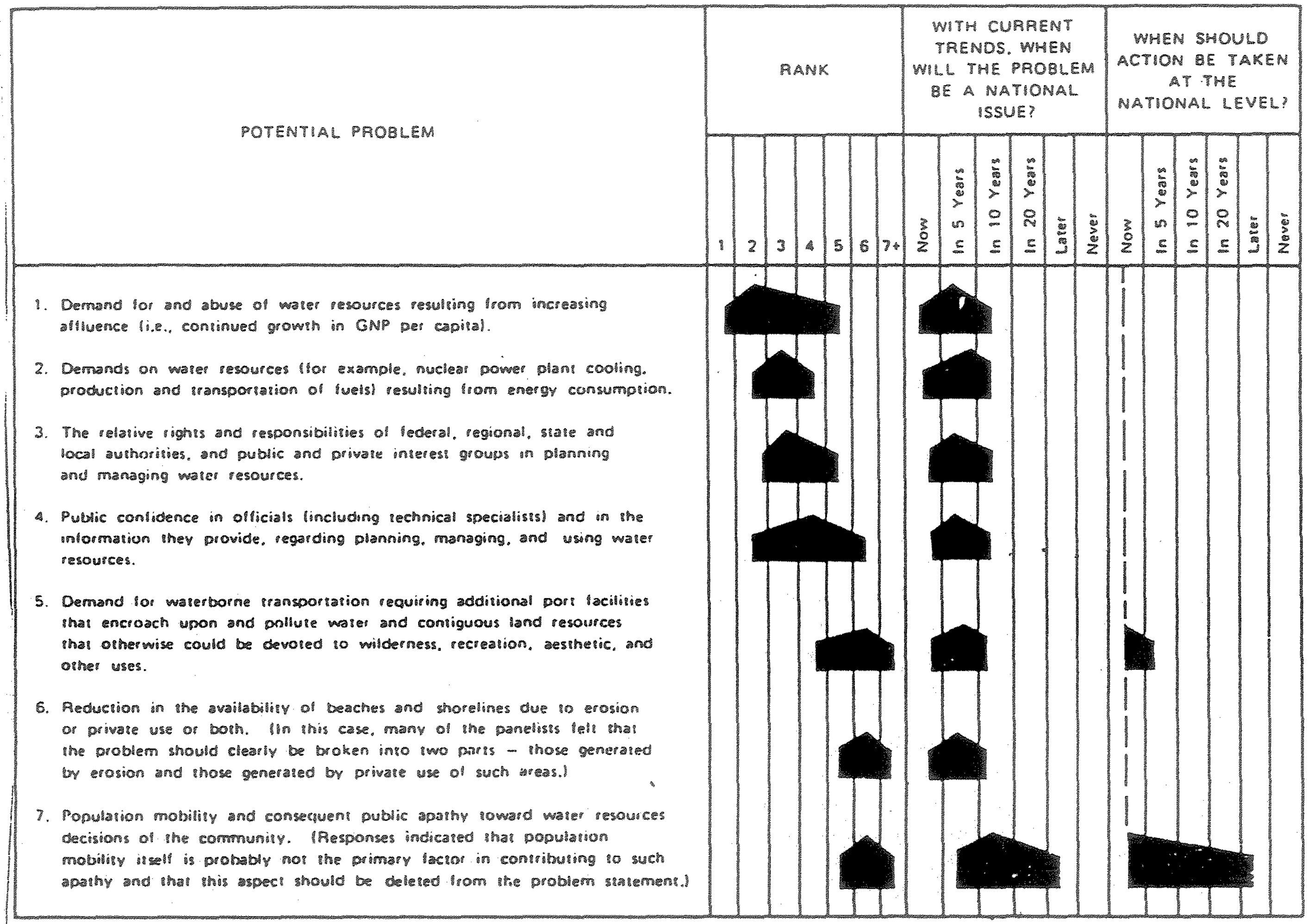
Exhibit T.23 illustrates a typical summary of Delphi results.

The Delphi technique has numerous adaptations and variations. Various machines, such as the Consensor, are available that allow voting or registering a judgement be done anonymously even in a face-to-face situation, with results being aggregated by computer &r electronically displayed on a screen in real time.

