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Enhancing impact assessment with extrapolative fiction

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ENHANCING IMPACT ASSESSMENT WITH

EXTRAPOLATIVE FICTION

by

RUTH-ELLEN MILLER

A dissertation submitted in partial fulfillment of the
requirements for the degree of
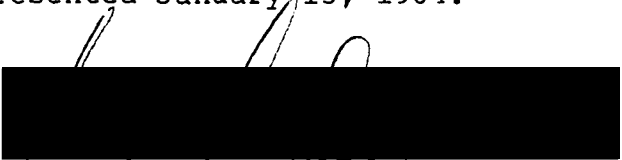
DOCTOR OF PHILOSOPHY
in
SYSTEMS SCIENCE

Portland State University
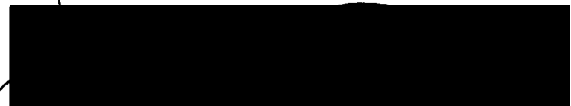
TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the Committee approve the dissertation of Ruth-Ellen Miller presented January 13, 1984.

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ACKNOWLEDGEMENTS

Thanks also go to Susan Page for her careful reading of early drafts, and to Sally Lopez for her assistance with this final one.

And, finally, most gratefully, I acknowledge the love, patience, and unwavering support granted me by my colleagues and co-workers, my good friend Michela, and by those very special people in my life: Jack, Dawn, and Aurora.

Thank you all, _very_ much.

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AN ABSTRACT OF THE DISSERTATION OF Ruth-Ellen Miller for

the Doctor of Philosophy in Systems Science presented

January 13, 1984.

Title: Enhancing Impact Assessment With Extrapolative

Fiction.

APPROVED BY MEMBERS OF THE DISSERTATION COMMITTEE:

Dr George G Lendaris, Chairman

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This dissertation proposes the use of fiction as

models to enhance the process of impact assessment (IA)

and to improve the quality of IA reports. It demonstrates

that works of extrapolative fiction (EF), a subset of

science fiction, raise issues and clarify concerns not cur-
rently included in the IA process, suggesting the potential
for improving the relevance of IA results for decisionmakers.
The dissertation also demonstrates that EF stories can en-
hance the presentation of IA results, making those results
more readable.

Through literature review and content analysis, the
current IA process is shown to lead to results lacking in
specific content areas (e.g., effects on emotional well-being
and community cohesiveness) necessary for their utility to
decisionmakers. The body of literature here called extrapo-
lative fiction is then shown to include many content areas
missing in existing assessments.

Two alternatives for an IA process that could incor-
porate extrapolative fiction are presented and discussed by
means of examples. The first includes existing EF stories
as a part of or an appendage to an IA report. The example
is a preliminary combining of published EF stories with an
IA report concerning life-extending technologies. The
second includes the use of existing EF stories in the assess-
ment process through inclusion of an EF-oriented reader on
the IA team. The example is a case description of an IA pro-
cess regarding the commercialization of guayule as a source
of natural rubber, a process in which the author incorporated
EF methods.

Several other results emerged from this research:

(a) an initial statement of objectives for a unified
field of impact assessment (recently emerging as an amal-
gamation of technology assessment, environmental impact
statements and social impact assessment); (b) a working
definition for an emerging subgenre of science fiction
here called extrapolative fiction; (c) a topical bibliog-
raphy of some hundred EF stories. These results extend
the current understanding of the field of impact assessment
and the emerging genre of extrapolative fiction and should
be useful to both the impact assessment and science fiction
criticism communities.

CHAPTER I

INTRODUCTION AND OVERVIEW

In 1979, having spent six years studying, practicing
and teaching impact assessment, this author was searching
for a new approach--one which included human concerns, as
well as political ones, in the assessment process. In that
frame of mind, I attended a writer's workshop directed by
the noted science fiction author and scholar, Ursula K.
LeGuin. Interestingly, many of the methods used for and
insights gained in that workshop were quite similar to the
methods used and results achieved in my own field. An
exploration of the similarities and differences between
these two activities seemed both interesting and useful, and
was undertaken in the fall of that year. The research
described in this dissertation builds on that exploration,
as an attempt to extend and enhance the field of impact
assessment by incorporating the processes and concerns of
fiction into the assessment process.

As with all such efforts, this research has built on
the work of many others in the fields on which it draws. A
number of works contributed substantially to the direction
of the research. Porter et al.'s Guide to Technology
Assessment and Impact Analysis (1980) formally integrated
technology assessment, environmental impact assessment, and
social impact assessment, and acknowledged the intuitive and

creative aspects of social forecasting. Similarly, I. F.
Clarke (1979) presented an historical framework linking
futuristic fiction with impact assessment and other futures
studies. In addition, the work of O. W. Markley at SRI
International and the University of Houston on the use of
mental images in social forecasting (1980), of Harold
Linstone at Portland State University's Future Research
Institute on the use of personal and organizational
perspectives in assessing impacts of technologies (1981,
1983), and of Gus Root (1976) and John Warfield (1975) on
alternatives to dynamic models in the systems research
process also contributed substantially to the orientation
and approach taken in this research.

Four writers in the field of science fiction criticism
contributed to the development of the proposals presented
here. Two of them are science fiction writers of the
highest order--Ursula LeGuin and Robert Heinlein--and two
are well-known and respected critics of the genre. LeGuin's
collection of essays entitled The Language of the Night
(1979) pointed out the relationship between an author's
mental images and the verbal models--stories--that depend on
them. Heinlein's essays (1969, 1980) on the requirements
for writing speculative fiction illustrated the strong
connection between the research necessary for effective
speculative fiction and that necessary for forecasting.
Darko Suvin's Metamorphoses of Science Fiction (1979)
provided a framework for discriminating between the

subgenres that was used in identifying the characteristics
of stories or novels that might be appropriate to this
discussion. Finally, Patricia Warrick's analysis of stories
and novels describing robots and computers (1980) covered
that topical area and offered a systems-theoretical
framework for selecting works that might be appropriate to
the IA process.

The research described here has also been encouraged by
the increasing number of practitioners and educators in
systems and policy science who have considered science
fiction as a possible contributor to impact assessment and
related disciplines in those fields. A number of their
suggestions have been published in the policy sciences
literature (e.g., Heckler, 1968; Greenberg and Warrick,
1974; Rabiega, 1979; and Porter et al., 1980), some of
which are discussed in detail in Chapter III. Others have
presented their recommendations at professional society
meetings. For example, the keynote address for the 1983
meeting of the International Association for Impact
Assessment, entitled "Science Fiction and Technology
Assessment: A Possible Interdisciplinary Correlation?"
(Michaelis, 1983), called for an analysis such as this
dissertation describes as a means for improving the quality
of technology assessments. In addition, the organizers of
the International Forecasting Symposium accepted a paper
entitled "Forecasts from the Individual Perspective:
Speculative Fiction" (Miller, 1983) for presentation at the

1983 session. Also, the agenda for the 1984 meeting of the Society for General Systems Research includes a session on impact assessment as an application of general systems theory and methodology, and the American Society for Cybernetics has scheduled a session on science fiction for the 1984 meeting, both of which will draw on and contribute to the research whose current results are presented here.

CONTEXT FOR THE RESEARCH

In the late 1960s, members of the U.S. Congress became concerned that they lacked necessary information to make effective decisions. They were aware that in an increasingly complex world, present actions may have long-term and unexpected impacts, impacts that could far outweigh any immediate benefits. So, over a period of several years they conceived and passed the National Environmental Protection Act (92nd U.S. Congress, 1970) and the Technology Assessment Act (94th U.S. Congress, 1972). These acts established of the Council on Environmental Quality (CEQ) in the Executive Branch and the Office of Technology Assessment (OTA) in the Legislature, setting both content and process objectives for the new agencies, and authorizing them to draw on the resources of the National Science Foundation, college and university research centers, and consulting firms to accomplish those objectives.

Through the 1970s many impact assessment (IA) reports were prepared and, in the review process, many criticisms

were leveled against those assessments. Observers have
criticized the process as relying too heavily on
quantitative, technical disciplines and methods (e.g.,
Armstrong and Harman, 1978; Arnstein and Christakis, 1975)·
Reviewers have criticized the reports as lacking in
quality-of-life and social impacts, clarity, and readability
(e.g., Bendix, 1980; Peele, 1980; Porter et al., 1980).
Such criticisms of a process and body of works intended to
inform decisionmakers of the possible outcome of their
decisions demand to be addressed.

During the same years that impact assessment was
emerging, a number of policy scientists were suggesting that
one field, with some apparent similarities in content, might
be appropriately used to enhance the instruction and prac-
tice of the policy sciences. Called futuristic fiction,
this particular form of short story or novel is usually
published in the science fiction journals and anthologies.
It deals with human responses to "what if?" questions posed
by authors or editors and is typically placed in far-distant
times and places.

I.F. Clarke explains the policy scientists' suggestion
in his history of futuristic literature (1979), when he
describes how impact assessment and futuristic fiction
evolved from the same tradition. According to Clarke,
futuristic literature has been a part of American literature
for over a hundred years, but in the 1960s and 1970s was
maturing and reaching a larger audience--in the varied forms

of technological and social forecasts, impact assessments, systems analyses, and science fiction. Clarke, along with other historians of the genre (e.g., Suvin, 1979), describes how, at the same time that Congress was institutionalizing impact assessment, an increasing number of science fiction writers seem to have outgrown the gadgets and battles of early "space opera" stories and to have begun extrapolating current cultural and technological trends into the future. The novels and short stories produced by these writers examine the possible consequences of present actions through the perceptions and experiences of story characters who live with those consequences.

Stories or novels of this type, dealing with near-term futures (i.e., fifty years or less) and located on this planet, make up a special, hitherto unrecognized subgenre of the larger genre of science fiction. I have called this subset extrapolative fiction (EF) in this dissertation to distinguish these works from other forms of futuristic fiction (e.g., fantasy, utopias). Figure 1 illustrates the relationship between extrapolative fiction and other types of stories that might be published in the same journals.

There are a number of apparent similarities between extrapolative fiction and IA reports. They both deal with the near future, looking at the immediate to fifty-year timeframe. They both assume that values and day-to-day behaviors remain relatively constant and so present few, if any, significant cultural changes. Most importantly,
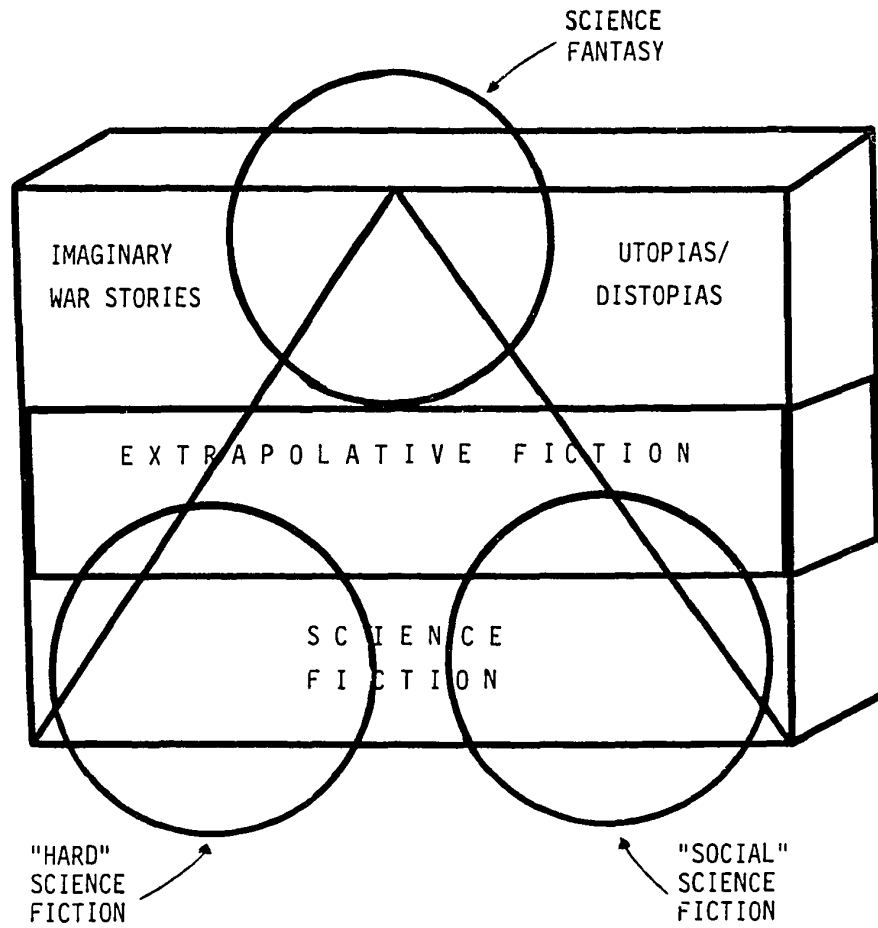
Figure 1. Extrapolative fiction in relation
to other forms of futuristic
fiction.

however, they both identify and examine the possible
consequences of innovations being considered in the society
in which they are written.

There are a number of differences between extrapolative
fiction and impact assessment, as well. While IA reports
use tables, graphs, and quantitative descriptors to present
the results of large changes on a societal level, EF stories
use symbols, images, and metaphors to present individual
consequences in qualitative terms. While IA reports use
what Linstone (1983) has called a "technoscientific" per-
spective to address large-scale, statistically measurable
effects, EF stories use what he has called a "personal"
perspective, focusing on the individual's response to the
innovation. In Elkins' terms (1979), these stories provide
"dramatic" models of human actions and responses to change,
while the reports provide "rational" models of the system's
behavior.

These differences suggest that extrapolative fiction
may provide an alternative set of techniques for reaching
the objectives for impact assessment. They suggest that the
use of extrapolative fiction in the IA process would
emphasize the qualitative presentation techniques and the
insights gained from a focus on individual and community
concerns and would therefore enhance the IA field's
effectiveness as an aid to decisionmakers.

APPROACH AND OVERVIEW

The intent of the research described in this dissertation is to determine whether extrapolative fiction can enhance the process and results of impact assessment. Specifically, the research seeks to show whether EF stories and novels (1) raise issues and clarify concerns that are not now included in the IA process, (2) provide present-ations of IA results that are more readily understood and acted upon by decisionmakers, and (3) can be effectively integrated into the process and products of impact assess-ment.

To answer these questions, a series of literature reviews and analyses was undertaken and a set of examples was formulated illustrating proposed alternative methods for achieving a synthesis (see Figure 2). (1) The IA literature was reviewed, and a catalogue of objectives and criticisms of IA reports was synthesized. (2) The science fiction literature was reviewed, leading to the identification of a list of works that, focusing on near-future on-Earth settings to explore the consequences of current actions, might be considered analogous to IA reports--works of fiction called here extrapolative fiction. (3) A statistical content analysis of selected EF stories and IA reports yielded objective measures of the similarities and differences between them. (4) A thematic analysis of EF stories related the themes and concerns presented in each to the content objectives for impact assessment. (5) A

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+------------------------------------------------------------------+
|                      LITERATURE REVIEW                           |
|                                                                  |
|  IA REPORTS                                FUTURISTIC            |
|  REGULATIONS  <--------------------------> FICTION,             |
|  GUIDELINES                                CRITICISM            |
|                                            GUIDELINES          |
|                                                                  |
|                      DEFINITION                                  |
+------------------------------------------------------------------+
                           |
                           v
+------------------------------------------------------------------+
|                                                                  |
|  STATISTICAL           THEMATIC             INDIVIDUAL           |
|  CONTENT ANALYSIS <--> RETROSPECTIVE  <-->  COMPARISONS         |
|  OF REPRESENTATIVE     ANALYSIS             OF IMPACTS          |
|  SAMPLE                (1940-1980)          DESCRIBED           |
|                                                                  |
|                      ANALYSIS                                    |
+------------------------------------------------------------------+
                           |
                           v
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|                                                                  |
|  ANTHOLOGY             EF METHODS           CONCLUSION          |
|     ON            <--> IN THE        <-->   DISCUSSION         |
|  LIFE-EXTENDING        IA PROCESS:          IMPLICATIONS       |
|  TECHNOLOGIES          GUAYULE              LIMITATIONS        |
|                                                                  |
|                      SYNTHESIS                                   |
+------------------------------------------------------------------+
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Figure 2. The research approach used for
this dissertation.

comparison of EF stories and IA reports describing the impacts of nuclear power plants provided a detailed single-case analysis of the specific similarities and differences. (6) Examples were developed to demonstrate the practical potential of including extrapolative fiction in the IA process and led to a set of guidelines for practitioners. (7) A discussion of the results explains some of the differences in content and provides some basis for understanding the criticisms published concerning the readability of IA reports. Finally, the implications of implementing the recommendations of the dissertation are discussed.

In the first literature review I examined the published methodological guidelines for and criticisms of IA reports. Journals, reports of symposia, and methodological guidebooks were examined. The results of this phase include: (1) a clearly defined set of objectives for a unified field of impact assessment, as it has evolved since the original legislation; and (2) an analysis of the content and process criticisms of impact assessment, within the framework of that set of objectives.

The next phase of research required a review of the science fiction journals, reviews, anthologies, handbooks, and bibliographies to select works with a potential for meeting some of the objectives for impact assessment. Such stories should deal with the timeframe of impact assessment (usually five to fifty years), should be placed on this

planet and in the context of our industrialized culture, and should have no extraterrestrial involvement. The results of this search led me to create a topical bibliography of some hundred near-future stories and novels written between 1940 and 1980, and to identify a separate subgenre composed of these works, which I have called here extrapolative fiction.

Using these results, I undertook a content analysis of a sample of eleven IA reports and ten comparable EF stories to determine the degree to which they met the content objectives for impact assessment. The statistical analysis required counting statements describing impacts in both the EF stories and comparable IA reports. A group of coders identified and counted impact descriptors by categories put forth in the IA guidelines synthesized from the first literature review. Because of the relatively small size of the sample, a series of t-tests were applied to the coders' data to establish the significance level of the differences between the mean numbers of statements in each impact category for each set of works. Out of that analysis it became clear that while neither the IA reports nor the EF stories fully met the content objectives for impact assessment, together (and with some overlap) they nearly covered the full set of impact categories. Specifically, in over half the categories, there was no significant difference between the samples. The IA reports had significantly more statements describing the aggregated physical, technological, and economic environments, while the EF stories analyzed showed

significantly higher means in certain (qualitatively rather than quantitatively defined) categories in the techno-economic and social environments, as well as quality-of-life factors, and described impacts in a wider range of categories than the IA reports did. Also, there were a significantly greater number of statements describing general impacts (that is, statements like "air quality will not be affected," or "little effect on plant life is expected") in the IA reports compared to almost no such statements in the EF stories, suggesting a substantial difference in level of focus.

An analysis of the themes and concerns described in EF stories set prior to 1980 demonstrates the degree to which those concerns reflect the emergent concerns of the culture as expressed later, in other media, and provides a basis for comparing them against the content objectives of impact assessment. Using a matrix framework derived from the IA literature (Martino, 1965; Miller et al., 1972), I analyzed over a dozen EF stories and novels to identify the social, technological, economic, environmental and political concerns expressed at three levels. These levels were (1) philosophy and ideals (values and ethics factors), (2) setting (sociocultural factors), and (3) the character's experience (quality-of-life factors). Descriptors from a given story in the cells of this matrix were indicators of the degree to which that work met the content objectives for IA. For most cases, each cell contained at least one

descriptor. The number of themes and concerns dealt with in professional and popular periodicals after a story's publication was used as the measure of that story's effectiveness in identifying emergent issues. For the stories dealing with innovations not yet implemented, many of the concerns raised in the stories were reflected in the literature by 1980. For the stories dealing with nuclear power plants, all of the issues raised in the stories were discussed in the literature.

A comparison of the impacts described by EF stories on nuclear power and transportation systems to IA reports about such systems shows the degree to which IA reports differ from EF stories in the scale and types of impacts described. The EF stories analysed included three on the operation of nuclear power plants (Heinlein, 1940; Piper, 1951; Edwards, 1953) and four on transportation systems (Heinlein, 1942; Herbert, 1956; Clarke, 1957; Ellsion, 1968). The nuclear power assessments studied include the report to President Kennedy which was the basis for his decision to support privately-owned nuclear power plants (Seaborg, 1962), and the environmental impact statement for the Three Mile Island plant (Nuclear Regulatory Commission, 1976). The transportation assessments were completed for the Department of Transportation by SRI International (1978) and Peat, Marwick, Mitchell, and Company in response to a request from that agency for technology assessments of current and emerging transportation technologies. The analysis showed

that EF stories described impacts relating to the causes and effects of accidents, the effects of stress and unionization on personnel, the effects of capital-intensive systems on policymakers, the displacement of related technologies, the location of population centers in relation to the technology, and shifts in power in related bureaucratic structures. The IA reports on nuclear power discussed the expected radiation exposure associated with accidents, the economic benefits and cost overruns associated with plant construction, the effects of such plants on the coal and transportation industries, and the utility of nuclear technologies to military and space programs. The IA reports on transportation described high-density traffic corridors, energy use, cost of construction, operation and maintenance, and aesthetic improvement in downtown cores.

These combined results suggest that integrating extrapolative fiction into the IA process is an obvious next step. Two basic alternatives were developed to be tested: (1) the use of already published works to augment a completed IA report, exemplifying and illustrating the conclusions; and (2) the use of extrapolative fiction early on in the IA process by including a person with fictive skills on an IA team to help shape research questions and concerns (See Figure 4). I developed examples for each of these alternatives as a way to demonstrate their feasibility and to provide a basis for evaluating the problems and potentials for implementing them. Based on the experience
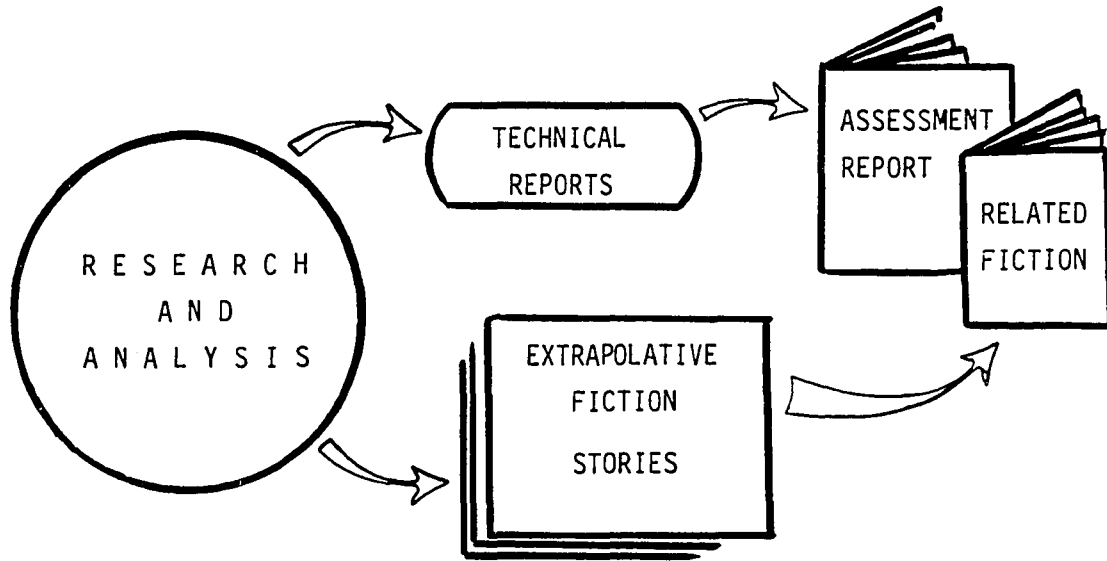
3a. EF stories are used to augment a complete report.
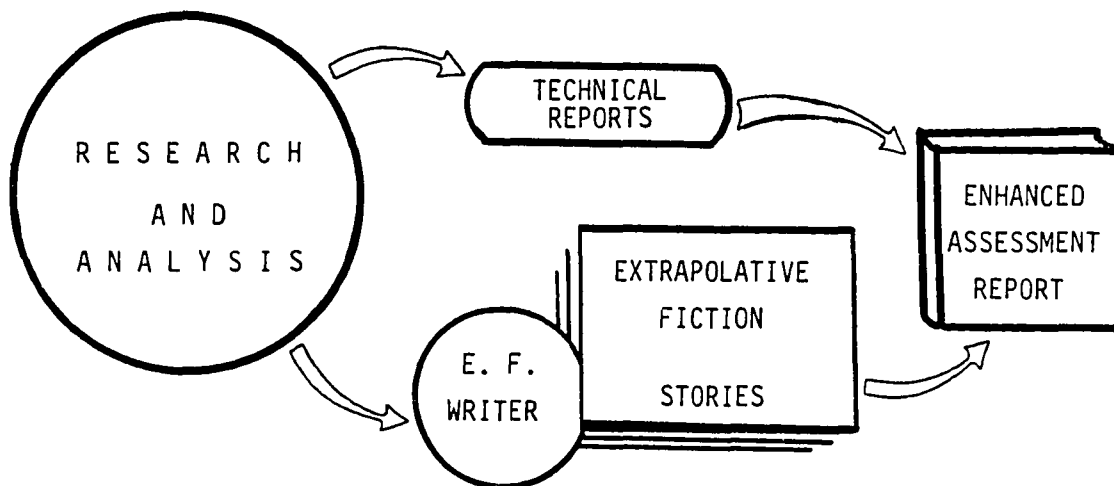
3b. A fiction-oriented person is included on the IA team.

Figure 3. Alternative configurations for integrating extrapolative fiction into the impact assessment process.

of developing the alternatives, I prepared some guidelines
for IA practitioners.

The first example for integrating extrapolative fiction
and impact assessment appends a collection of published
short stories and excerpts from novels to an IA report on
life-extending technologies. Focusing on the experience of
life extension, these works of fiction complement the
assessment at several levels and exemplify and extend the
issues and concerns raised in the IA report. Where the
report provides the statistical, demographic, policy and
ethical factors associated with these technologies, the
stories illustrate the conflicts involved in the experience
of living with extended lifespans. Where the IA report
describes the general demographics of a population with an
increasingly large proportion of senior citizens, the
collection of stories helps the reader feel the hopes and
fears of characters living in such a culture. By illus-
trating such contrasts and similarities, this example
demonstrates the way that published EF stories can provide
individual and quality-of-life impacts and provide imagistic
models of the innovation-in-context, enhancing the utility
of a traditional IA report.

The second alternative for integrating impact
assessment and extrapolative fiction requires including EF
stories or methods in the IA process. The example developed
here describes including a person with an orientation toward
fiction as part of an IA team, introducing EF methods in the

team's process. Personal experience in that role provides the basis for this example. As a member of a team studying transportation alternatives some years ago, I was one of several who insisted on the use of anecdotal material and imagination in developing the scenarios. The result was a set of scenarios that included anecdotal vignettes and fanciful illustrations alongside the text, describing the lives of people who might live in those scenarios (SRI, 1977). I contributed to that process through team discussions and suggestions for images and anecdotal material.

In 1979-80, an assessment of the commercialization of guayule (as an alternative source of natural rubber) again permitted a fiction orientation. The guayule study had a smaller team, so, in addition to contributing to the team's process, the results of my interviews and analyses were included as separate contributions to the report (Linstone et al., 1980). The story that emerged served to synthesize the study results and provided many of the insights that were documented in the final report (Linstone et al., 1981).

Together, the research results documented in this dissertation provide a basis for assessing the potential usefulness of extrapolative fiction as part of impact assessment. The analyses--comparing the issues raised and impacts described by EF stories and IA reports--show that the fiction can point out important and otherwise overlooked considerations to assessors. The first alternative for

integrating the fiction and the assessments--collecting a supplemental set of EF stories--shows the complementary nature of the two forms and provides a way to illustrate the range of experiential concerns raised by some technologies. The second alternative--including a person with skills in ᵣesearching and writing works of fiction on an assessment team--has been utilized with some success on at least two funded studies (described in this dissertation), and leads to substantially different insights and reports, suggesting considerable potential usefulness for that approach.

A number of guidelines, caveats, and suggestions for further research come out of this study of extrapoaative fiction and impact assessment. First, assessors need to be clear about the differences in form and content between traditional, estranged science fiction and the emerging new form of extrapolative fiction. They can make use of aficionados of this genre as starting points and decide early on whether it is appropriate to include someone who has some experience with the fictive mode on the team. They should recognize that writing EF stories is, in itself, a useful device for synthesizing complex information, even though a story may not be appropriate in the final report of results of the synthesis. Finally, using the bibliography developed here (See Appendix A) as a starting point, future assessors should continue to search for EF stories, exploring possible uses and misuses of fictional tools in the IA process as they gain experience.

Should the recommendations of this dissertation be implemented, the implications for the evolution of impact assessment are substantial. The enhanced process may lead to "model" reports that are published to reach a mass market and lead to a new level of citizen involvement in the IA process. These enhanced reports may, in turn, lead to the development of new, humanities-based methodologies. In addition, the writing of EF stories as part of the IA process may affect the quality and form of the currently unrecognized subgenre of extrapolative fiction, perhaps evolving to form a wholly separate genre, of fictional near-future forecasts and speculations.

CHAPTER II

THE EMERGING FIELD OF IMPACT ASSESSMENT

Having been legislated into existence in the early
1970s, the various forms of impact assessment have just
begun to become established among the policy sciences. As
with any new branch of research, much of the early work in
this area was plagued with methodological and substantive
difficulties that caused a number of observers to wonder
whether the effort was in fact worthwhile. Toward the end
of the decade, however, the processes had been sufficiently
standardized and large enough databases had been established
to permit a fairly consistent quality of product. As a
result, practitioners and observers are now able to crit-
ically assess the utility and relevance of the IA process
and its results, and to offer some possible improvements to
the field as a whole.

This chapter defines the field of impact assessment in
an historical context and reviews some of the criticisms
which have been leveled against it. A set of objectives for
a generalized IA process are derived from the literature and
a sample set of IA reports are critiqued in light of these
objectives.

FORMS AND FUNCTIONS OF IMPACT ASSESSMENT

As the pace of industrial development increases and the interrelationships between people, their institutions, their technologies, and their physical environment become more complex, traditional assumptions concerning the effects of actions falter. Decision-makers can no longer afford to assume that individual actions resulting in local good will also contribute to the general good. For example, a power plant intended to supply needed electricity to a city in one state can result in acid rains and coal-smoke haze that affect several other states, or the town in which the power plant is placed may experience a "boom-and-bust" period, destroying the social fabric of the community.

How impacts are identified and then mitigated or enhanced has become an increasingly important concern for society as a whole. The rise of the environmental movement in the early 1970s and the associated rise in political activism are measures of that concern. Activists have increased the pressure on lawmakers and regulators to prevent negative environmental consequences. Federal and state decisionmakers are faced with the increasingly difficult task of ensuring that their choices do in fact result from the consideration and mitigation or enhancement of all relevant impacts.

In the late 1960s, decisionmakers began to hope that, using the tools of systems science and technological forecasting, they could truly comprehend--perhaps even

manage--the consequences of their actions. In an age when
the democratic decisionmaking process seemed doomed to
failure, elected leaders finally felt that they could make
truly informed decisions. As a result, in the 1970s, laws
were passed and agencies established to provide legislators
and elected officials with appropriate information. Various
forms of impact assessment were defined, starting with the
environ-mental impact statement (92nd U.S. Congress, 1970).
Later forms included technology assessment (94th U.S.
Congress, 1972), social impact assessment (Wolf, 1980), and
program or area-wide assessment (U.S. Department of
Highways, 1980). Each of these forms had its own guide-
lines, regulations and methodology, and each addressed a
different aspect of (or level of concern regarding) the
future consequences of present actions.

Environmental Impact Assessment

The need to consider the implications of change--for
both society and its environment--became institutionalized
in this country with the passage of the U.S. National Envi-
ronmental Policy Act of 1969 (NEPA) (92nd U.S. Congress,
1970). Emerging out of a decade of heated debate over the
potential harm caused by pollution of air and waterways,
this act aimed to "encourage productive and enjoyable
harmony between man and his environment" (92nd U.S.
Congress, 1970: Sec.101 (a)). Specifically, NEPA required
that federal agencies and their contractors include an
environmental impact statement "in every recommendation or

report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment" (Sec. 102(2)(c)). This statement was to detail the impacts of the action, unavoidable adverse effects, possible alternatives, short-term vs. long-term effects, and "irreversible and irretrievable" resource commitments associated with the action (Sec. 102(2)(c)(v)).

Further, NEPA established the Council on Environmental Quality (CEQ) to set guidelines and (later) regulations for agencies and organizations to follow in preparing impact statements. The Council was also to review such statements and make policy recommendations to the President (92nd U.S. Congress, 1970: Title II). CEQ regulations describe the NEPA process as intended to "help public officials make decisions" by providing them with the information they need to understand the "environmental consequences" of their decisions and to act in ways that "protect, restore, and enhance the environment" (CEQ, 1980: Sec 1500.1 (c)). The regulations further define the environmental impact state- ment (EIS) as "an action-forcing device to insure that the policies and goals defined in the Act are infused into the ongoing programs and actions of the Federal Government" (CEQ, 1980: 1500.1 (a)). They specify more clearly the definition of the term "human environment" as used in NEPA, to be "the natural and physical environment and the relationship of people with that environment" (CEQ, 1980: 1508.14).

CEQ regulations state four main objectives for the EIS:

1. provide full and fair discussion of significant environmental impacts

2. inform decisionmakers and the public of reasonable alternatives

3. be concise, clear, and to the point

4. be supported by evidence (1502.1)

Further, when the assessment process discloses that "economic or social and natural or physical environmental effects are interrelated," the EIS must include all of these effects in a discussion analyzing their significance at several levels "such as society as a whole (human, national), the affected region, the affected interests, and the locality" (CEQ, 1980: 1502.16). The CEQ regulations at once established the content of environmental impact statements and set the tone for others to follow.

Following the federal example, a number of state governments (thirty as of the summer of 1980) enacted similar legislation. There is some variation in language and review process across them, but the intent of all is the same. In most states, therefore, projects using state or federal funds or making use of a state- or federally-funded service (e.g., waterways maintained by the Army Corps of Engineers) are subject to the preparation and public review of a statement describing the full range of environmental impacts likely to result from the project's implementation. As a consequence, virtually every major program (e.g., research

in recombinant DNA), development (e.g., the commercial-
ization of guayule), or construction project (e.g., dams,
roads, major buildings) proposed in this country must be
assessed and reviewed for its potential impacts on the
local, human environment.

Together, federal and state regulations establish the
legal necessity for an IA process focusing on the effects of
a specific project or program on the natural (or physical),
social, and economic environment in which it will be placed.
They indicate the form of document needed and provide exten-
sive instructions for reviewing the contents. However,
although the regulations define the need for, the intent,
and the use of impact assessment, they proovide few guide-
lines for the process of researching, analyzing, and
preparing IA reports. Since this process is a new one, such
guidelines have been sorely needed.

Thomas Dickert and Jens Jorgensen provide one of the
earliest attempts to meet this need for procedural guide-
lines in their article, "Content and Organization of
Environmental Impact Statements" (in Dickert and Domeny,
1974). Unlike the framers of NEPA and the CEQ regulations
who were concerned with the IA report, Dickert and Jorgensen
consider impact assessment primarily as a process and so
give assessors an initial set of guidelines for that
process. They define impact assessment as consisting of
three functions:

1. identification of impacts;

2. prediction of the state of society and the environment at some future time (along with effects likely to be felt at that time);

3. evaluation of the costs and benefits associated with those impacts and effects (in Dickert and Domeny, 1974).

Dickert and Jorgensen are particularly concerned with establishing the scale of impacts, which they describe as "one of the most important functions in assessment" (1974: 32), and which is dependent on reliable forecasts for utility. They suggest that, although regulations and reviewers tend to focus on the contents and format of the final EIS report, for the assessor, performing the assessment in a methodologically sound manner is as important as the content of the report. This view is supported by the criticisms leveled against completed EISs by reviewers and other practitioners (e.g., Bendix, 1980; Porter et al., 1980). Together, they will be discussed in detail in a later section of this chapter.

Table I illustrates some of the types of EISs that have been submitted in the last decade or so. The statements illustrated are representative of four main types of project that are subject to the NEPA review process, and hence to the preparation of an EIS. They describe the impacts of a federal policy, a regional or areawide project, a local project, and modifications on an existing project.

The first example in Table I describes the expected impacts of a federal policy. The policy was enacted on the

TABLE I

SOME EXAMPLES OF ENVIRONMENTAL IMPACT STATEMENTS

TITLE	SOURCE

FEDERAL POLICY EIS

NIH Guidelines for Research Involving Recombinant DNA Molecules	National Institutes of Health, U. S. Department of Health, Education, and Welfare, DHEW (NIH) 1489 and 1490, Washington, D. C., 1977.

REGIONAL OR AREAWIDE EIS

Proposed Increase in Acreage to be Offered for Oil and Gas Leasing on the Outer Continental Shelf	Bureau of Land Management, U. S. Department of the Interior, DES 74-190, Washington, D. C., 1974

LOCAL PROJECT EIS

Environmental Assessment, Rossman Processing Station, Portland, Oregon	Solid Waste Division, Metropolitan Service District, Portland, Oregon, 1976.

MODIFICATIONS EIS

U. S. 59 in Stevens County, Minnesota	Federal Highway Administration and State of Minnesota Department of Highways, EIS-MN-74-o180-F. St. Paul, Minnesota, 1974.

demand of public interest groups and members of the research community to establish guidelines for experimentation with recombinant DNA molecules (National Institute of Health, 1977). The statement describes the costs involved in enforcing the regulations, their effects on laboratory personnel, the likely secondary impacts resulting from their enactment and enforcement, the probable impact of experiments conducted according to the suggested guidelines, and the likelihood of spreading agents resulting from those experiments. The draft report was issued according to CEQ regulations and was reviewed by scientists, practitioners, and public servants, whose comments are included in the final report.

The second example may be called a "regional" EIS. This report describes the effects of a project across a large but fairly well-defined region--in this case the continental shelf of the United States (Bureau of Land Management, 1974). The format, typical of many controversial IA reports, consists of a number of reports from experts describing in great detail the impacts of the project--a coastal oil and gas leasing program--on the coastal zone as defined by those experts' fields of expertise. It includes descriptions of the effects of extracting oil and natural gas from offshore wells on fish and aquatic wildlife, local coastal fishing industries, on the economics and demographics of local urban areas, and on

the use and development of alternative energy sources (i.e., coal).