T.24. Nominal Group Technique. This consensual technique is useful in small groups for generating evaluated lists of trends, potential impacts, policy issues, etc. A group of six to eight people is best; several groups can be run simultaneously. After some initial discussion aimed at defining the question to be addressed -- e.g., what are the most important factors constraining the adoption of industrial robots in the U.S.? -- each participant is asked to write on a piece of paper 4-6 answers, in order of importance. The leader then asks each participant to give his top priority answer, which is displayed on a blackboard or flip chart. He or she may explain his reasoning; other participants may speak briefly in support, but at this point no negative feedback or critic is allowed. If some participant finds that his top priority answer is already on the board, he gives his second priority answer, and so on. The responses continue, around the table, until all responses are on the board (In the process, however, some responses will have been coalesced or reworded, by negotiation among the participants.)

At this point there is discussion, both pro and con, of each entry on the board, each participant speaking in turn. Then participants vote on the 4 or 5 critical factors, with each participant having multiple votes (perhaps 3) which may not be loaded onto one candidate. There may be

Exhibit T.23 Delphi Results



WATER RESOURCE ESTIMATES, ROUND TWO

from: Kruzic, p.226.

Nominal Group Technique, con'd.
two or more rounds of voting if necessary, with those candidates receiving fewest votes being eliminated after each round, until participants reach a concensus on the five more important factors.

T. 25. Mathmatical Modeling. Mathmatical models are described as "computational procedures designed to help a decision maker and his staff predict the consequences of proposed alternatives. In some cases the model includes an optimizing procedure which computes the optimal alternative"(Guide cited below, p.3). Most mathmatical models may be thought of as elaborate signed digraphs (T.1) with the factors/components quantified, and the relationships between them being expressed as mathmatical equations. Such models have many and important uses in policy analysis and technology assessment, but the analyst should always be aware that models introduce a bias into the analysis -- an emphasis on terms which can be quantified and a strong tendency to ignore those which cannot be readily quantified.

Few if any OTA assessments have the resources to develop special models. However, projects can sometimes make use of models which are already available and operating, or results from earlier model runs. The analyst is therefore referred to a useful compendium prepared for EPA: A Guide to Models in Governmental Planning and Operations, Office of Research and Development, EPA, 1974. The volume has an informative discussion of the use of models in government-oriented analysis.

with detailed discussion of models developed for use in analysis of:

- air pollution
- water resources
- solid waste management
- urban development
- transportation
- law enforcement & criminal justice
- educational planning & operations
- energy
- health services
- general policy analysis

T.26 Values Analysis. Values cannot well be ignored in policy analysis and technology assessment, since there would be little reason for policy analysis if there were no competing or conflicting values with regard to allocation of public resources and government actions. But technology assessors have great difficulty in

-- specifying either dominant values or a range of values, because this is such a heterogeneous, diverse, pluralistic society, with almost no unifying religion, ideology,, or institutional membership;
-- anticipating shifts in values or in the proportion of the populace who will subscribe to any specific statement of value
-- making any statement about values however empirical/objective which can be "heard" by those who have other value preferences.

The one cardinal rule to be followed, as far as humanly possible, in TA is to state all assumptions - especially about values - explicitly: "if one assumes that small is beautiful, then...."

Some ways of handling values discussions are suggested below, to be con= sidered when it is necessary to make some assumptions or reach some conclusi as to what will or will not be publicly acceptable; that is, be unlikely to violate prevailing norms:

o Values as culturally determined - one can assume that dominant values in a subgroup or geographical region may have some relationship to a dominant religion, ethnic culture, etc., as reflected in official pronouncements and exhortations of the insitution. Trends in membership rates, etc., then give some clue as to present and future prevailance of the ascribed values.

o Values by inference: one can infer values on the basis of economic or other interests -- "poor people want X..." "businessmen favor Y...."

o Values by representation: public participation provides one credible way of getting at values. However, participants whether carefully selected or volunteers may not be representative of the population at large or of particular groups, and even officials of public interest groups have limited evidence as to (and often little knowledge about) the identity, or number, of their constituents.

o Values by self-report: one can rely on polls, questionnaires, etc. Social Indicators reports trends in public opinion on some issues, and other such compilations are available. These provide some evidence of the amount of diversity or consensus on particular values and of directions of changes in values, although much depends on exactly how the qeustions were asked.

o Values by evolution, Mazlov and others have developed typologies of values, usually arranged in an ascending order meant to indicate some evolutionary progression in values over time.

o Values by adaptation. One can assume that values tend to change in response to changes in resource availability and other environmental changes. Thus growing affluence leads to increased valuing of cultural and recreational activites and a weakened work ethic; better birth control produces new sexual mores, etc.; values are a dependent rather than an independent variable. This at least offers a handle for forecasting value change.

o Values as behavior. A number of techniques such as gaming (T. 27) and policy capture (T. 27) are designed to reveal values through the acting out of value-laden situations.