The third EIS listed describes a new project, intended by its sponsor to reduce one type of load on the environment --landfilling--by creating an electricity-generating incinerator (Portland Metropolitan Service District, 1976). This report is of medium length, something less than 200 pages, and offers minimal-level analysis of the impacts such a plant would have on air, water, noise, traffic, land use, wildlife, and local aesthetics. It also describes the economic costs and potential benefits to result from reduced landfilling in the local area.

Finally, the fourth example describes the modification of an existing structure, the creation of a short by-pass around a city, using some existing roadway and building some new (Federal Highway Administration, 1974). This report is typical of the "pro forma" reports that tend to emerge from projects that it is assumed everybody wants. It is brief, highly qualitative, and assumes--hence finds and reports--no negative impacts.* Since the by-pass includes a bridge, the report describes its potential impacts on the river, the water quality, the floodplain to be crossed, and local wildlife. The report assumes that increased commercial

*It has been suggested by Dickert and Domeny (1974) and Porter et al. (1980) that by far the largest number of EIS reports are of this type and that political acceptance of a project prior to its assessment is a common--and dangerous--hindrance to an effective IA process since it discourages careful research and analysis.

development along the by-pass will have positive effects on the economy of the region.

Technology Assessment

Technology assessments are like environmental impact assessments in being concerned with the full range of impacts. However, while environmental impact statements focus on the effects in a specific community or locale of introducing a project or program, technology assessments focus on the effeects of introducing a new technique or product into the societyy as a whole. This difference in focus stems, in part, from the difference in the audience receiving the report (TAs are prepared for members of Congress, for the most part, as opposed to executive branch regulators for EISs) and in the structure of the agency established by the legislation.

Congressman Emilio Daddario coined the term Technology Assessment when, in the same year that NEPA was passed, the House Committee on Science and Astronautics considered his bill to establish a federal Office of Technology Assessment (OTA). In October, 1972, President Nixon signed the Technology Assessment Act, according to which OTA is governed by a board made up of members from both the House and the Senate and serves as a research arm for Congress. The office is charged with providing Congressional committee chairmen the information they need to determine whether the long-term effects of a technological innovation--defined as production

method or line of products--or new federal program (e.g., strategic stockpiles) would be favorable or adverse for the nation as a whole (94th U.S. Congress, 1972).

The Technology Assessment Act defines technology assessment as a means for enabling Congress "to gain a legislative capability for policy determination in applied science and technology and for anticipatory decisions involving technological matters" (94th U.S. Congress, 1972). With this act, the legislative branch joined the executive (with its environmental impact assessment) in requiring policy decisions to be made based on an understanding of the potential social and environmental consequences of the policy or innovation under consideration.

In technology assessment, the effects of using the technology rather than the technology itself are examined. Emphasis is placed on the "explicit consideration of societal costs and benefits" (94th U.S. Congress, 1972). Seeking to enrich the decisionmaking process, technology assessment aims "to identify affected parties and antici- pated impacts in as broad and long range a fashion as is possible" (Hetman, 1973:44). This includes individuals and social groups, the ecosystem, the economy, other technolo- gies, and politics (Hetman, 1973). Technology assessment has been described as an "early warning system," providing decisionmakers with a glimpse of what could happen before it actually does happen (Carpenter, R., 1972). As such, it gives legislators some basis on which to develop long-term

or nation-wide policies regarding new technologies or technology-related innovations.

In order to more fully understand the nature of technology assessment and to point out the ways in which it differs from and is similar to environmental impact assessment, it is useful to consider some examples. Table II lists a few reports as examples of Technology Assessment. Together, they represent the three main approaches to technology assessment.

The first of the reports listed in Table II, concerning the impacts of residential use of photovoltaic systems (Krupka, 1979), more closely resembles an environmental impact assessment than a technology assessment. In the kinds of impacts it explores (e.g., use of resources and fabrication residues) and in its lack of policy analysis, this report offers little assistance to legislators considering policy options regarding the implementation of solar photovoltaic energy systems on a nationwide basis. It does, however, provide some very useful information to the individual considering implementing such a system in a residence. Based on a "model" residence in Phoenix, Arizona, using silicon cells to generate about ten kilowatts (peak) electricity, the report identifies major uses of resources, operating residues, and decommissioning residuals. It suggests major environmental impacts when fabrication and transportation of cells are considered. Cost estimates are developed using a computer model, and

TABLE II

SOME EXAMPLES OF TECHNOLOGY ASSESSMENTS

TITLE	SOURCE
QUANTITATIVE DESCRIPTIVE TA	
Decentralized Solar Photovoltaic Systems	Krupka, M.C., report to the U. S. Department of Energy Office of Technology Impacts, prepared under contract: Los Alamos Scientific Laboratories, Los Alamos, New Mexico 1979.
HOW-TO TA	
An Assessment of Information Systems Capabilities Required to Support U. S. Materials Policy Decisions	Office of Technology Assessment OTA-M-40, December, 1976
NEW POTENTIALS TA	
The Implications of Electronic Funds Transfer	Ernst, M. V. et al., report to the National Science Foundation, Research Applied to National Needs Program, Arthur D. Little, Inc., 1975.

zoning and building codes, along with interaction with
utilities are described as social impacts.

The second report, by contrast, is almost purely a
policy document (Office of Technology Assessment, 1976).
Developed by OTA on request from Congress as part of a
larger study, this assessment of information system
capability describes the options available to Congressmen
for dealing with the information related to policy decisions
concerning maintaining materials stockpiles. The report is
intended to provide Congress with information concerning
policy options. It describes existing information systems
and their inadequacies, based on interviews. It offers
three alternative approaches and seven institutional
mechanisms for implementing the. Qualitative analysis of
impacts deal with governmental, economic, social, legal, and
international policy concerns. Policy issues are analysed,
and three alternative approaches and seven institutional
mechanisms are described, with their related governmental,
social, legal and international policy concerns. The
emphasis of this TA is on how such systems may be
implemented rather than on what may happen if they are.

The third report (Ernst, 1975) studies the potential
new applications of computer technology in the banking
community, describing the possible uses (e.g., automated
teller machines) without identifying or analyzing their
effects. Conducted by a professional management consulting
firm, this study emphasizes the potential uses of the new

technologies in the banking community, including automated
teller machines, automated clearinghouses, check safe
keeping, and direct inter-corporate transactions. The
report has been hailed as one of the most readable yet least
verifiable assessments published (see Linstone et al.,
1980).

The three assessments presented in Table II provide
examples of three different approaches. The first exemp-
lifies the highly quantitative descriptive report. The
second is a typical "how-to" report. The third provides an
exploration of new potentials. Each report, then, deals
with one part of the technology assessment process as
defined under the 1972 Congressional act.

A GENERALIZED DEFINITION FOR IMPACT ASSESSMENT

The above discussion suggests that there is a great
deal of congruence between the goals and processes of tech-
nology assessment and environmental impact assessment. The
two were formalized with a common intention: to encourage
measures protecting the society and its environment, and to
provide an information base for decisionmakers. Similar
methodologies and philosophies--many drawn from the prac-
tices of technological forecasting and policy analysis--
underlie the two forms' processes.

This similarity is made obvious in Table III. Here,
several recommended strategies for performing impact
assessments are compared: three from the EIS guidelines and

TABLE III

RECOMMENDED STRATEGIES FOR TA AND EIS

	Technology assessment study strategies			Environmental Impact statement guidelines		
	Jones (1971)	J. Coates (1976b)	Armstrong and Harman (1977)	U.S. CEQ (1974) Guidelines	U.S. Department of Housing and Urban Development (1974) Format	Zajic and Svreck (1975)
Problem definition	1. Define assessment task	1. Examine problem statements 7. Identify parties at interest	Ib. Bounding the assessment domain	1. Project description	1. Describe proposed project	1. Statement of objectives 3. Proposed actions
Technology description	2. Describe relevant technologies	2. Specify systems alternatives 8. Identify macro-system alternatives	Ia. Data acquisition	2. Land-use relationships 4. Describe alternatives	3. Discuss impact of environment on project design 5. Discuss internal project environment 6. Discuss alternatives	2. Technical possibilities for achieving objectives
Technology forecast			Ic. Technology projection			
Social description	3. Develop state-of-society assumptions	9. Identify exogenous variables or events	IVa. Whole societal futures IVb. Societal values	1. Describe present conditions	2. Describe existing environment	4. Environment prior to proposed action
Social forecast						
Impact identification	4. Identify impact areas	3. Identify possible impacts	IIa. Impact criteria selection			
Impact analysis	5. Make preliminary impact analysis	4. Evaluate impacts	IIb. Predicting and assessing impacts	3. Describe probable impact 5. Describe adverse impact	7. Discuss short- and long-term impacts 9. Describe reaction to program development	5. Impacts including magnitude and importance
Impact evaluation			IIc. Impact comparisons and presentations	6. Short- vs long-term impacts and their relationships 7. Irretrievable and irreversible impacts	4. Evaluate impact on environment	6. Assessment of impact
Policy analysis	6. Identify possible action options 7. Complete impact analysis	5. Identify decision apparatus 6. Identify action options for decision apparatus	III Policy analysis	8. Other considerations offsetting adverse effects	8. Note actions taken to mitigate impacts	
Communication of results		10. Conclusions (and possibly recommendations)	IVf. Validation. and public participation			7. Recommendations

SOURCE: Porter et al., A Guidebook for Technology Assessment and Impact Analysis, New York, North Holland, 1980.

regulations, and four from the TA literature. The similarities in process between these several approaches have led Porter and his colleagues to combine them and to describe a more generalized form (Porter et al., 1980). The strategy recommended by Porter and his colleagues (column I)--problem definition, technology description, technology forecast, etc.--incorporates the essential elements of the other six strategies and guidelines. The Porter team's strategy is a flexible structure that permits the inclusion of elements from the other strategies as appropriate to a given assessment. Further it meets the criteria which they suggest in their guidelines for a combined TA/EIA process:

> It must accurately describe the state of the art of the relevant technology and forecast the changes that the technology is likely to undergo. It should also describe the relevant features of the society, its values, and ways of managing the technology, and should anticipate how these factors might limit and shape the context in which the technology must function in the future. It must identify areas of the social and physical environments that are likely to be impacted by the technology and analyze the character and extent of significant impacts. Policy options . . . must also be identified. Finally, since no TA/EIA can be effective unless its results are communicated to the user, it should be presented in a clear, logical, and effective manner. (Porter et al., 1980: 5)

Objectives for Impact Assessment

The criteria for TA/EIA put forth by Porter et al. (1980) do not fully cover social impact assessment (as defined by C. P. Wolf, 1980) and program or area impact assessment (currently seen as a special case of EIS or TA, depending on who the client is (see Hornick and Enk, 1980)).

To include these forms of impact assessment it is necessary to make a few additions to Porter et al.'s contribution.

Table IV lists Content and Process Objectives for environmental impact assessment, technology assessment, area-wide or programmatic assessment, and social impact assessment, combined. These objectives are synthesized from the guidelines and regulations for each of these IA forms and are presented here as a framework to permit further analysis and discussion of the IA process as a whole, along with its results.

The content objectives presented in Table IV illustrate impact assessment's orientation to the broadscale impacts of an innovation. They are clearly tied to the decision-making process and the user's need to be fully informed. The process objectives are, similarly, oriented to making the IA results useful to the decisionmaker. The objectives in both categories are specific enough to permit analysis and evaluation of existing IA reports and establish the degree to which such reports meet these objectives.

Concerns and Criticisms

The first decade of impact assessment has produced over fifty thousand environmental impact statements--prepared to meet National Environmental Protection Act requirements and equivalent state regulations (Hornick and Enk, 1980)-- and a hundred or so technology assessments (based on reports from OTA, the National Science Foundation, and the National Technical Information Service), including some two dozen

TABLE IV

OBJECTIVES FOR IMPACT ASSESSMENT

Objectives	Source
CONTENT OBJECTIVES	

Provide full and fair discussion of significant impacts on
  -the natural or physical environment
  -individuals and groups in society
  -the economy
  -related technologies
  -politics
	Arnstein and Chistakis, 1975; Porter et al., 1980; National Environmental Protection Act (NEPA)

Analyze the extent and character of impacts	NEPA
Inform the public and decisionmakers of reasonable alternatives	Technology Assessment Act, NEPA
Anticipate changes in the physical and social environment—longterm, indirect, or unanticipated	NEPA; Hetman, 1973
Focus on the effects rather than the technology or project under study	Hetman
Consider explicitly the costs and benefits to society	Hetman
Relate forecasting and evaluation activities closely to identified impacts	Porter et al.
Describe society's values and ways of managing	Porter et al.
PROCESS OBJECTIVES	
Ensure congruence between predicted and actual results	NEPA
Ensure adequate evidence so that study results are credible	NEPA
Maintain a neutral and objective position	Congressional Research Service
Present results in a clear, concise, and meaningful statement	Porter et al.; NEPA
Release statement at an appropriate time to assist the decisionmaking process	Porter et al.; Council on Environmental Quality, 1980
Improve the methodology by carefully designing and documenting the process	Hetman; Porter et al.

from the Office of Technology Assessment and another thirty-odd supported by the National Science Foundation.

The IA reports listed in Tables I and II (pp. 28 and 34) are examples selected on the basis of recommendations from other professionals in the field as typical of assessments of their type. Table V summarizes the comments on these reports as they have either (for EIS's) been included in the final draft based on public review of the review draft, or (for TA's) been printed in the methods literature.

These comments fall into four main categories: those calling for more analysis, those calling for more documentation of results, and those requesting additional descriptions of impacts or alternatives. Several of the reports reviewed were cited for assuming, rather than analysing, either initial data or the impacts themselves. Lack of documentation was cited in several reports--for assumptions, data, effects, and analysis. Inadequate discussion of impacts, effects, or "evolutionary consequences", was cited in most of the reports reviewed. In addition, a few were noted as lacking in alternative policy options or means for implementation.

These and other reviews of IA results have raised serious questions about the validity and utility of the impact assessment process and its products. Reviewers have criticized the reports as lacking in important and essential information. Practitioners have suggested that lacks in

TABLE V

SOME COMMENTS ON IA REPORTS

REPORT	COMMENTS

Environmental Impact Statements

Research Guidelines for Recombinant DNA (NIH, 1977)	- inadequate participation by the public - insufficient discussion of possible evolutionary consequences of accidents - need more discussion of implementation - insufficient speculation on deliberate misusage - need documentation for assertion of lack of harmful effects
Proposed Increase in Acreage for Off-shore Oil and Gas Leases (Bureau of Land Management, 1974)	- excessive use of technical language - inadequate support documentation for certain figures - excessive focus on highly detailed discussion of specific impacts
Rossman Garbage Processing Station (Portland Metropolitan Service District, 1976)	- air quality from monitoring stations assumed to be representative for site - no "moving baseline" for defining physical impacts - no assessment of the hazard of waste residues
U.S. 59 in Stevens County Minnesota (Federal Highway Administration, 1974)	- no quantitative analysis - no attention to social or insitutional effects - little attention paid to alternatives - careful consideration of construction concerns - inadequate discussion of economic effects

Technology Assessments

Decentralized Solar Photovoltaic Systems (Krupka, 1979)	- no summary of issues, impacts - little attention paid to social impacts - good use of appendix for explanations - conclusions regarding impacts not closely tied to discussions of same - no policy options discuss
Information System Capabilities Required for Materials Policy Decisions (OTA, 1976)	- little or no quantitative data, analysis - expert judgement plays heavily - useful summary - little attention paid to nonfederal institutions
Implications of Electronic Funds Transfer (Ernst, 1975)	- based on existing, not emerging technology - strong focus on organizations involved - good use of scenarios to illustrate impacts

Comments on EISs from the Final Drafts. Comments on TAs from Porter et al., 1980; Armstrong and Harman, 1981; Linstone, 1981.

information are the result of inadequacies of assessment methodology. These concerns, pointing to underlying problems in the assessment process, are discussed below.

Sociocultural Factors. Major criticisms of the content of impact assessments emphasize their ineffectiveness in dealing with socio-cultural factors. Porter and his colleagues (1980) report a "tendency for most TAs and EIAs to neglect social descrip-tion, social forecasting, the analysis of social and political impacts, and policy analysis" (p. 153); the examples described earlier illustrate these lacks. Porter et al. also note a lack of "historical perspective" (quoting Lynn White, Jr., p. 153), which may be illustrated by the assessments describing off-shore leasing programs (Bureau of Land Management, 1977) and an urban incinerator (Portland Metropolitan Service District, 1976), both of which treated the projects as if they were being implemented in an historical vacuum. Anthropologist Bodley expresses the concern that future needs are "characteristically identified on the basis of current cultural conditions and past trends" with little consideration for the dynamics of culture change (Bodley, 1976: 218). As a result, for instance, it is assumed that oil will continue to be consumed and garbage produced at current rates (or will increase at current rates).

Length of Reports. Other content concerns emphasize the unnecessarily lengthy reports. Dickert and Jorgensen raise the issues of "padding" and "a strong natural tendency

for public agencies . . . to present their project in the most favorable perspective", as factors that reduce the usefulness of the EIS to the decisionmaker, as well as the credibility of the impact assessment process (1974: 37). It is not unusual, for example, for a report to have negative impacts buried in a list of seemingly unimportant details while positive impacts are displayed prominently in an executive summary. In the early days of impact assessment, when a study might be as long as fourteen volumes, this technique has been particularly effective.

Lack of Synthesis. Selena Bendix (1980) states that the training of the assessment's team members in single disciplines lead them to prepare sections of the report individually, each section detailing the concerns of a team member's discipline. In such cases, says Bendix, the authors have typically

> written something appropriate for a professional
> journal, but . . . have become unintelligible to
> the members of the community activist group, . . .
> the city council members . . . who would like to
> have an informed opinion and be able to answer the
> questions of their constitutents, and the decision-
> makers who have to decide whether to approve . . .
> (Bendix, 1980: 19)

The resulting whole lacks a synthetic statement of the relevant issues and options, as well.

Process Concerns. A number of process concerns have been expressed, as well. Bodley comments on a "tendency to deemphasize the cultural implications" of an innovation and the effects of specialization on the research. "Problems," he notes "are seen in isolation . . . [hence] their

aggregate consequences and implications may be overlooked"
(1976: 219). Thus, for example, the study of solar
photovoltaics--a step to individual energy self-sufficiency
--does not include descriptions of other steps in that
direction and so does not address the cultural shift to
self-sufficiency which solar photovoltaics may help to
create.

Revised Guidelines. In their 1980 regulations for
EIS's, the Council on Environmental Quality has taken note
of these criticisms. CEQ regulations include specific
instructions for "reducing paper-work" and "reducing delay"
in the research and review process (1980: 1500.4). CEQ has
implied a number of specific criticisms of the IA process
through their use of such phrases as "reducing the length
of" and "preparing analytical rather than encyclopedic"
impact statements, as well as "following a clear format",
"reducing emphasis on background material" and "emphasizing
interagency cooperation . . . rather than adversary
comments," (1500.1 - 5). These regulations, if enforced,
may significantly reduce the amount of effort required by
the decisionmaker to understand the assessment, but they
address only some of the concerns expressed in the
literature.