T.27 Policy capturing is a technique used with small groups of decision makers, special interest group representatives, corporate executives, or concerned citizens to determine what trade offs they would be willing to make in formulating public policy. The participant is presented with an array of alternative futures, in the form of a series of cards (perhaps 2! which are written brief scenarios (Exhibit T.27 a and b). He or she is asked to arrange these in order of preference.

These scenarios are constructed to embody several social conditions which can be scaled along some dimension of "more" or "less." For example, the scenarios shown in the exhibit are from a set constructed from five conditions -- more or less energy, risk, environmental quality, social cohesiveness (or equity), and active Federal action.

Since no scenario is optimal, one discloses by one's preferences in order the scenarios the trade off which one is willing to make. Multiple linear regression analysis is used to calculate from the choices made, how much weight the participants want placed on each factor in making (and evaluating) policy. (A computer program is available for making the calculations.)

Ex T.27 →

T.28. Morphological Analysis. This technique is one of the techniques of exhaustion, where the objective is to rigorously and systematically identifyall alternative routes to a goal. As developed by Zwicky, it was applied to the design of technological systems (it can be used in TA to identify possible configurations of a technology which is still in the early planning stages, for anticipatory assessment). The goal -- e.g. a propulsive power plant -- is specified and resolved into functional specifications that detail what basic functions must be performed, For each function, a complete list of possible means of performing that function. These are arranged in a matrix with functions as rows and solutions as columns. Each path through the matrix from first to last rows represents a potential design for the power plant. (Many of these paths, of course, will be impossible). The analyst then goes through the matrix assigning efficiency or other preferential weights to each option. The combination of ratings along a path indicates the few combinations that merit further study. Adaptations of this technique have been tryed with policy objectives and policy options instead of functions and alternative designs. The paths selected would then represent strategies for reaching a specified goal.

Ex. T.28 →

Ex. T127

Figure 1: Two Representative Scenarios

A. This national energy situation was to a large extent influenced by political groups which attempted a scientific management approach to energy production and consumption. To assure proper uses of this vital national resource, energy was rationed to major end-use sectors. Wasteful energy uses were discouraged and efficient uses promoted.

The material well-being of the nation is considered below expectations, with an energy consumption at 350 million Btu per capita.

There is a low level of risk to the society if energy is reduced. The decrease in uncertainties has occurred from allocating energy away from energy intensive products, decentralized farming, and widespread availability of public transportation.

The environment is considerably more degraded than that of the 1970s, since extensive strip mining was required for increasing domestic energy supplies.

The distribution of energy in the society is skewed in favor of the upper classes. Lack of services to the poor of inner cities severely constrains their energy consumption.

SUMMARY OF LIFESTYLE - YEAR 2000

Federal Role		Energy Intensity	Risk	Environment	Social Cohesiveness Population - Total Energy
Regulator	60%	(Million			Lower 1/3 = 10%
Technologist	10%	Btu)	Low	-50%	Middle 1/3 = 40%
Economist	20%	350			Upper 1/3 = 50%
Teacher	10%				

B. This national energy situation was to a large extent influenced by technological innovations which increased energy supplies through nuclear fast breeder reactor plants and allowed continual economic growth.

There has been a continually improved standard of living since the 1970s, reflecting a 2% annual increase in energy consumption. Energy intensity is 400 million Btu per capita.

There exists a high level of risk and uncertainty in the society. Since there is a totally energized food production system, a loss in energy availability (e.g., a nuclear plant shutdown) would severely curtail food distribution in the society.

The nation has avoided scarring the landscape from fossil fuel extraction. The society does not perceive a potential high environmental threat, however, through radioactive material and risk of plant explosion.

SUMMARY OF LIFESTYLE - YEAR 2000

Federal Role		Energy Intensity	Risk	Environment	Social Cohesiveness Population - Total Energy
Regulator	20%	(Million			
Technologist	60%	Btu)	High	-20%	Lower 1/3 = 25%
Economist	10%	400			Middle 1/3 = 35%
Teacher	10%				Upper 1/3 = 40%

from from: Jean M. Johnson, "Policy Capturing in Energy," in Methodology of Social Impact Assessment, Finstervusch and Wolf, ed., (Dowden, Hutchinson, and Ross, 1977).