Underlying Problem Areas. Other areas of concern
include a lack of social forecasting, insufficient identi-
fication of impacts, inadequate models of social and

cultural change, treatment of problems in isolation, wordiness, and lack of timeliness. According to Joseph Coates, then director of NSF's Technology Assessment Program*, these concerns result, in large part, from five basic process problem areas. These are (1) interdisciplinary team research, (2) identification of impacts and (3) their evaluation, (4) drawing conclusions and making recommendations, and (5) the writing, presentation, and communication of results (Arnstein and Christakis, 1975). Of these, Coates states, problems in interdisciplinary team research are fundamental, as differences in language and thought patterns associated with the different disciplines tend to lead to a breakdown in communication and a lack of unity in reports. This problem usually becomes apparent in the type of report described by Bendix, above.

Coates' other problems have been the basis for much of the critical literature on impact assessment. Current methods for identification and evaluation of impacts are inadequate for the nonquantifiable social forecasts and resultant impacts. Problems of interdisciplinarity combine with this lack of adequate forecasts to prevent the team from developing the clear image of the study's results necessary to draw conclusions and make recommendations, or to present either effectively.

*Coates later became Director of the Office of Technology Assessment and currently owns a consulting firm specializing in technology and other forms of impact assessment.

Methodological Concerns. Porter and his colleagues
document a number of specific methodological criticisms from
practitioners. These include:

1. arbitrary weightings of cost-benefit variables

2. averaging out of costs and benefits per capita

3. quantitative treatment of subjective probability
ratings which permit them to "take on a life of
their own"

4. a "lack of conceptual advance in development of
methods [as opposed to imcremental improvements
in techniques]" (Porter, et al, 1980: 462-464)

Of the problem areas most frequently mentioned in IA
critiques, identification and evaluation of impacts--and the
societal forecast on which these activities depend--have
been said to be the heart of the impact assessment process
(Porter et al., 1980). As was illustrated in Table III, (p.
38) these activities, though present in all of the published
guidelines, take on different forms in each. Identification
and evaluation are, in Porter's terms, "the least developed
components of the assessment process" (1980: 58). Another
writer suggests that they proceed "without any standardized
method and with serious analytical deficiencies" (Peele,
1980:6).

Participants in Arnstein and Christakis' workshop also
identified these concerns, stating that while there are
numerous methods for the analysis of quantifiable impacts
such as those on resources, demographics, and economics,
there are none that permit the quantitative measurement of
significant social impacts such as institutional shifts

(Arnstein and Christakis, 1975). Many impact assessments, therefore, have neglected social impacts entirely. Others have limited discussion to those economic and demographic impacts for which there exist both baseline data and a substantial body of theory and methodology. Still others have substituted "generalities and disclaimers" for credible forecasts and impact analyses (Dickert and Domeny, 1974: 135). According to C. P. Wolf, the effect has been that

> As matters now stand, even if responsible agencies
> and officials know they should take account of social
> impacts, they are far from confident about how this
> might be done and what to do with the results (Wolf,
> 1980: 32)

The problems associated with identification and evaluation of social and other qualitative impacts, therefore, are crucial to the utility of the IA report. They are compounded by and contribute to: problems of interdisciplinarity, a lack of historical perspective and knowledge of cultural change processes, and an encyclopedic rather than analytical approach to presenting results.

The Call for Alternative Approaches

Taken together, such criticisms reflect fundamental lacks in impact assessment as currently practiced. They suggest that the hope and dream that led to the establishment of impact assessment as a legally required activity have come far short of being met. Recognizing this, new reports and guidelines are calling for a new approach (see Porter et al., 1980; Linstone, 1983)--one which enables decisionmakers to develop an intuitive understanding of the

innovation-in-context so that its impacts are easily
grasped.

These new reports assert that the traditions of the
disciplines and backgrounds of the investigators have led to
assessments with a limited perspective. They state that the
typical "techno-scientific" perspective in which impact
assessments are conducted (Linstone, 1983) sees situations
only as problems to be solved; offers only quantitative
analysis as the tool-set to solve those problems; ignores
the individual in the interest of statistical averages; and
pretends that investigators can be totally objective about
whatever they study. The result, these reports state (and
the above review of the critical literature supports), is an
assessment that is presented in quantitative terms, with
numerous generalizations and abstractions, and without a
clear presentation of the consequences of alternative
actions.

These reports call for a new, enlarged perspective that
considers individuals and values as well as artifacts in the
IA process, that recognizes that much information of value
to impact assessment is nonquantifiable, and that permits--
even encourages--subjectivity in the investigator, the
decisionmaker, and the people being investigated in
developing IA results. The reports suggest that assessment
is "as much art as science" (Porter et al., 1980) and offer
the possibility of drawing on other disciplines as a source
of material and methodology for the assessment process. One

such discipline is literature, and in particular, the form of literature that describes hopes, fears, and possibilities for the future.

CHAPTER III

EXTRAPOLATIVE FICTION

Over the late 1960s and the 1970s, while impact
assessment was emerging as an institutionalized activity,
fiction about the future was becoming a major literary form
in our society. One historian of the field, I. F. Clarke
(1979), points out that such fiction--which he calls
futuristic fiction--has been a literature based in and
expressing the hopes and fears of society for many years.
Drawing on the "most recent inventions and social changes"
as its source, Clarke states, such fiction has typically
reflected its authors' perceptions of the relationship
between science and society at the time of writing (Clarke,
1979). Alongside the technical-academic reports of
professional futurists, he goes on to state, futuristic
fiction has emerged in a variety of forms, including
utopias, dystopias, "imaginary war" stories, science
fantasy, and realistic science (sometimes referred to as
'hard' science) fiction.

This chapter reviews suggestions that futuristic
fiction may be considered a potential tool for the policy
sciences in general and examines an emergent form, called
here 'extrapolative' fiction, as a possible analog and tool
for the special field of impact assessment.

FUTURISTIC FICTION AS A TOOL FOR THE POLICY SCIENCES

A number of policy science educators and practitioners have recommended futuristic fiction as a useful tool for studying and practicing the policy sciences. Through the 1970s, many new classes, texts, and anthologies were created, using carefully selected stories to demonstrate possible relationships within disciplines. For example, political scientist M. H. Greenberg, in collaboration with anthologist Patricia Warrick, produced an anthology of short stories exemplifying the principles of political science and illustrating some possible developments in political systems (1973). The Sierra Club commissioned anthologist Terry Carr to put together a collection--made up of stories published in earlier anthologies--about "problems of our immediate future". They hoped that such works might, in the same way that the early space travel stories encouraged readers to become actively involved in astronautics, motivate "people to devote their working lives to solving environmental problems" (Carr, 1980). Some years earlier, the Council of Planning Librarians published William Rabiega's bibliography "Environmental Fiction for Pedagogical Purposes" as an aid for instructors in urban planning programs (Rabiega, 1974).

Both Greenberg and Rabiega are explicit about their reasons for using this form of literature in the classroom. According to Rabiega,

> First, the literature contains expressions of those
> future conditions which are most feared or desired by

the elements of the population the authors have given voice to in their prose. Thus, they set some loose parameters on the types of policies those who can affect the future through their current administration might consider. Second, they represent entertaining portrayals of possible futures against which current environmental information and trends may be compared to teach about these contemporary situations (Rabiega, 1974: 4).

For these reasons he specifically recommends the use of such fiction in "future studies" or "man and environment" courses as an introduction to these topical areas within the more traditional disciplines. His bibliography is a tool to make such use more effective.

Greenberg also considers the fictional portrayal of developing trends as an important contribution to classroom study, along with the presentation of alternatives. Most importantly, however, he finds that "the student who encounters political theory only in a textbook tends to see it as already determined, fixed, and static," when the political process and the theory describing it are constantly changing and dynamic (Greenberg, 1973: 23). He suggests three ways in which this "emerging fictional mode" assists the student to understand political theory. A story

(1) translates the abstractions . . . into particular situations and individuals that are representative of these concepts . . .

(2) can sharpen the [student's] awareness of technology's impact on . . . systems . . .

(3) [develops] flexibility in considering alternatives . . . Greenberg, 1973: 27).

Carr and Rabiega have shown that these characteristics are also found in stories describing the concepts of and

developments in ecological, social, and cultural systems.
Effectively, then, futuristic fiction is an alternative mode
for presenting and understanding the complexities of and
alternatives for our culture.

Similarly, a number of policy analysts and IA practi-
tioners have suggested that such stories might be useful to
the policy sciences, and to impact assessment. SRI Inter-
national's Ellen Heckler suggests that the genre is a
"valuable source for policy research analysts" (Heckler,
1968: 16). Based on her analysis of some hundred novels and
short stories, Heckler concludes that the writers have
"been able to visualize technological trends, and to an even
more accurate degree, they have been able to visualize
social and cultural trends" in such a way that their works
may be considered appropriate resources for policymakers and
reearchers to use when considering the implications of
present actions (Heckler, 1968: 18). She quotes an early
issue of The Futurist, stating that the writer in this genre

> is valuable not because he predicts the automobile,
> but he may foresee the parking problem; not because
> he foresaw radio, but because he might have anticipated
> the soap opera. "Not the action but the reaction."
> (Futurist, 1967: 32; quoted in Heckler, 1968)

The potential value of such stories to policy science
has been considered by others, as well. Anthony R.
Michaelis, addressing the 1983 Annual Meeting of the
International Association for Impact Assessment, suggested a
possible "interdisciplinary correlation" between science
fiction and technology assessment. He concluded that:

> in a certain number of cases . . . a definite
> correlation exists between technology assess-
> ment and science fiction namely when the author
> of a fictional tale has thought through the
> full implications of his imagination. (Michaelis,
> 1983: 9)

He concluded with a request for "continuation of the

experiment [I have] here begun, as it may help the

methodology of technology assessment" (1983).

During discussion following Michaelis' presentation,

Joseph Coates indicated that his group had found using a

fictional autobiography to describe the experience of using

an emerging technology to greatly enhanced the utility of

one of their reports.* Other participants were also

intrigued with the possibilities, but were clearly at a loss

as to what kinds of fiction to use or how to use it.

Futuristic Fiction And Scenarios

The question that must be answered before such

uncertainty can be resolved is: what is it about futuristic

fiction that causes these educators and practitioners to

suggest that it may be useful to the policy sciences?

A step toward answering that question is taken by

Porter et al. when they describe the potential use of 1984

as "a booklength scenario" (1980:153). A number of practi-

tioners have used scenarios in impact assessment and other

futures research activities (e.g., SRI, 1977; Krupka, 1974).

Several sets of guidelines have suggested using scenarios to

*The report itself is proprietary and is not
available for review.

present such forecasts and enhancing the IA process (e.g.,
Armstrong and Harman, 1980; Mitchell et al., 1975).

These references suggest that the use of descriptive
images of the state of society at some point in the future
is an accepted practice in impact assessment. Moreover,
such descriptions are recognized to be less analytical and
quantitative in their development and presentation. Porter
and his colleagues, summarizing the writers quoted above,
state that "common sense, insight, and intuition are still
the author's best guides" to developing and describing
possible scenarios for the future (1980: 153). They go on
to quote Ascher's (1978) description of the scenario as a
"blend of insightful forecasting with storytelling" (1980:
151), suggesting a close link between scenario development
and fiction.

There are four main characteristics linking futuristic
fiction with scenarios. These include: the subject matter
of futuristic stories, the language used to write them, the
orientation or perspective the author takes in writing a
story or novel, and the use of technically accurate detail
to ground the story in known reality. These four charac-
teristics also distinguish the fictional account from the
technical or academic report in which the scenario is
embedded.

Subject Matter. The first of these characteristics
relates to fiction's subject matter. The subjects of
futuristic fiction are often very similar to that of

contracted policy studies. As speculations about the social

and technological potentials associated with emerging

innovations, policy studies and futuristic fiction have much

in common. Rabiega, Heckler, Michaelis, and the others

cited above have reviewed stories describing urban problems,

educational systems, modes of transportation, and political

processes. Based on those results, they emphasize commonal-

ity of subject matter when they propose the use of this form

of fiction for instruction in and the practice of the policy

sciences.

Language. Another characteristic mentioned by several

of the policy scientists who have suggested futuristic

fiction as a useful tool is fiction's ability to capture and

hold the reader's interest, while conveying understandings

of complex interrelationships. This characteristic is a

function of the form of language used in fiction, what

Embler has called the highly imagistic and subjective

"language of the arts" (1966). In contrast, scenarios,

impact assessments and other futures research reports are

typically written in Embler's "language of reports," using

objective, precise terminology and focusing on abstractions.

The use of symbols, metaphors, and images in fiction lend a

sense of concreteness to the material and shift the reader

from the consideration of abstractions to the experience of

a possible reality. Since the reader is experiencing that

possibility, his or her attention is held. And since the

interrelationships between the elements of the setting and

the characters are presented through the use of commonly held images of concrete reality--rather than the abstractions, graphs, or tables found in technical reports and academic studies--they may be understood more readily by a reader not trained in interpreting such graphs and tables.

Perspective. The third characteristic of futuristic fiction also distinguishes such tales from policy reports, by shifting the reader's perspective. Policy scientists are confined to, in Linstone's (1983) terms, the "techno-scientific"--objective, problem-oriented, rational and analytical--perspective. The writers of fiction, on the other hand, use intuition and imagination from what Linstone calls the "personal" perspective. They describe individual human concerns--the feelings, changes in lifestyles, actions expected or required, etc.-- about and responses to innovations and their effects. This difference in perspective combines with the difference in language to provide for the reader a personal, concrete, and intuitive experience (hence understanding) of the innovation being described.*

Accurate Detail. Finally, the educators and practitioners who recommend the use of futuristic fiction in the policy sciences have suggested one other important characteristic of such fiction. This fourth quality is the use of technically accurate detail to enhance both the sense

*Charles Elkins (1976) calls this a "dramatic" model of future possibilities, as opposed to the "rational" models developed by policy scientists and futurists.

and the possibility of reality in the story (Heinlein, 1965; Heckler, 1968; Warrick, 1980). Many authors of futuristic fiction draw on their own backgrounds and training in the sciences to develop explanations and useful gadgets for the situations they create in their stories. These explanations and gadgets add richness to the story while enhancing the reader's understanding of the story's focus--the impacts of the innovation being described.

Forms of Futuristic Fiction

Together, these characteristics explain the interest expressed by policy science educators and practitioners in using futuristic fiction in the study and practice of the policy sciences. They provide some guidelines for selecting fiction that may be useful to the policy sciences in general. They do not, however, address the question of which stories or novels may be useful to which fields within the discipline, or the more practical question of how to use them.

There are a number of forms of futuristic fiction that deal with times and places so far removed from present reality as to greatly reduce their utility to the study or practice of a given field. For example, the many "space operas" (e.g., Smith's Lensman series and Lucas' Star Wars) provide vivid opportunities for the imagination but may contribute little to the reader's understanding of how to deal with immediate issues. More realistic speculation, placed in far distant times and places (e.g., LeGuin's The

Dispossessed (1969), or Asimov's Foundation Trilogy (1951, 1952, 1953)), may contribute to the reader's understanding of systems and processes, but do not typically describe immediately available policy options.

Clarke (1979), Suvin (1979), and others have divided futuristic fiction into the fields of utopias (including both positive and negative utopias), "hard", realistic, or speculative science fiction (which deal with the potentials associated with known scientific principles or emerging technological developments), fantasy (works placed outside of known physical or psychological constraints which may or may not depend on scientific or technological advances), and imaginary war stories (which extend current strategies, technologies, and tactics by introducing new ones or bringing up old ones to consider the possible outcomes of imagined battles). Clearly, selection criteria must be established if futuristic fiction is to be used effectively in specific policy applications.

EXTRAPOLATIVE FICTION AND IMPACT ASSESSMENT

The consideration of futuristic fiction as a useful tool for the policy sciences in general suggests that, for specific fields within the larger discipline, there may be specific forms of futuristic fiction that meet those fields' specific requirements. If a subset of this fiction were to be useful in meeting the special needs and requirements of impact assessment, such fiction should be limited to a

timeframe and location equivalent to those of impact assessment. That is, it should deal with the next fifty years in a clearly defined locale on this planet. Moreover, fiction, to be useful to impact assessment, would have to be similar in scope of concern regarding the impacts of the innovation being described. Then, such fiction should be supported by sufficient accurate technical detail to be credible to the informed reader who is involved in the IA process.

Within the larger body of hard science, or speculative, fiction, there has been emerging over recent decades a group of works that explore the near-future consequences of current actions. These stories and novels look at political and social as well as technological innovations, and present scenario-like images of what is likely to occur in the next few years. Rather than create far-distant alternatives that might provide clearer perspectives on what is now, as most of the works published in science fiction journals currently do, these works extrapolate current developments into a cultural context that is changed only by those developments.

The favorite themes of this fiction, according to one critic, "involve the impact of developments or revelations derived from the human or the physical sciences upon the people who must live with those revelations or developments" (Rose, 1969: 5). Using the techniques and forms of one subset of futuristic fiction--realistic science fiction--as their medium, the authors extrapolate from issues and

developments emerging now to systems and structures that might be in place some years hence.

Clearly, the authors who accomplish these tasks are more than skilled storytellers. One major author emphasizes the need for an "adequate knowledge of the real world, past and present," combined with "a thorough understanding of the nature and significance of the scientific method" to develop such scenarios (Heinlein, 1969: 26). Only thus, he states, can the author be in a position to logically extrapolate current developments and create a realistic context for them.

Those works that deal with the near-term future consequences of emerging issues and technologies I have called here "extrapolative" fiction (EF) as it deals with timeframes, locations, and problems that are comparable to those dealt with in the impact assessment process.

PRODUCING EXTRAPOLATIVE FICTION

The process of producing Extrapolative Fiction is highly individual and creative, yet relies on the long tradition and the analytic techniques of futuristic fiction. EF writers use a variety of models and engage in primary and secondary research to develop their stories and novels. A number of guidebooks have been published, (e.g., Block, 1969; Elrick, 1979; Bova, 1983) and other writers, critics, and editors often have strong views on how a story should be written to be both plausible and entertaining. Most of

these apply to near-future extrapolative fiction as well as other forms of futuristic fiction.

The Editors

Perhaps the most significant of these other actors in the field of futuristic fiction are the editors, for unless they choose to publish a work, neither the fans nor the critics will comment on it. Over the last four decades a few editors have had a powerful effect on the development of futuristic fiction, through their work with writers and choice of works for publication. To a large extent, these men have shaped the genre, and more, have opened up new possibilities for authors and readers alike.

In 1938, John W. Campbell, Jr. became editor of the magazine Astounding Stories. Unlike editors of other pulp magazines at the time, Campbell refused to cater to his young audience's naivete. He insisted on a quality of logical and scientific coherence, or "reasonableness." He changed the name to Astounding Science Fiction and required that his writers describe plausible extrapolations of known scientific phenomena. This requirement ushered in a new phase of development in science fiction literature and reestablished futuristic fiction in this country. Under Campbell, technologies were the dominant theme in the story, and new, technically trained writers were fostered. Among others, these included Robert Heinlein, Isaac Asimov, L. Sprague DeCamp, A. E. van Vogt, and Theodore Sturgeon. Together they produced a body of work that inspired Ossip K.

Flechtheim, coiner of the term "futurologist," to say that such fiction "may yield insights that are more revealing than the voluminous writings of learned system-builders" (quoted in Clarke, 1979: 273).

As an editor, Campbell insisted on stories with real people--e.g., housewives, crewmen, businessmen--instead of the cardboard caricatures of symbolic personalities which were the previous norm. One of his authors, Theodore Sturgeon, points out that what was required was

> a story built around human beings, with a human
> problem and a human solution, which would not have
> happened at all without its scientific content
> (Platt, 1980: 64).

Campbell looked for stories and novels in which the use of a technology presented a problem to be solved, and which explored possible solutions in the context of a changing society. For this reason, one of his authors, Isaac Asimov, has said that "if Gernsback [the founder of Astounding] is the father of science fiction, Campbell is the father of social science fiction" (Asimov, 1972: 16). Campbell used his magazine to set the tone and, through it, provided his audience with consistently entertaining and rationally plausible stories about possible futures.

Over the years, Campbell changed the title and format of the magazine, as the new form of fiction grew and evolved. By 1960, he said that the content of the fiction was analogous to science facts and called the magazine Analog, The Magazine of Science Fact and Fiction. He defined an analog as "a system which behaves in a manner similar to some other

and less manipulable system so that it is easier and more convenient to study" (Campbell, 1960: v), and declared that the term was representative of the kinds of stories that he chose to print. Using the letters-to-the-editor column as a forum, he involved his readers in the change and selection process. Partly due to this participative style, by the mid-1960s Analog was, for most, the baseline standard for good science fiction.

With Campbell's heavy emphasis on science and technical accuracy, the stories he published often described changes in society that many people felt might be right around the corner. They often dealt with subjects like the problems and potentials of nuclear power, or nuclear war, or the effects of automation (in the form of robots). While this made his magazine particularly timely for those following the development and implications of new technologies, Campbell's journal was coming too close to a reality that many people were not comfortable with. Moreover, many of the stories tended to assume the current socioeconomic structure as a constant and history as repeating itself in clearly definable and recognizable cycles. As a result, editor Campbell was not providing room for the reader to hope or for the imagination to explore, and, more importantly, was not reaching some of the potential audience--those who were concerned with longterm social or ideological, rather than shortrange scientific or technological problems.

Horace L. Gold, recognizing the need for science fiction with a more social orientation, began publishing Galaxy Science Fiction in 1950. He built on Campbell's efforts but emphasized possible social structures and political alternatives. Under editor Gold, writers such as Robert Sheckley, Cyril Kornbluth, Frederik Pohl, and Damon Knight began to develop an additional set of standards, outside of Analog's mainstream. In stories describing shifts in corporate power (e.g., Pohl and Kornbluth's Gladiator-at-Law (1955)) or the new forms of society to be formed in space colonies, they required accuracy in institutional and cultural as well as technological extrapolation. Gold's Galaxy provided the opportunity for exploring very different socioeconomic systems, either as extrapolations from the system of the time or as carefully constructed alternatives.

As a result, Galaxy encouraged the growth of social science fiction. New possibilities were opened up and many new writers entered the field at this point. Works such as Tiptree's "The Women Men Never See" (1968) explored gender relations in our culture by placing them against the context of extraterrestrial visitations. Other women writers created whole new cultures exploring the social implications of parapsychological developments (e.g., Bradley's "Darkover" series and McCaffery's "Dragonriders" series). The "New Wave" writers began to appear, including Michael Moorcock with his "Cornelius" series, Harlan Ellison with

his "A Boy and His Dog" (a post-World War III story--1968)
and "Repent, Harlequin! Said the Ticktockman" (1969), and
Thomas Disch with his "334" stories (1978). These new
works, combined avant garde writing styles with biting
social commentary and extended the genre still further.

By encouraging and publishing specific authors and
styles, editors such as Campbell and Gold played a major
part in defining the genre as a whole. Their editorial
requirements and expectations motivated the writers to
expand and enhance their knowledge and skills. Particularly
for authors who "trained" under Campbell and Gold, these
skills included the use of the scientific method in
researching and structuring their works, the extrapolation
of current social and technological trends, and the creation
of plausible, coherent settings--or scenarios--in which
human characters experience alternatives to present-day
reality.

Fans as Critics

Then there are the fans. As noted by Elrick (1979),
during World War II, one hundred fifty copies per month of
Astounding were purchased by scientists at Oak Ridge
National Laboratories within three days of publication. A
few years later, in 1948, a survey of one thousand readers
found the majority to be male, between seventeen and twenty-
seven years of age. In 1961, Elrick states, a similar
survey found that 85 percent of readers were only or oldest
children who built their lives around "fanzines"--the

newsletters prepared by and circulated among fans. By 1974, however, the average fan had matured. He was slightly over 26; 81 percent were college-educated males, and some 29 percent held advanced degrees.

Such "savvy fans", having read or viewed a piece of science fiction, conduct

> an autopsy that's virtually a vivisection. God help any author or script writer who makes a technical mistake 'because they're on you like a pack of wolves' [quoting editor Ben Bova] . . . They demand accuracy--or at least a gestalt-like consistency--in supportive details . . . They regard the so-called space-opera' with scorn. . . . Readers rightfully expect their pet authors to provide penetratingly fresh visions of life presented via a wedding of the scientific and the aesthetic. (Elrick, 1979: 14)

This attention to detail means that, in order to convince an editor that one is publishable (i.e., acceptable to the fans) or to continue to sell, a writer must know and provide a plausible explanation for both the technological and social developments around which the story is built.

One long-established author, describing the process of writing fiction in this context, says that

> speculative fiction is the most difficult of all prose forms. Not only does it require greater knowledge to do it well, greater imagination to make it rational and consistent . . . But also, [the writer of] a speculative novel, to be entertaining, must . . . create the scene and the culture and make it come alive. . . (Heinlein, 1969: 35)

Heinlein distinguishes between the style expected of early authors writing for younger audiences and that demanded of a writer addressing a sophisticated adult audience:

> it is not enough to say 'With a blast the spaceship took off for Mars.' Oh, it may do for comic books

and for pulp magazines aimed at 10-year-olds, but not for serious literature; the writer must fill in this strange scene clearly enough to create empathy. . . . he must do it without slowing up the story . . . he must get his gadgets in . . . without getting them in the way of his human characters and their human problems--yet get them in he must, else the story takes place in a literary vacuum and suffocates at once! . . . It still gives me headaches with each new story I write. (Heinlein, 1969: 36-37)

Clearly, special demands are placed on the authors of this genre--by the editors and by the readers--with accuracy, consistency, and a good idea being as important as a pleasant and entertaining style.

The Authors

The authors of extrapolative or other futuristic fiction create plausible and coherent environments based on more-or-less formal, logical "formulae" for social change. These contexts take the form of the setting for the story (which could be described as a scenario, or forecasting model, of the society) in which the responses and perceptions of the characters reveal something about the innovation, the particular context that the author has created, and the author's own experienced reality.

The authors of science--and especially extrapolative-- fiction, therefore, tend to be scientists and engineers* whose interests go beyond the development of a technology to the implications of its application. As John Campbell pointed out, his publication was

*Most of the early EF writers have degrees in the physical sciences or engineering. More recent writers may have their degrees in one of the social sciences, instead.

one of the few places in the modern world where a
scientist is permitted to publish his speculations on
what might be done with present scientific knowledge.
(Campbell, 1960: vi)

This scientific awareness, together with the "intensiveness

with which the writers are required to develop logical

detail" by both their editors and their readers (Heckler,

1968), and a heavy emphasis on cognitive logic (Suvin,

1979), make the work of science fiction--and particularly

near-future-oriented extrapolative fiction--highly plausi-

ble, and hence of interest to the impact assessment process.

ALTERNATIVE VERBAL MODELS

One framework for model use in research and analysis is

illustrated in Figure 3 (Root, 1976). According to this

framework, the investigator uses different model forms for

different phases in the research and analysis process. In

impact assessment, as illustrated by the figure, consider-

able attention is paid to the structural and dynamic models

available for analysing systems. In both impact assessment

and extrapolative fiction, the process of writing the report

or story involves mental and verbal models almost entirely.

For fiction, the writer develops an idea and a set of

images. He or she may write out a few descriptive notes or

paragraphs and outline the plot. Then, if necessary, the

writer may go to experts or related publications for

supporting information. Such analysis and research

contribute to the author's mental model and to the verbal

model being created. As the writer proceeds, the story or

novel that results may seem to take on a life of its own,

extending the author's mental model as he or she sees the

verbal model on paper.

Describing this process, Isaac Asimov, one of the best-

known and most prolific science fiction (and science fact)

writers, says

> When I am writing, I am fascinated by what emerges,
> for all of it is more or less unexpected . . . I am an
> interested spectator (in Olander and Greenberg, 1977:
> 203-204).

Clearly, the verbal models and mental models are working

together to extend each other.

As an example, in an early work within this genre,

written before the successful maintenance of the first

atomic Pile at the west stands of the University of Chicago

and updated in 1946, Robert Heinlein considered the impacts

of the nuclear power plant (Heinlein, 1940; 1946). One of

his characters tries to comprehend the nature of "the pile."

As part of his process, the character asks a local merchant

if he is not afraid to live so close to the nuclear power

plant.

> The tavernkeeper's eyebrows shot up. "Afraid of
> the pile? But it is my friend!"
> "Makes you money, eh?"
> "Oh, I do not mean that." He leaned toward them
> confidentially. "Five years ago I come here to make
> some money quickly for my family before my cancer of
> the stomach, it kills me. At the clinic, with the
> wonderful new radiants you gentlemen make with the
> aid of the Big Bomb, I am cured--I live again. No,
> I am not afraid of the pile; it is my good friend."
> "Suppose it blows up?"
> "When the good Lord needs me, he will take me."
> He crossed himself quickly. (Heinlein, 1946: 43)

In this fashion, Heinlein uses his own technical
knowledge of the nature and potentials of nuclear reactors
(consistent with the state-of-the-art in 1940-46), shifts
his perspective to that of his characters, and permits his
reader to "have a feeling for" the nature of the technology
in question--both its destructive and healing potential.

A similar process, focusing on organizational
developments, occurs in a recent story--specifically with
reference to the possibilities of space industrialization.
Author Charles Sheffield looks at emerging bureaucratic
roadblocks through the eyes of two starstruck young men
applying for a license to develop a new rocket propellant in
the year 2005 (Sheffield, 1981). They are disillusioned by
a sympathetic bureaucrat:

> "I've been around this office for thirty-five
> years--as long as we've had the evaluation procedure.
> When I first started here, I read all the appli-
> cations. . . I'd take each application, and I'd study
> it for a day, maybe two days. For something like a
> propellant, I'd dig out the relevant patents, and the
> engineering handbook. Maybe do a few calculations,
> see if things seemed to be in the right ballpark.
> And you'd get an answer, yes or no. It took a week,
> sometimes two weeks, from start to finish."
> "But we've waited over four months," said Len.
> "Right." A rueful smile. "That's progress, yer
> see?"
> Delso looked around his office, at the ranks of
> file cabinets, the computer terminal, and the ela-
> borate multi-channel telephone. "I had none of this
> in the old days. Look at what we have to do now.
> Rocket propellant, see, first thing I have to do is
> look up the Industrial Codes. . . . That tells me
> which Government departments must be involved in
> the evaluation procedure, where they are, and so on."
> "Hell, if we'd known that we could have contacted
> them before we sent in the forms," said Len. "We
> could have saved you a lot of time here."
> "Not the approved method." Henry Delso poured tea
> into three chipped cups and pushed the tray forward.

"Help yourselves to milk and sugar."

He picked up a cup. "I can tell you the complete list if you want it, but it wouldn't help you. The law says they have to be contacted from here, whether you talk to them or not. Let's look at just a few of them. Environmental Protection Agency, naturally-- you have to get their approval, because you'll be releasing some substances into the air. It might affect the environment when you do the bench tests. Center for Air Quality, same thing applies to them. Food and Drug Administration"--he looked at them over the top of his thick glasses--"didn't think of them, did you?" You'll be working with new compounds, they'll want samples to test for the effects on hu- mans, plants and animals. . . Then there's Defense, they have to be involved on anything that might have defense implications. Then, let's see, the Office of Safety are on the list--with a new material test, they have to be sure there's no danger to workers who'll be involved."

"But we're the only two people who'll be involved!" Gary's eyes were bulging. "We don't want their stu- pid protection."

"Ah, but it's for your own good--you don't have a say in it. Where was I?" Delso leaned back, checking off his fingers.

"Health Department, naturally--they duplicate some . . . but they have they're own checking system and that has to be followed."

Len Martello's scarred mouth was more twisted than usual. "I just can't believe it. You mean we have to get approval from all those groups . . . that we can't do any more testing until that's finished?"

"That's right." Delso handed him a cup. "All those groups--and we're just getting started. Equal Opportunity, there's a dilly for you. They have to be sure that your company will have a posi- tive action program for minorities."

"But there's only the two of us in it!"

"Makes no difference, laws are laws. Then there's the Women's Civil Commission. They'll have to be satisfied that there's no sex discrimination in the operation--that's not considered the same thing as the minority question. Mustn't forget the Depart- ment of . . . (Sheffield, 1981: 36-38).

And so forth. In this fashion, through the use of images and the creation of an experience, the reader is given a clear idea of where current trends may be leading in terms

of bureaucratic process and the potential barriers being
placed for new technologies emerging from small shops.

As further examples of the effectiveness of EF stories
in accomplishing this, the following paragraphs summarize
several stories written between 1940 and 1970 and describing
innovations to take place prior to 1980 (See Table VI).

Transportation Stories

Possible developments in transportation technologies
are common themes in science--and extrapolative--fiction.
Typically, these stories focus on space transport devices,
but a number of authors have explored the potential effects
of earth-bound transports. The stories in this group are
early works whose storyline is driven by a new transport-
ation technology.

"Historical Note", by Murray Leinster (1951), presents
a lightly farcical account of "what would happen if" a
Russian scientist discovered a principle permitting clean,
individual air-transport devices. The discovery is
immediately declared a State Secret until the following May
Day parade, when a battallion floats over Red Square in the
devices. After that, although the principle technically
still remains a secret, it becomes very difficult to keep
the devices themselves inside the country. Soon, independ-
ent "garage shop" inventors up and down the West side of the
Iron Curtain are turning them out--each new shop producing
them for slightly less than the last, until, finally, the
transporters are mass produced and sold on both sides of the

TABLE VI

EXAMPLES OF EXTRAPOLATIVE FICTION

TRANSPORTATION	R & D	NUCLEAR POWER
"Historical Note" Murray Leinster (1951)	"The Mercenaries" H. Beam Piper (1950)	"Blowups Happen" Robert Heinlein (1940, 1946)
"The Roads Must Roll" Robert Heinlein (1946)	"What Thin Partitions" Clifton & Apostolides (1953)	"The Day of the Moron" H. Beam Piper (1951)
Under Pressure Frank Herbert (1957)		"Counterspy" K. Edwards (1953)

SOCIETAL FORECASTS

OPEN SYSTEM	CLOSED SYSTEM
Alongside Night J. Schulman (1979)	The Sheep Look Up John Brunner (1972)
Equality in the Year 2000 M. Reynolds (1979)	Stand on Zanzibar John Brunner (1968)
Commune, 2000 A.D. M. Reynolds (1974)	

Atlantic (and in Japan) for considerably less than the cost
of a bicycle. In a very short time, land use patterns have
been substantially altered, and national boundaries have all
but disappeared. In the end, the scientist who made the
discovery is wooed to the U.S., where he is kept in an
isolation only differing from that he experienced in the
U.S.S.R. in its comparative luxury--and in the absence of
his favorite red cabbage soup.

The story explores the relationship between nationalism
and controlled access. An omnidirectional, virtually
undetectable transporter removes the control and invalidates
the concept of border. In the story it

(1) makes it impossible to keep a standing (floating?)
    army

(2) renders border guards and customs officials useless

(3) eliminates mountains, rivers, and walls as barriers

(4) opens up whole new areas of wilderness, frontier and
    security sites to the general public

(5) makes rural and suburban, island, or wilderness homes
    reasonable for commuters.

Clearly, implementing the concept has the ultimate effect of
completely changing the shape of the whole culture.

In developing this storyline, the author has assumed
several behaviors as characteristics of human nature:

(1) soldiers will get out of duty if they can

(2) people will help them do so--especially if there's
    something interesting in it for them

(3) if it is produced once, someone else will figure it
    out again, cheaper

(4) if there's a market people will fill it

(5) people don't need borders, only heads of state and
    their generals do.

The process Leinster describes whereby the fliers move from
unique and expensive toys to the mainstay of a redefined
cultural pattern is dependent on these assumptions.
Interestingly, it parallels that of television in the
fifties, stereos in the sixties, calculators in the
seventies, and (apparently) microcomputers in the eighties.
In all of these cases, a technology was introduced with an
apparently limited usefulness and market, that for several
reasons became incredibly popular, used for a significantly
broader range of activities than expected, and led to the
creation of a whole new subculture within the larger society
while affecting numerous unforeseen aspects of everyone
else's life.

Robert Heinlein's "The Roads Must Roll" (1946) is
another story describing the new cultural patterns emerging
from new transportation modes. Here, using a power source
from an earlier story in his timeline ("Let There Be Light"
(1940), describing photoelectric panels), Heinlein draws on
the conveyor belt/"slidewalk" concept to create great bands
of multiple spead "roads" that are the main distributors of
people and goods throughout the country. Strip Cities, such
as Diego-Reno and Chicago-St.Louis, form along these
roadways, and people combine rural, urban, and industrial
lifestyles as they move at speads up to one hundred miles
per hour between home and work, work and play, or one home
and another.

In this novella, Heinlein has created an image of a roaring mass of moving people and buildings that the reader can hear and feel, has introduced some of those who must live with that, and presented some of the major issues that must surround such a technology. Using the "out-of-towner" device for explanations, providing considerable foreshadowing for the story's action, and relying heavily on his own military experience and engineering training for the necessary realistic detail, Heinlein carries us through an engineer's strike that badly cripples the automated roadway. The technology is explained as the out-of-towner encounters it. The political-technological infrastructure is an extension of the current Army Corps of Engineers, with an undercoat of Annapolis to provide the "esprit de corps" necessary to avoid future such incidents. The general social system is an expansion of our current freeway-oriented commuter and trucker society, including "strip cities" (e.g., Diego-Reno, St.Louis-Chicago, San Francisco-Los Angeles), and chain restaurants.

Under Pressure by Frank Herbert (1956) is a novel describing the use of nuclear mini-submarines as undersea tugboats. It assumes that the United States' oil reserves are depleted and the military must mine the sea-bed off Eastern Bloc shores to maintain the needed supply. To accomplish this, the Navy has designed a special four-man nuclear submarine that can dodge enemy patrols crossing the Atlantic and can tow back a bag--a

subsurface barge--full of oil. The problem which
determines the storyline is that the last several subs
have not succeeded, and the Navy leadership wants to
know why. They suspect psychological problems, so a
specialist in psychology and electronics is assigned to
a sub crew with equipment that allows him to monitor the
captain's emotional state.

The plot of the novel follows the psychiatrist's
attempts to be effective in his position while the sub
completes its assignment. Secrecy, of course, is
absolutely essential to the success of the research--and
of the mission (whose failure means certain death for
the four men in the sub)--and maintaining secrecy is a
primary source of tension for the story. The psychiatrist
must keep his identity and research secret, the agent on
board must be discovered even as he keeps his own identity a
secret, the whereabouts of the vessel must be kept a secret
from Eastern Bloc vessels, and the Navy's involvement in
both the mission and the research must remain secret--even
from the protagonist's wife.