Exhibit T.28 (a)
Morphological Box,
from: Martino, p.305

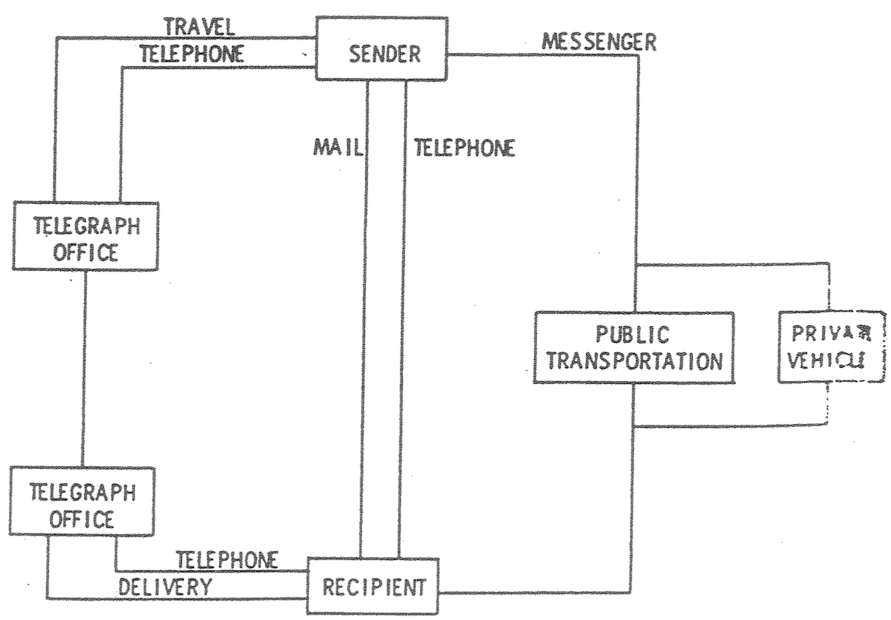
AUTOMOBILE PROPULSION

MORPHOLOGY

P_1	WHEELS	3	4			
P_2	DRIVEN WHEELS	1	2	3	4	
P_3	ENGINES	1	2	3	4	
P_4	TRANSMISSION	NONE	MECHANICAL	FLUID		
P_5	ENGINE TYPE	INTERNAL COMBUSTION	EXTERNAL COMBUSTION	TURBINE	ELECTRIC	
P_6	POWER SOURCE	HYDROCARBON FUEL	PRIMARY BATTERY	SECONDARY BATTERY	FUEL CELL	THIRD RAIL

~~FIGURE 9-10.~~ **Automobile propulsion morphology.**

Exhibit T.28 (b)
Mission flow diagram
based on morphological
analysis
from Martino, p.318



~~FIGURE 9-14.~~ Mission flow diagram for sending a message.

T. ~~30~~ 29 Simulation and gaming. Gaming is the acting out of decisionmaking situations by players taking defined, goal-oriented roles. The object is to study the interactions between the behavioral strategies which are adopted -- especially negotiation, compromise, and alliance formation -- and the range of outcomes which result. Gaming is a social science adaptation of mathmatical simulation in which computer models are used to represent real-world dynamic relationships between problem components or between participants in decisionmaking (See models, T. 2), ~~T. 28~~ The merger of gaming with information manipulation, in which a computer program plays a role in the game, introduces exogenous events or trends, or mediates between the players in some fashion, is called simulation gaming. War games are the best known version of simulation gaming.

The steps in constructing and using a game are generally as follows:

a) a decision situation is analyzed in terms of the actors and roles which would be involved.
b) each actor's role is specified in terms of objectives (often ordered by priority), constituents, resources, and constraints.
c) a set of rules is developed to govern interactions between actors, and
d) several rounds of the game are played out and the outcomes recorded and analyzed.

Exhibit T ~~30~~ 29 lists some games which have been developed and the sources of further information.