A secondary source of tension lies in the fact that
the sub is nuclear-powered and must travel through radio-
active waters, making the crew's environment doubly hostile,
and ensuring that any mistake means certain death--either
immediately (under the ocean) or lingeringly (on land) from
overexposure. Under these circumstances, strained relation-
ships crack. The Captain's function is to keep the crew

working together and, though the psychiatrist's job is to
find out how the Captain does so, he himself cracks and ends
up in a catatonic state, only to come out of it as the sub
approaches home base. He has learned much, however, and
will ensure that some changes are made in the system to
allow other captains to succeed as well.

Research and Development Stories

The period immediately following World War II saw
the formation of many new independent and corporate-
owned "thinktanks." Research and development was seen
as the basis for and backbone of industrial, hence
economic progress. Seeing this, writers of the period
began to explore the possible directions and effects of
this new development. The following stories focus on
research and development methods and structures in the
context of our changing society.

"The Mercenaries," by H. Beam Piper, (1950)
provided a new idea in science fiction that has become a
common idea for extrapolative fiction: looking at the
politics of the research and development process instead of
at the search for a solution. Rather than focusing on the
crises that determine whether a solution can be found, Piper
uses this story to look at who is doing the seeking and what
their roles are and what relationships exist among them-
selves and with those governments or corporations who have
hired them.

The story takes place in the late 1960s or early 1970s. The main character is the leader of a team of independent contract researchers which includes basic and applied scientists--men and women of several nationalities, including his wife--who have been hired to "launch the first spaceship to reach the moon and build a fortress . . ." (1950: 63). The plot involves two main themes: (1, traditional) the identification of a spy; and (2, innovative) the maintenance of the team's independent status, untouchable by any nation's laws except as agreed upon in their contract.

As the story proceeds, it becomes clear that in order to raintain the group's independence and integrity, the leader must convince one of its members to acknowledge selling information from the team and to take the appropriate action to undo the effects of those sales. The whole team becomes involved, in various ways. Working with the local security personnel (who told them about the leak in the first place), they find out what form the information is going out in and begin to pass on "wrong" information. Paired interactions and smallgroups within the team increase the pressure on the culprit until, finally, he commits suicide in a way which permits the rest of the team to present it as a natural death to the press and as an execution to the concerned security personnel and their contractors.

The identification of the channel by which the information has been leaked off the station remains to be solved, however, and the teamleader finally discovers the weak link in security--one which is totally invisible to the security personnel observing from within their system. In spite of detailed, even nude searches of all personnel entering or leaving the station, one car--the commanding officer's--enters and leaves without question. The leader points this out to the security personnel who apprehend the chauffeur. Now, saddened, though relieved, the team resumes work with their independence and integrity assured, and with a teamleader who wishes psychology were not as essential as his beloved physics to the effective accomplishment of his work.

"What Thin Partitions", by Clifton and Apostolides (1953), provides an interesting account of the problems and possibilities associated with developing a product that has been observed to work but is lacking the theoretical basis to explain how it works or to effectively replicate it. The authors use the story to develop a caricature of the corporate research and development process, from the initial accidental discovery through the selling of the idea to the bitter realization that simply too little is known about the process to replicate it in a manufacturing setting.

The personnel officer of a manufacturing corporation has an idea based on observations of an employee's child

and attempts to implement it in the corporation. Working with the Research and Development department and the chief executive officer, he attempts to recreate the observed situation so that others can develop a production process for it. A meeting with representatives of the Department of Defense ensures that there will be a market for the product, but, unfortunately, while he is negotiating the arrangements, the original behavior is eliminated and the process is no longer replicable.

Nuclear Power Stories

One of the exciting possibilities projected for the post-Hiroshima world was the "peaceful use of the atom;" specifically, the use of controlled nuclear reactions as a source of industrial heat and electrical power. Several EF writers saw the potentials for good and, at the same time, wondered about the potential problems associated with this new power source. Based on the theoretical understandings of the process then being published, these writers explored both sides of the question in some of the best-known stories of the period. Stories by three writers are summarized in this section.

"Blowups Happen", written by Robert A. Heinlein in 1940 and updated in 1946, is one of the earliest EF stories. His presentation of the technology is limited by what was known at the time, but his presentation of the human problems associated with operating nuclear power plants has been shown (by the experiences at Three Mile Island and of the

Washington Public Power Supply System, among others) to be
relatively accurate.

The story opens in the control room of an atomic power
plant located in the Arizona desert. An engineer-operator
has just been relieved of duty for behavior suggesting that
he "had at last broken under the strain of tending the most
dangerous machine in the world" (Heinlein, 1946: 6). The
psychologist and the engineer he has asked to have relieved
are to meet with the general superintendant. On the way,
they are greeted by the secretary, a former engineer who
"had suffered a blanking out of the ability to handle
mathematical operations" (Heinlein, 1940: 9) and had been
rehabilitated for office work.

Once in the office, the psychologist reports his
obervations. In response, the general superintendent
suggests that the engineer take a vacation, then take the
psychometrical examinations or be transferred to another
department. The engineer, however, points out that the
strain of the job is compounded by the strain of being under
observation all the time. The superintendent agrees, and
decides that it's time to bring in the leading specialist in
situational psychosis to help him find a solution to the
problem of keeping his engineers from going crazy.

The engineer who has been relieved and his buddy
decide that, as long as the engineer will be engaged in
research, he should work on a problem they both are
intrigued with: developing an "atomic fuel for inter-

planetary flight" (Heinlein, 1946: 12). They proceed to set up a series of experiments to test the possible combinations of isotopes.

When the top man in situational psychosis arrives, he is given a history of the plant and an outline of the problem, including the mathematics predicting a "dampening" effect in the plant's design that is predicted to prevent a full explosion should the fuel ever reach critical mass. They agree that although not enough is known about either human or subatomic interactions to make valid predictions, such predictions are necessary if people are to function, so the psychologist agrees to stay on and observe the situation for a few days.

Wandering around the plant, the psychologist happens into the two engineers' lab and causes a foul-up in their preparations which, amazingly, leads to the desired results--they have found a compound that might work as a fuel. After several days of observing, listening, and reviewing files, however, the psychologist must report to the superintendent that "short of shutting down the bomb there is no solution to the problem--none whatsoever!" (Heinlein, 1940: 20). At that point a Naval officer arrives--another mathematician. He, too, is particularly concerned that the plant should be shut down, based on his recalculations of the predictive mathematics the two had discussed earlier. According to his results, an explosion would not be dampened, and would instead lead to incompre-

hensible damage. He insists that the plant be disassembled,
immediately.

The three discuss the fact that since thirteen percent
of the nation's power--that portion supporting much of the
heavy industry in the country--is provided by the plant, it
cannot be shut down, or if it were--given a profit-making
board--it would not be for long. The psychologist redirects
some of the officer's anger about the situation away from
the superintendent by pointing out that

> . . . we're not faced with a problem in physics,
> but with a political and economic situation. . . .
> [Superintendent] King doesn't own that bomb out
> there; he's only the custodian. If he dumps it
> against the wishes of the legal owners, they'll
> simply oust him and put in someone more amenable.
> (Heinlein, 1946: 26)

The only possibility is to convince the Board of Directors
that it is in their best interest to shut the plant down.
When the superintendent and the psychologist try--and fail--
to do so, however, the Board's response to their attempt is
to accept the superintendent's (untendered) resignation, on
the grounds that he has bad attitude.

At this point the two engineers announce their new
fuel. They have succeeded in isolating a series of isotopes
that can lift a rocket free of earth's gravitational pull.
This revelation leads to a new plan: to set the power plant
on a satellite and sell the isotopes generated by it
(including the new fuel). The Board members object, again,
seeing no reason why they should invest further in an
already lucrative venture. The psychologist only persuades

them by threatening to destroy their reputations if they
don't move the plant, and offering them full credit if they
do.

This major crisis having passed, there is still the
actual implementation of the plan. Enough fuel must be
produced by the plant to lift its mass into orbit, and
facilities must be built to maintain it and its operators in
orbit. Then, just as the tension reaches an intolerable
level and an operator goes berserk, knocking out his
observer, the word comes through. The superintendent, in
the control room to deal with the berserker, can finally
"dump" the fuel into its storage containers, rendering it
harmless until it is reassembled out in space.

"The Day of the Moron", by H. Beam Piper (1951) was a
classic in this group, and was the cover story for the
September, 1951 issue of Astounding. This novella was
written when the United States government was installing
some of the first nuclear power plants and the "atoms for
peace" movement was emerging. Like Heinlein's, the story
deals with the personnel problems in building and operating
such a plant and, again, presents the technology as it was
understood at the time of his writing, although with an
insider's awareness of the potential dangers.

The opening lines are:

> There were still, in 1968, a few people who were
> afraid of the nuclear power plant. Oldsters, in whom
> the term "atomic energy" produced semantic relations
> associated with Hiroshima. Those who saw, in the
> towering steam-column above it, a tempting target for
> enemy--which still meant Soviet--bombers and guided

missiles. Some of the F.B.I. people who realized how futile even the most elaborate security measures were against a resourceful and suicidally determined saboteur. And a minority of engineers and nuclear physicists who remained unpersuaded that accidental blowups at nuclear-reaction plants were impossible (Piper, 1953: 13).

The next paragraph refers to "several nasty, meticulously unpublicized near-catastrophes" (Piper, 1953: 13).

In the opening description, the protagonist, an independent contracting engineer who specializes in cybernetic control mechanisms, is described as "reviewing the eight different ways" a breeder reactor could go critical and "wondering if there might not be some unsuspected ninth way" (Piper, 1951: 14). His primary concern is about "the ubiquitous lame-brain with a dangerous mechanism" (Piper, 1951: 14). To prevent this, he has hired a psychologist to function as a "dimwit detector" so that no one who does not think first can be placed in a critical position and cause the reactor to reach critical mass. The tests the psychologist will use are expected to lead to the dismissal of three or four workers out of a team of about thirty.

The union, however, is not about to run the risk of having any of their senior people declared mentally unfit to work on a nuclear power plant. Their violent reaction to the testing leads to the first confrontation. In defense of what has been called his "obsession" about fools, the engineer points out that a worker "can go on for years, doing routine work under supervision . . . then, someday, he does something on his own lame-brained initiative, and when

he does . . . wholesale catastrophe" (Piper, 1951: 16).

He bolsters his argument with the introduction of another

thread in the story--the role the reactor plays in its

environment. The engineer points out that when energy

systems and communities were pretty well self-contained,

people could do little damage, but that the scale and

interconnectedness of the system, combined with the immense

power of the reactor, makes a moment of foolishness

extremely dangerous and the current situation ripe for

disaster.

The psychometric tests are given, over protests from

the union leaders, and the work goes on. Equipment is being

built and the reactor is being prepared to take it. One of

the reactor cells (still graphite blocks, but containing

breeder-fuel plutonium) is not emptied properly in the

process, but appropriate corrective action is ordered before

continuing with the installation.

When the psychometric test results come in, the two

people to be fired are the union leaders--the ones who have

objected most strongly to the testing. All work stops as

the union leaders scream persecution. The engineer arranges

to bring in his own company technicians to install the

equipment while the cell is still empty, then is called to a

negotiation meeting with union and government executives in

New York. As he leaves, he is informed that the union

workers have countermanded his orders and are reloading the

reactor cell they were emptying so that his own people won't be able to work on it during the strike.

At the meeting, the engineer is, once again, required to defend his position regarding workers who don't think about the consequences of what they're doing. At the point in the conversation when the negotiator is asking what the engineer imagines might happen if someone did something stupid with the reactor, there is a sudden blast of light to the north. The plant blows up.

New York state is blasted with radiation and is completely without electrical power because "some moron-- some untested and undetected moron--made the wrong kind of mistake" (Piper, 1951: 29), and reloaded an incompletely emptied cell in the reactor, bringing it to critical mass and destroying the centralized power source in a highly interconnected grid. The meeting is adjourned. As they work their way down the long, dark staircase and out into the darkened streets, the engineer considers the fate of a city "that had put all of its eggs in one basket, and left the basket in the path of any blundering foot" (1951: 34).

K. Edwards' "Counterspy" (1953) also deals with the problems surrounding atomic piles, though in this case the pile is only secondarily a power generator: its primary purpose is for weapons research. The security precautions are similar to those described in the other stories, however. The site is removed from other habitation. The perimeter is fenced and guarded. Only those with clearances

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There are two main questions dealt with in this story: (1) what are the mechanisms and the consequences of sabotage? and (2) is there such a thing as "enough" security where nuclear plants are concerned? Clearly, there is a high degree of similarity between this and the two stories already discusses. The primary difference between them is one of focus. The first two are concerned with the consequences and prevention of accidental blowups, while this one deals with the prevention of intentional blowups and the consequences of the actions necessary to that prevention.

This story, written in 1953, takes place a very few years later—sometime in the late 1950s. (The characters, in their mid- to late thirties, are World War II veterans who went through college on their G.I. benefits.) Because it

was written later than the other two, the technological

descriptions are more sophisticated. Rather than graphite

bricks, stainless steel slugs contain the uranium. Steam

turbines, rather than direct conversion, generate the

electricity, while the water cools the reactor coolant--

liquid sodium. Pencil dosimeters, rather than clock times,

are used to measure exposure. Finally, several levels of

failsafe mechanisms minimize the potential for the kinds of

problems dealt with in the other stories. But still, weak

points exist, and again, human frailty is the one

unpredictable determinant.

The story opens with a team of technicians practicing

the discharge process, using a "dummy" slug to develop their

skill with the specialized tools and techniques. As the

plot unfolds, the protagonist--a physicist--is informed that

there is a traitor in their midst, someone who has managed

several minor accidents and is trying to destroy the

reactor. The physicist is told that he is expected to help

identify the man responsible, and, if possible, stop him

from succeeding. The question of who the traitor might be

colors his thoughts and experiences for the rest of the

story, as he interacts with his team-mates in a variety of

social and work settings (interestingly, none including

women).

Not surprisingly, relationships become strained, and

the feeling of pressure mounts up until the protagonist

finds himself locked in the reactor room with the signaling

device broken and the slugs (real, this time) about to be discharged. Someone is determined to prevent him from discovering who the traitor is, and is willing to kill him to do so. Even as he makes himself heard and is rescued, who that person might be dominates the physicist's thoughts, and when he observes himself going through the habitual motions of washing the radioactive dust off his hands and removing the protective covers from his shoes, the means for answering the question comes to him. His assailant did not stop to clean up, and therefore has left an invisible trail of radioactive particles behind him in the hallways. He grabs a geiger counter and some of the everpresent (except when you need them most) security guards to identify and take into custody the former friend and co-worker who nearly became a murderer in his attempt to destroy the plant.

However, how the assailant was going to do so remains to be discovered. Finding it provides a secondary theme for the story, as the protagonist and the security personnel work through the alternatives. After lengthy discussions of what might and won't work, they finally hit on the one that will. They find a few tools near the heat exchanger, a small bomb in the gridwork of pipes containing liquid sodium and immersed in the water bath which simultaneously cools the coolant and turns into high-pressure steam to run the generators. A few broken pipes here would, very simply and elegantly, destroy the reactor and probably cause the whole plant to blow up. So the physicist and security chief

retire to figure out how to secure that weak spot, and wonder what others there might be.

These stories each describe a (when they were written) not-yet-existent technology--nuclear power reactors--from the point of view of the people who must work with them on a day-to-day basis. In doing so, they provide insights into the problems and emergent issues associated with the technology that are likely to arise from human actions, interactions, and responses.

Societal Forecasts

Another type of story that may be considered here is the "whole body projection," in which the author attempts to portray life in a society that is extrapolated as a whole from his own. In many ways, this form is most like the scenarios currently being used in impact assessments and other policy research documents. Over the late 1960s and 1970s, during the period of expansion for futuristic fiction as a whole, a number of novels of this type were published,* examples of which are listed in Table VI (p. 73). They are typically full-length novels, tracing one character's coming-to-terms-with the nature of that society. Moreover, they generally conform to one of two of Warrick's (1980) classes: those based on what she terms an "open" system model, and those based on her "closed" system model.

*Until that time, the market for futuristic fiction was limited to short stories. It took increased public interest to persuade publishers to buy novels.

between ordering it and its arrival his appetite
seemed to be eroded by apathy. He put on a record he
had bought and sat down to watch the play of colour on
the screen which matched the music; it had hardly
begun before he was on his feet again . . . [S]omeone
had persuaded him to get a polyforming kit. He opened
its box and cosidered starting a copy of Rodin's Kiss,
but halted his hand in mid-movement and let the lid
fall shut again. . . .

   He was suddenly appalled. These days, a great many
people never left their homes at night except for some
specific purpose, when they could call a cab to the
door and expose themselves for no longer than it took
to cross the sidewalk. It wasn't inevitably dangerous
to wander the night streets of the city--the hundreds
of thousands who did still do so were proof enough of
that. In a country of four hundred millions there
were two or three muckers per day, yet some people
acted as though they couldn't get past the next corner
without being attacked. There were rollings,
robberies and rumbles; there were even riots. . . .

   The habit had settled on Donald's mind unnoticed,
like gradually thickening fog. He had stopped going
out after six or seven in the evening for the mere
sake of not being at home. . . . And [when he did] the
cab that came to fetch them was driven by a man or a
woman secure behind armoured glass, its doors could
only be opened from the dashboard, and affixed to the
neat little nozzle of the air conditioning system was
a certificate stating that sleepy-gas cylinders had
been approaved by the City Licensing authority. For
all its smoothness and fuel-cell silence, it was like
a tank, and encouraged the feeling that one was
venturing on to a battlefield. (Brunner, 1968: 128-
129)

Later, another character states the case at a larger level

of focus:

   Why do you think you get such a generous trade-in
allowance when you switch from next year's model of
some gadget to the year after nexts's? Because some
of the parts are going to be put right back into the
new sets, and what can't be cannabalised will be sold
as precious--I repeat precious--scrap.

   The biggest single building project in this country
right now is costing a hundred million buckadingdongs.
What do you think it is? You're wrong. It's a jail.

   Friends, you don't have to go to India or Africa to
find people existing on the borderline of poverty.
You are. Our resources are stretched to the point
where reclaiming a gallon of water so someone can

drink it a second time costs eleven times more than it did in 1960. TV you can live without, a phone you can live without, but water? Uh-huh! We don't starve to death but if you want a diet that's fit to match your unprecedented tallness and muscularity you pay . . . like nine or ten times [as much as your grandfather] depending on how you take your vitamins and other supplements. (Brunner, 1968: 353)

This diatribe concludes:

Did you ever wonder how a doctor feels, faced with a disease he can't cure, which he knows is so contagious he's liable to catch it off the patients he can't help? That's me at this minute. . . .
There seems only one thing to do, and that's get drunk. (Brunner, 1968: 435)

And, in this dying world, there are plenty of ways to alter consciousness, some of which, it seems, are the causes of the very violence they are taken to avoid. There is no way out of a closed system.

In contrast, the "open" system stories in this group are those which are based on the possibility of a solution to current social and environmental ills. Schulman's Alongside Night, (1979), with its "agorist revolutionary cadre" ousting the existing corporate-political power structure epidomizes this group. In this novel, people who believe in a free market structure (hence "agora") build an underground economy replete with underground marketplaces. This set-up means that, when the existing structure finally gives way under the force of hyperinflation, a new structure is ready to take its place, in an information-based transformation of the politico-economic structure. By including the possibility of new ideas, and of new energy to

implement those ideas, Schulman rejects the "closed" system hypothesis of Brunner and other similar writers.

Another "open" system writer is Mack Reynolds, who has written a series of books taking place in A.D. 2000. In each of these, he explores the texture of life in the society he has projected.* Equality in the Year 2000 (1979) (modeled after Bellamy's Equality (1893), a classic of the 19th century) provides a view of life from the perspective of a university professor's family. Commune, 2000 A.D. (1974) contrasts that life with the lives of those "on the dole"--who are not called for jobs.

In Commune, the main character is an anthropologist with a Ph.D. who must complete another degree to be given a position. He is asked to research the communes that surround the towering cities as a possible topic for his thesis. The request is seconded by the head of the National Data Banks . . .

> He began to see some of the reasons why George Dollar was anxious to get more material on the communes into his data banks. Why, whole new ways of life were developing in them. . . .
> "I'm in rebellion because I can't get a job. I'm ashamed to take my Universal Guaranteed Income. But here you are saying that this whole commune wouldn't do their share, even if requested [on job muster day]."
> "You're doing your share . . . . You're trying to work. So are all the artists in New Woodstock. It's just that the human race has gotten to the point where practically no work is necessary to produce plenty." . . .(Reynolds, 1974: 60-61)

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*Reynolds' interest is econometrics, which provides the basis for most of his work.

So less than ten per cent of the people work, and the rest
are free to live the life they choose. There is a flaw in
this utopia, however: if a citizen chooses not to take a job
in production or administration when called for it, he or
she loses all citizen's rights, including the Guaranteed
Income.

> "I don't have any credit, so when I need
> something I have to ask someone else to buy it for
> me. . . . I'm not a citizen, not eligible for the
> guaranteed income." . . .
> "But how'd you make a go of it before you came to
> New Woodstock, where they're willing to take you in?"
> She shrugged . . ., "When I was younger I had an
> aunt and uncle who were citizens and they supported
> me. Later, I'd usually tie up with some man who'd
> take care of me for the use of my fair body.
> Theoretically, we don't have whores anymore, but in
> actuality, if a girl's in a spot, she puts out--and
> to just about anybody." . . .
> He couldn't figure out how to handle such things .
> . . The fact was, she was illegal. . . . she was
> currently, by the laws of United America, a criminal
> if she subsisted on UGI. Theoretically, it was his
> duty to report her. Theoretically. (Reynolds, 1974:
> 63-65).

In this fashion, Reynolds clearly shows the potential social
and personal consequences of current socioeconomic trends,
illustrates the systems law that apparent solutions
usually bring on new problems of their own, and offers a new
form of solution--the mutual support of the communes.

Such fiction draws on personal feelings and experiences
to present insights about the technical, economic, and
institutional aspects of our culture. As the authors create
an experience for the reader which parallels their own
personal, imagined experience, they produce a work of
fiction. As their own experience is founded in technical

understanding and rational extrapolations of emerging technological, economic, and institutional possibilities, EF writers produce a work that may be useful to those whose role it is to make decisions about those possibilities.

As they describe such experiences in a story, these writers create a work of extrapolative fiction which is at once entertaining and informative, capturing the reader's attention, engaging the imagination, and providing an alternative image of future possibilities for the reader to consider. These alternative models, then, have the potential for communicating to decisionmakers insights that may not be communicated through the traditional verbal models in impact assessment: the technical report or academic study. By focusing on the individual human being's experience of an innovation and using the language of the arts to examine the near-future effects of innovations within a clearly defined locality, extrapolative fiction appears to have some potential as a useful tool for ameliorating some of the criticisms of impact assessment described above.

CHAPTER IV

COMPARATIVE ANALYSES OF IMPACT ASSESSMENT

AND EXTRAPOLATIVE FICTION

A comparison of EF stories with IA reports addresses
the question of whether extrapolative fiction can enhance
impact assessment by identifying those content areas in
which IA reports are lacking and those which EF stories may
include. In this chapter, three analyses are described,
comparing EF stories and IA reports in increasing detail.
The first of these analyses compares the mean numbers of
statements that describe impacts by category in a represent-
ative sample of EF stories and IA reports, with a t-test
establishing the significance of the differences found
between the two samples. The second analysis examines a set
of EF stories published between 1940 and 1975 (describing a
number of innovations to take place prior to 1980) and
traces the themes and concerns described in those stories
through the journals to test those stories' effectiveness in
identifying emerging policy issues issues. The third
analysis compares three EF stories focusing on nuclear power
plant technologies to historically significant IA reports on
the same subject, demonstrating the degree to which the
extrapolative fiction complements the impact assessment in
the types of impacts described. Together, the three
analyses demonstrate the degree to which extrapolative

fiction and impact assessment overlap and differ in their
descriptions of impacts of innovations.

STATISTICAL CONTENT ANALYSIS

A statistical content analysis of a representative
sample of works in extrapolative fiction and impact assess-
ment is one way to test the degree of similarity and
difference between the two. Such comparison provides a
quantitative test of the hypothesis that EF stories raise
issues and clarify concerns that are not now included in the
impact assessment process.

Methodology

The methods used here to analyse EF stories and IA
reports conform to the standard content analysis procedure
illustrated in Figure 4, where messages from two sources
are compared to identify differences between the two
sources.

Source A   Source B

Message A ◄──────────┬──────────► Message B

Difference?
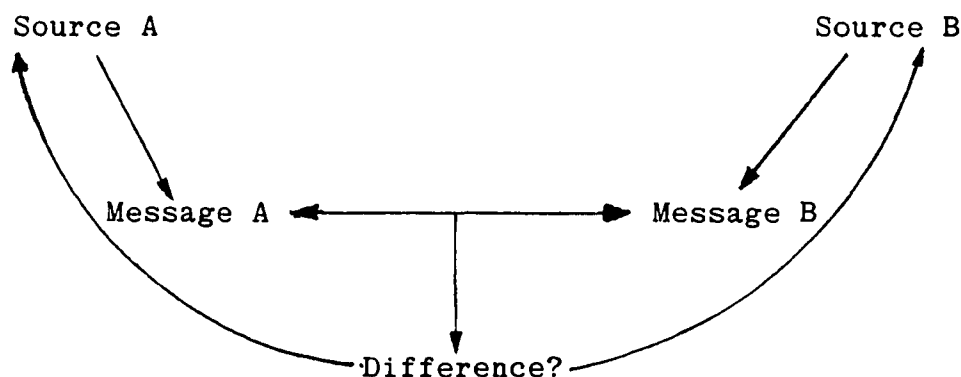
Figure 4. Content Analysis Procedure, in which
the contents of message A are compared to the contents in
message B to learn about the sources. (SOURCE: Holsti, 1964)

In this analysis, EF stories and IA reports were analyzed to identify statements describing impacts of the innovations under study. For the purposes of this research, statements were defined as sentences, phrases, a line of cells on a table, lines or bars on a graph, or descriptions of behaviors that depend on impacts not explicitly described in the text. The statements were tallied and categorized according to impact area described and the mean number of statements in each category was compared for the two forms. A t-test, establishing the statistical significance of the difference between the sets of means, was used to identify the areas of similarity, difference, or complementarity between the works of fiction and the IA reports.

Samples for this analysis were selected on the basis of recommendations in the literature (Greenberg and Warrick, 1973; Porter et al., 1980; Linstone, 1981) and from practitioners in both fields (Rabiega, 1979; Heckler, 1981; Lehnhoff, 1982) as being exemplary works of their type. As listed in Tables VII and VIII, eleven IA reports and ten EF stories were analysed in this task. Of the reports, six are technology assessments and five are environmental impact assessments. Of the fiction works studied, seven are short stories and three are short novels; all deal with specific innovations in the context of a society whose elements and relationships have been extrapolated from the present. The topics covered by both groups of works include programmatic, regional, local, and conceptual innovations. All of them

TABLE VII

WORKS SELECTED FOR THE STATISTICAL ANALYSIS:

IA REPORTS

AUTHOR	TITLE	BIBLIOGRAPHICAL DATA	PREMISE
Foster, K. et al.	A Technology Assessment of Guayule Rubber Commercialization	University of Arizona Office of Arid Lands Studies, report to N.S.F. #PRA 78-11632, Tucson Arizona, May, 1980, pp149-183	production of rubber from the guayule plant is commercially feasible in the southwestern U.S.
Krupka, M.C.	Technology Assessment of Solar Energy: Solar Photovoltaic Energy Systems	Los Alamos National Laboratories report to DOE #LA 7866-TASE, Los Alamos, New Mexico, 1979 pp. 16 - 40.	widespread use of photo-voltaic devices for decentralized generation of electricity
Gordon, T.J. et al.	A Study of Life-Extending Technologies	The Futures Group reoprt to N.S.F. #NSF-C1034, Glastonbury, Conn., also published by Pergamon Press, Elmsford, N.Y., 1979, pp. 119-230.	technologies are in use and being developed which will extend the lifespan of the current population 25-50 yrs
Burt, L. et al.	Light Rail Transit: the Banfield	Portland State University Systems Science Ph.D. Program Portland, Oregon, May, 1979, pp. A-3 - IV-6	building a light rail system between downtown core and outlying suburbs concentrates population
Kaufman, E.L. &	Environmental Analysis of Fenton Hill Hot Dry Rock Geothermal Test Site	Los Alamos National Laboratory report to DOE #LA-7830-HDR, Los Alamos, New Mexico, May, 1979, pp. 40-54	closed-loop cycling of cold water through hot magma layers produces electricity and cascaded heat
Bonneville Power Administration	Environmental Assessment: Proposed BPA Region-wide Weatherization Program	Bonneville Power Administration Division of Energy Conservation Portland, Oregon, April, 1981	negative effects on health from sealing/insulating buildings may outweigh gains from energy savings
U.S. Forest Service	Methods of Managing Competition: A Programmatic Environ-mental Impact Statement	U.S.D.A. Forest Service, Region May, 1981	comparison of several ways to reduce vegetation that competes with forest growth
Land Mangement Service	Draft Environmental Impact Statement: Veterans Adminis-tration Medical Center	Veterans Administration Office of Construction, Washington, D.C., May, 1979, pp. 2-1 --2-86	construction of a 600-bed hospital in a low-income neighborhood
Northern Energy	Environmental Impact Statement: The Spring Creek Project	VTN Environmental Consultants Oregon, 1979, pp. IV-1 -- IV-61	a strip mine is placed near the state line between Montana and Wyoming
Office of Appropriate Technology	Genetic Technology: A New Frontier	Westview Press, Boulder, Colorado 1982, pp. 242-254	patenting living organisms has effects on research and commercialization of rDNA
Landis, R.C.	A Technology Assessment Method-ology: Mariculture (sea farming)	The MITRE Corporation, report to the Office of Science and Tech-nology, #PB 202778-05, Washington, D.C., June, 1971, pp. 70-95, 108-113	intensive seafarming could alter third world's diet and hence their economy

TABLE VIII

WORKS SELECTED FOR THE STATISTICAL ANALYSIS:

EF STORIES

Vinicoff, E. & M. Martin	Malthus' Last Laugh	Destinies, Vol 1, No.3, 1979, pp. 261-293	population growth and poor harvests lead to a new solution
Raphael, R.	Code Three	New York, Berkeley Medallion, 1967, pp5-57	continental thruways permit groundspeeds to 600mph and require special police
Disch, T.	Emancipation: A Romance of Times to Come	in P. Sargent, Bio-Futures, New York, Vintage, 1976, pp. 57-86	a marriage is saved when a husband is given a test tube baby to nurse
Pournelle, J.	Power to the People	in High Justice, New rk, Pocket Books, 1977, pp. 40 - 60	a nuclear-reactor-based agro-industrial complex is sited in the Namib desert
Felice, C.	No One Said Forever	in V. Kidd Milennial Women, New York, Dell, 1978, pp. 5 - 20	a woman's career path breaks up her family
Heinlein, R.	Blow-Ups Happen	in Expanding Universe, New York, Ace, 1980, pp. 35-90	engineers at a nuclear power plant behave stragnely under the pressure
Herbert, F.	Under Pressure	New York, Ballantine Bookes, 1978.	oil shortage and war lead to U.S. submarines pumping oil off Soviet territory
Asimov, I.	Evidence	in I, Robot, New York, Doubleday, 1946,	an android is elected mayor
Dervic, C.	Adrift on the Policy Level	in M.H. Greenberg and P. Warrick Political Science Fiction, Englewood Cliffs, New Jersey, Prentice-Hall, 1974, pp.111-127	a needed scientific advance must be sold to each level of decisionmaker before it can be implemented
Heinlein, R.	I Will Fear No Evil	New York, Berkeley Books, 1970	the C.E.O. of a giant corporation has his brain transplanted into a young body

deal with a fifty-year-or-less time frame and directly extrapolate current sociotechnical parameters. Although the reports tended to considerably greater length than the fiction works, the sections describing potential impacts were generally comparable in length.

Table IX lists the impact descriptor categories used for the analysis. Derived from a combination of federal guidelines (Department of Agriculture, 1976) and suggestions from practitioners in the field (cf, Arnstein and Christakis, 1975; Enk et al., 1978; Porter et al., 1980), these categories represent general impact areas within which a variety of specific statements might be made. For example, category A.2, "Earth," includes any statement describing land use, soil availability and quality, radiation levels in the area, or presence of mineral resources. Category E.2, "Population," includes any statements describing the innovation's effect on the size, age, mobility, or demographic structure of the population under study.

Counting the statements in each of these sixty-one categories for each of the twenty-one works analyzed required the efforts of several people. Two coders were used, with the author spot-checking to ensure consistency between coders. Statements were counted if they were direct statements ("two hundred jobs will be created"), implied statements ("they avoided the radioactive areas along the roadway"), or were tabular data (typically a line across the columns in a matrix was counted as one statement). Among

TABLE IX

IMPACT DESCRIPTORS FOR STATISTICAL CONTENT ANALYSIS

IMPACT CATEGORY

IMPACT CATEGORY

A. PHYSICAL ENVIRONMENT
   1. General
   2. Earth--soil, radiation, etc,
   3. Water--quality, temperature, etc
   4. Atmosphere--air quality, climate
   5. Geological Processes--floods, etc

B. BIOLOGICAL ENVIRONMENT
   1. General
   2. Flora
   3. Fauna
   4. Microorganisms
   5. Disease
   6. Food chains

C. TECHNO-ECONOMIC ENVIRONMENT
   1. Structures--design, use
   2. Production systems--mining, etc
   3. Utility networks--power sources
   4. Transportation systems
   5. Waste Disposal systems
   6. Communication systems
   7. Distribution systems
   8. Employment patter
   9. Labor availability
   10. Revenues
   11. Capital availability
   12. Market/property value shifts
   13. Research and Development
   14. Resource Supplies
   15. Alternative market structures
   16. Technological processes
   17. General economy

D. SOCIAL EFFECTS
   1. General
   2. Population--density, mobility, etc.
   3. Gender/race relations
   4. Community growth
   5. Institutional Shifts
   6. Decisionmaking Processes
   7. Relationship between change process/env
   8. Power structures
   9. Role of mass media
   10. Health care
   11. Social Services
   12. Community cohesion
   13. Leisure, recreation services

E. QUALITY-OF-LIFE FACTORS
   1. General
   2. Aesthetics
   3. Food--quality, availability
   4. Shelter--quality, availability
   5. Clothing--quality, availability
   6. Security
   7. Physical well-being
   8. Emotional well-being
   9. Stability/Change balance
   10. Companionship, love family
   11. Job opportunities, satisfaction
   12. Education opportunities, quality
   13. Leisure/recreation opportunities
   14. Personal mobility
   15. Social mobility
   16. Personal growth opportunities
   17. Privacy
   18. Freedom
   19. Philosophical rootedness--faith, values
   20. Cultural, historical, archaeological res.

the IA reports analyzed, no graphs or maps were used to describe impacts.

Differences of opinion occasionally arose between coders as to whether sets of statements did in fact describe impacts of the innovation. In one study a large number of statements describing the general effects of radon were ascribed to the specific project under study (this was later corrected). For the most part, however, the differences between coders were of the type and frequency illustrated in Table X. Where differences were considered significant, the author met with the coders to come to an agreement. (In the case of the radon statements, the general statements were dropped from the count and the revised figures became the basis for calculations.)

In order to test for significant difference, it was first necessary to establish means for each impact category. Means were also figured for the major categories: Physical Environment, Biological Environment, Techno-economic Environment, Social Effects, and Quality-of-Life Factors. Then, means were calculated for each sample as a whole, to provide a comparison of the relative number of descriptive statements, given comparable lengths (in number of words).

These means and information in the form illustrated in Table XI are necessary to perform the standard t-test for means of independent samples. A standard one-tailed t-test was used to determine the significance of the differences between the means of the two samples: that is, whether it

TABLE X

SAMPLE OF CODER RESULTS IN THE STATISTICAL ANALYSIS

STATEMENT (from "Physical Impacts")	IMPACT CATEGORY SELECTED BY	
	CODER A	CODER B
PARAGRAPH ONE:		
near-term increases in air and water pollutant emissions . . .	A4, A3	A4
relative reductions after . . .	A1	A3
on balance impacts would be small	A1	A1
long-range impact . . . on materials production would be reduced . . .	D2	D2
accelerate the weatherization of homes	D2	D2
industries . . . absorb the demand . . . without construction of new facilities	D1	D2
PARAGRAPH TWO		
major impact . . . production of insulation	D2	D2
amounts of air pollutants in (5 areas)	A4 (x5)	A4 (x5)
use of other types . . . total maounts of pollutants would decline	A1	A4
production of other materials . . . lesser quantities	D2	D2
PARAGRAPH THREE:		
reduction in loads . . . no effect on impacts of generation . . .	D3	D14
schedules of resources . . . unchanged	D14	D14
PARAGRAPH FOUR		
energy savings . . . lessen the need for purchases from other sources	D3	D14
the reduction . . . would . . . reduce impacts of the operation . . .	A1	A1
TABLE: landuse--2, water--6, air--4, waste--2, radioactivity--2	A2 (x6) A3 (x6) A4 (x4)	A2 (x6) A3 (x6) A4 (x4)
impacts of generation (of hydro) . . . not displaced ·	A3	A3
PARAGRAPH FIVE		
reduce risk of curtailment of loads	D3	D3
probability of curtailment extremely low	D3	D3
program . . . reduce the need . . . during daylight hours . . .	D3	D3
impact . . . minor	D3	A1
PARAGRAPH SIX		
effect . . . (on regional loads . . . 1%	D3	D3

TABLE XI

INFORMATION USED IN t TESTS (ILLUSTRATIVE)

	EF Stories	IA Reports
Number in Sample (N)	10	11
Number of Statements (X)	1330	3657
Mean of Statements (X)	133	332.4
X	235222	1508393

degrees of freedom (N + N - 2) = 19

would be possible to reject the hypothesis that IA reports
will have consistently higher means than EF stories.
Ferguson (1966) states that for such a directional test, in
order to reject the null hypothesis (that the difference
results from chance--i.e., that the difference between the
means is less than or equal to zero) and accept that Sample
A (in this case, the IA reports) have significantly higher
means (of statements), a positive value of t corresponding
to five percent (or less) probability is necessary. Ferguson
also states that an equivalent negative value of t is neces-
sary to accept the hypothesis that Sample B (EF stories)
have a significantly higher mean (number of statements in
any given category). To test these hypotheses, sixty-one
values of t were calculated, including values for each
impact category, for each aggregated, major category, and
for the two samples as a whole.