Ex. T. 29

SOCIAL IMPACT IN CURRENT GAMING

REAL WORLD SITUATION	PROCESS INVOLVING GAMING (example)	SOCIAL IMPACT DETERMINED (example)	SOURCE
Internation Relations	Warring Coalitions	War Decisions Made	Abt (1964)
Arab-Israeli Relations	Superpower Manipulation	Reconciliation Scenarios Identified	Ben-Dak (1970, 1972)
Personal Strategies Learning	Social (Primary) Relations	Better Learning Explored	Boocock and Coleman (1966) Boocock and Schild (1968)
City and National Politics	Leadership, Compliance, etc.	Change in Power Occurred	Coplin (1968)
Dyadic Behavior	Group Representation	Bargaining Behavior Predicted	Druckman (1966)
Satisfaction/Consumption Standards	Economic Explanation	Economic Theories Evaluated	Elder and Pendley (1966)
Community (City) Process	Land Use	Ownership and Pressures Manifested	Feldt (1972)
Physical Conflict	Retaliation	Punishment and Abstention Predicted	Friedell (1968)
Interest Groups Societal	Conflicting Coalitions	Societal Welfare Interpreted	Gamson (1966)
Community Leadership	Natural Disasters	Training in Coping and Coordination	Inbar (1966)
Waste Management	Sanitary Conditions	Effective Decisions Realized	Wahi and Peterson (1972)
Community Learning	Running Simulation Exercises	Broadcasting Affected	Gray (1969)

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REAL WORLD SITUATION	SIMULATED PROCESS	SOCIAL IMPACT DETERMINED	SOURCE
Market Conditions	Competing Responses	Market Responses Linked	Amstutz (1967)
Irrigation Planning	Water Supply and Agricultural Production	Farm Income Affected	Anderson and Maass (1971)
Drought Variation	Comparative Critical Drought	Community Needs Identified	Asken, Yem and Hull (1971)
City Trends	Urban Crises	Multi-Faceted Trends Identified	Forrester (1969)
City Services	Ambulance Services	Emergency Needs Answered	Gordon and Zelin (1968)
Peasant Community	Information Diffusion	Information Availability Differentiated	Hanneman (1969); Hanneman and Carroll (1969)
Urban Waste	City Waste Parameters	Solid Waste Managed	Helferich, Hoffner and Gee (1972)
International Process	International Interaction	Multi-Faceted Trends Identified	Smoker (1968)
Global Trends	Ultimate Growth	Limits Diagnosed	Meadows and others (1972)

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T.30 Figures of Merit . This is a paper and pencil technique useful both to compare alternatives and for displaying results. The technique can be used individually and as a group exercise.
A set of criteria are selected for the comparison. Each alternative is rated by each criteria, ~~perhaps~~ along a scale of 1-100. Each criteria is then given a weight representing its importance in policy formulation (or a set of alternative weights); final values are calculated, and their sum is the figure of merit for that alternative (see Exhibit T.31), and can be compared to the figures of merit for the other alternatives.

Each row summing to 100

xhibit T.30 Figure of Merit for Alternative Sources of Energy

	Criteria: Energy Effic.		Safety		Env. Qual.		Employ-ment		Secon. Ec.Dev.		SUMMARY Fig.of Merit
Weight	.39		.21		.24		.08		.08		
Alt.	R*	WR*	R	WR	R	WR	R	WR	R	WR	
A	50	19.5	15	3.5	45	10.8	20	1.5	25	2.0	37.3
B	40	15.6	25	5.25	10	2.4	50	4.0	55	4.4	31.65
C	10	3.9	60	12.6	45	10.8	30	2.4	20	1.6	31.30

* R= initial rating. R values for one criteria should sum to 100.
WR = weighted value (weight x R)

T.32. Decision Analysis. The intellectual roots of decision analysis lie in psychology and engineering; important elements include systems analysis and mathmatical modeling (T.25), probability theory (T. 17), multiattribute utility theory (T. 14), discounting (T. 12) and risk analysis (T. 15). Procedures consist of decomposing a decision problem into basic elements -- choices, information, preferences, quantifying each of these elements, and then applying axioms of normative decision theory to identify a logically consistent alternative. In the most basic approach, the analyst begins by asking a decisionmaker to create alternatives (choices) and to provide a set of variables (the outcome vector) on which the outcome will be judged. The decisionmaker is then asked to assign a joint probability distribution on the outcome vector for each alternative (information), and then to specify a multiattribute utility function (preference) on the outcome vector. The best alternative is taken to be the one with the highest expected utility.

Although the basic procedure is conceptually simple, it places an onerous burden on the decision maker. An important extension of the basic approach incorporates an extrapersonal model to ease the assessment burden. Relying upon the information possessed by the decision maker the analyst constructs a model of the decision. The model specifies relationships between the various system variables: decisions, uncertainties, and outcomes. This allows information to be collected from experts -- e.g., legal information from lawyers, materials technology information from metallurgists, etc. The model then is a vehicle for focusing all the information and the decisionmaker is free to accept, reject, or modify this information and establish preferences.

M.W.Merkhofer, under a contract to the Task Force on Management and Methodology, has prepared a detailed report on "A Process for Technology Assessment Based on Decision Analysis," available in OTA's Information Center.

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