To find t, the difference between the means is divided
by the square root of a sum of squares of deviation about

the means (that is, the standard error) in the formula

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\hat{} \sqrt{\dfrac{s^1}{\overline{N}_1} + \dfrac{s^2}{\overline{N}_2}}}$$

where

$$s^2 = \frac{X_1{}^2 - \dfrac{(X_1)^2}{N_1} + X_2{}^2 - \dfrac{(X_2)^2}{N_2}}{N_1 + N_2 - 2}$$

This formula, applied to each of the impact categories, yields a number that indicates the statistical probability that the two samples will have those means. Referring to a standard t-test table (Ferguson, 1966) it is possible to determine at what significance level the difference between them lies.

For this one-tailed, directional test, with nineteen degrees of freedom (11 + 10 - 2), the results for IA reports are significant at the .05 level where t is greater than 1.729, the .025 level where t is greater than 2.093, the .01 level where t is greater than 2.63, and at the .005 level where t is greater than 2.861. The results for EF stories would be significant if the same values of t were negative (i.e, t less than -2.093 would be significant at the .025 level, etc.) (Ferguson, 1966).

After these calculations and comparisons, I reviewed the impact categories to identify any that were completely missed by either the IA reports or the EF stories, and any that might be covered by all works in either sample.

Results

A number of interesting results emerge from this
analysis. In over half of the categories tested (51%) there
was no significant difference between the means of the two
samples. In over one quarter of the categories (fourteen,
or 26%) EF stories had mean numbers of statements equal to
or greater than those of the IA reports, of which one third
had values of t indicating a significant difference.

Table XII lists the categories in which the EF
stories tested had significantly greater mean numbers of
statements describing impacts. These were: (C.6) communi-
cation systems, (C.16) technological processes, (D.9) media
role, (E.5) clothing, (E.8) emotional wellbeing, and (E.10)
companionship, love, and family. The first two of these
(C.6 and C.16) are in the major category of techno-economic
environment, and describe the qualitative relationships
within that environment--namely the types of communication
systems used and the types of and changes in technological
processes over the period being investigated. The category
(D.9) describes the role of the media regarding changes in
the social environment. The last three (E.5, E.8, and E.10)
describe quality-of-life factors: the types and quality of
clothing worn (an indicator of the degree to which physical
needs are met), the degree to which emotions are affected or
supported as a result of the innovation, and the presence,
absence, or role of intimate companionship, love, and family
resulting from changes in the human environment.

TABLE XII

SIGNIFICANCE OF DIFFERENCES

IMPACT CATEGORY	X̄ IA	EF	t	SIGNIFICANCE
	IA REPORTS HAVE SIGNIFICANTLY GREATER MEANS			
A.1. Physical, general	3	--	1.82	.05
A.2. Earth/land/soil	26	3	3.42	.005
A.3. Water	22	1	1.95	.05
A.4. Air/Climate	15	1	2.78	.01
B.3. Fauna	10	.4	1.87	.05
C.3. Utilities/power source	8	2	2.0	
C.9. Labor availability	7	1	1.8	.05
C.10. Revenues	5	1	2.222	.025
C.12. Market values shifts	11	1	2.07	.05
D.1. Social Effects, general	2	--	2.56	.025
E.7. Physical well-being	16	6	1.77	.05
E.20 Cultural resources	2	--	1.83	.05
	EF STORIES HAVE GREATER MEANS			
C.6. Communication systems	4	7	-.54	--
C.16 Technological processes	1	2	-.97	--
D.8. Power structures	3	7	-1.31	--
D.9. Media role	--	1	-2.929	.005
E.5. Clothing	--	3	-4.62	.005
E.8. Emotional well-being	1	6	-2.0	.05
E.10. Companionship/love/family	.1	5	-2.275	.025
E.15. Social mobility	--	1	-3.02	.005

Table XII also lists the categories in which the IA reports showed significantly higher means. Four out of the twelve listed describe the physical environment, three the biological environment, four the techno-economic environment, two quality-of-life factors, and one describes social effects ("general"). These twelve categories represent less than a quarter (23%) of the total number of impact categories in this list, indicating that the first hypothesis (that IA reports will have consistently higher mean numbers of statements describing impacts than will EF stories) should be rejected for three quarters of the impact categories suggested in the IA guidelines and regulations.

TABLE XIII

DIFFERENCES BETWEEN AGGREGATED CATEGORIES

CATEGORY	EF STORIES		A REPORTS		t	SIG.
A Physical Environment	50	(5)	70	(77)	3.80	.005
B Biological Environment	15	(1.5)	291	(27)	3.68	.005
C Techno-Economic Env	462	(46.2)	134	(130)	2.49	.025
D Social Environment	298	(29.8)	495	(45)	1.326	none
E. Quality of Life	505	(50.5)	667	(61)	.901	none
TOTAL	1330		657		2.37	.025

At another level of analysis, as shown in Table XIV, the IA reports as a sample showed a significantly greater number of statements describing impacts than the EF sample at the .025 level (t = 2.286), as well as in the major categories of Physical, Biological, and Techno-economic Environment (at levels of .01, .01 and .025 respectively). There was no significant difference between EF stories and IA reports in the aggregated categories of Sociocultural effects and Quality-of-life factors.* These results suggest that the hypothesis should be modified to say that, in general, IA reports contain a higher mean number of statements describing impacts than EF stories, and that those impacts are most frequently described in the areas of the physical, biological, and techno-economic environments.

A third set of results emerges from a comparison of the categories in which all of the EF stories or IA reports describe impacts. Table XIII lists those and shows that while all of the EF stories tested describe impacts in eight of the fifty-three categories (15%), no categories of impacts are described by all IA reports, indicating that a major difference between the two samples lies in the fraction of works describing impacts in each category. Only impacts on Employment (category D.8) were described by ten

*This result appears to derive from the high number of statements which the IA reports showed in the "General" categories for Social Effects (D.1) and Quality-of-Life Factors (E.1), compared to no statements in those categories for the EF stories.

TABLE XIV. IMPACT CATEGORIES DESCRIBED BY
ALL OR NO IA REPORTS AND EF STORIES

Categories	All EF	All IA	No EF	No IA
A.1. Physical Environment, General			X	
A.2. Earth/Land.Soil	X			
C.4. Eutrophication			X	
D.1. Structures	X			
D.4. Transportation Systems	X			
D.6. Communication Systems	X			
D.13. Research and Development	X			
D.15. Alternative Market Structures			X	
D.17. General Economy			X	
E.1. Social Effects, General			X	
E.5. Institutional Shifts	X			
F.7. Physical Well-Being	X			
F.8. Emotional Well-Being	X			
F.5. Clothing				X

of the eleven IA reports and those on Earth (A.2), Water (A.3), Market Value (D.12) were dealt with in nine of them.

So, while the IA reports studied showed a significantly higher mean number of statements describing the Physical, Biological, and Techno-Economic environments than the EF stories, EF stories showed significantly higher means in certain categories in the Techno-economic environment, social effects and quality-of-life factors, and consistently described a wider range of impacts than the IA reports.

THEMATIC ANALYSIS

A thematic analysis of extrapolative fiction (EF) stories, with its qualitative methodology, at once complements the statistical analysis described in the preceding section and permits the examination of extrapolative fiction at a higher level of generality. Rather than counting the number of statements, the method used here identifies underlying themes in the work. The degree to which these themes conform to the content objectives for scenarios in impact assessment was taken as a measure of the potential utility of extrapolative fiction in the IA process. The degree to which these themes are dealt with as issues in news, opinion-forming, and political analysis literature over the years subsequent to the story's publication was taken as a measure of EF's potential relevance to decision-makers concerned with public response to an innovation. Together, then, these measures provide substantive support

for this thesis, helping to answer the question of whether the inclusion of EF stories can improve the IA process and IA results.

This section presents the description and analysis of a set of EF stories published between 1940 and 1975 that deal with innovations to occur during the last forty years, through 1980. A number of innovations dominated these stories: exploration of the oceans and journeys to the moon were common; so were atomic/nuclear power plants and alternative transportation modes and systems. Many of these stories are concerned with the social and personal effects of political and institutional shifts in the culture, based on the techniques of extrapolation, speculation, and interpretation (see Chapter Three). Moreover, tradition indicates that often such fictional interpretations reflect concerns held by the larger public. This dissertation, however, must answer a specific question: are these stories useful to IA practitioners? This section, looking at the historical record, asks a variation on that question: would reading these stories have been useful to someone trying to decide between alternative sets of actions at the time of their writing?

Approach

In order to answer the last question, a retrospective analysis was designed. A set of EF stories written since 1940 and dealing with the years through 1980 was selected, as listed in Table XV. These stories were published in a

TABLE XV

EF STORIES SELECTED FOR THE

THEMATIC ANALYSIS

TITLE	AUTHOR	SOURCE
Blowups Happen	Robert A. Heinlein	Astounding Stories, 1940 Conklin, The Year's Best SF The Past Through Tomorrow, 1967 Expanding Universe, 1980
The Roads Must Roll	Robert A. Heinlein	Astounding Stories, 1940 The Man Who Sold The Moon, 1950 The Past Through Tomorrow, 1967
Inheritance	Arthur C. Clarke	Astounding Stories, September, 1948, Vol. XLII #1, p.145 ff.
Unite and Conquer	Theodore Sturgeon	Astounding, Stories, October, 1948 Vol XLII #2, pp63-99
The Mercenaries	H. Beam Piper	Astounding Scince Fiction, March, 1950, Vol XLV #1, pp. 57-77
Quixote and the Windmill	Poul Anderson	Astounding Science Fiction, November, 1950, Vol XLVI #3, pp. 95-102
Historical Note	Murray Leinster	Astounding Science Fiction, September, 1951, Vol XLVII, #2 pp. 45 ff.
The Day of the Moron	H. Beam Piper	Astounding Science Fiction, September, 1951, Vol XLV!!!, #1, pp7-34
What Thin Patitions	M. Clifton and A. Apostolides	Astounding Science Fiction, September, 1953, Vol. LII #1 pp. 9 ff
Counterspy	K. Edwards	Astounding Science Fction, December, 1953, Vol LII, #4 pp. 122-139
Under Pressure (originally The Dragon in the Sea)	Frank Herbert	Ballantine Books, New York, 1926
The Deep Range	Arthur C. Clarke	Ballantine Books, New York, 1957
A Different Purpose	Kim Burnett	The Best of Fantasy and Science Fiction Ninth Series, 1958
Brain Twister	Mark Phillips	Pyramid Books, New York, 1960

variety of places--predominantly in Campbell's Astounding--
by a number of authors, many of whom were well-known. They
were selected on the basis of recommendations from
aficionados and from scanning a complete collection of
Astounding and Galaxy which covered the period in question.

The stories were read and analyzed according to a set
of parameters developed on the basis of suggestions for
preparing scenarios and societal forecasts from IA practi-
tioners and futurists (e.g., Martino, 1972; Mitchell, 1975;
Armstrong and Harman, 1978; Porter et al., 1980). These
areas include the Social, Technological, Economic,
Environmental, and Political sectors of the culture. The
forecasting parameters were cross-compared with the levels
of focus generally found in fiction--the character's
experience, the social and physical setting, and the philo-
sophical ideas or moral issues that underlie the action in
the story. These headings also conform to the content
requirements established in the legislation for IA: the
character's experience as quality-of-life factors, the
setting as sociotechnical environment factors, and the
philosophy/ideas level as values/ethics factors.

As each work was read the resultant matrix cells were
filled with statements describing issues or themes that
emerged from the story. This placement required a thorough
understanding of the sectors and levels used, and involved a
number of qualitative judgements. In order to improve the
reliability of the results, the matrices were put away and

reviewed some months later to identify inconsistencies and oversights. A few corrections and additions were made in this second pass and are reflected in the current matrices.

On completion of the individual analyses, a collective matrix was prepared. (Table XVI, described in the Results Section, below, shows this matrix.) The individual story matrices were synthesized to identify issues and themes which appeared in greater than half of the works studied. This phase also identified clusters of innovations or foci for the stories analysed, as recurrent themes were listed. The stories analyzed fell into three main groups according to the type of innovation considered--atomic power, transportation, and research and development--and one "grab-bag" group of unrelated topics..

A model for tracking the general literature on a subject, developed by Graham T. T. Molitor to identify emerging issues, was used to determine whether the themes developed in an EF story have, in fact, reached a level of national concern. As Figure 5 illustrates, within Molitor's framework, if the theme is dealt with in professional journals, but has not yet reached his "instantaneous coverage" stage with TV, radio, and newspapers reporting on the issue as it develops, then it has not yet emerged as an issue of national concern. If, on the other hand, articles describing the theme are to be found in papers such as The New York Times, then the theme is an emergent issue. If such coverage was present at the time the story was being
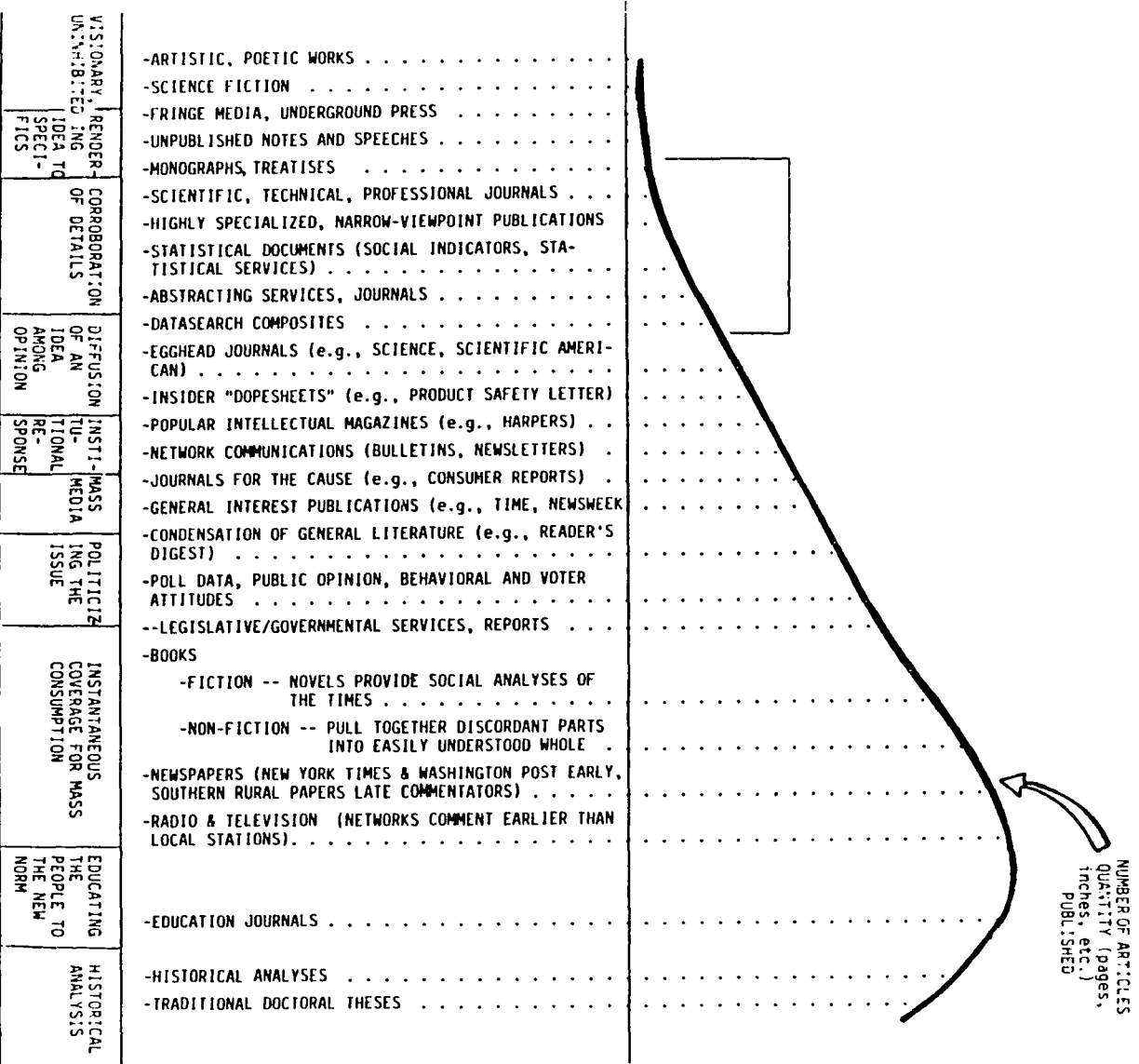
Figure 5. Molitor's framework for identifying emerging issues through analysis of communications media.

The chart lists (top to bottom):

- ARTISTIC, POETIC WORKS . . . .
- SCIENCE FICTION . . . .
- FRINGE MEDIA, UNDERGROUND PRESS . . . .
- UNPUBLISHED NOTES AND SPEECHES . . . .
- MONOGRAPHS, TREATISES . . . .
- SCIENTIFIC, TECHNICAL, PROFESSIONAL JOURNALS . . .
- HIGHLY SPECIALIZED, NARROW-VIEWPOINT PUBLICATIONS .
- STATISTICAL DOCUMENTS (SOCIAL INDICATORS, STA-
  TISTICAL SERVICES) . . . .
- ABSTRACTING SERVICES, JOURNALS . . . .
- DATASEARCH COMPOSITES . . . .
- EGGHEAD JOURNALS (e.g., SCIENCE, SCIENTIFIC AMERI-
  CAN) . . . .
- INSIDER "DOPESHEETS" (e.g., PRODUCT SAFETY LETTER) . . . . . .
- POPULAR INTELLECTUAL MAGAZINES (e.g., HARPERS) . .
- NETWORK COMMUNICATIONS (BULLETINS, NEWSLETTERS) .
- JOURNALS FOR THE CAUSE (e.g., CONSUMER REPORTS) .
- GENERAL INTEREST PUBLICATIONS (e.g., TIME, NEWSWEEK
- CONDENSATION OF GENERAL LITERATURE (e.g., READER'S
  DIGEST) . . . .
- POLL DATA, PUBLIC OPINION, BEHAVIORAL AND VOTER
  ATTITUDES . . . .
- -LEGISLATIVE/GOVERNMENTAL SERVICES, REPORTS . . .
- BOOKS
  - FICTION -- NOVELS PROVIDE SOCIAL ANALYSES OF
    THE TIMES . . . . . .
  - NON-FICTION -- PULL TOGETHER DISCORDANT PARTS
    INTO EASILY UNDERSTOOD WHOLE .
- NEWSPAPERS (NEW YORK TIMES & WASHINGTON POST EARLY,
  SOUTHERN RURAL PAPERS LATE COMMENTATORS) . . . . .
- RADIO & TELEVISION (NETWORKS COMMENT EARLIER THAN
  LOCAL STATIONS). . . . .
- EDUCATION JOURNALS . . . .
- HISTORICAL ANALYSES . . . .
- TRADITIONAL DOCTORAL THESES . . . .

Left side columns:

VISIONARY, RENDERING IDEA TO SPECIFICS / UNINHIBITED SPECI-FICS
RENDER-ING OF DETAILS / CORROBORATION OF DETAILS
DIFFUSION OF AN IDEA AMONG OPINION
INSTI-TUTIONAL RE-SPONSE
MASS MEDIA
POLITICIZING THE ISSUE
INSTANTANEOUS COVERAGE FOR MASS CONSUMPTION
EDUCATING THE PEOPLE TO THE NEW NORM
HISTORICAL ANALYSIS

Right side: NUMBER OF ARTICLES QUANTITY (pages, inches, etc.) PUBLISHED

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written, then, rather than presenting an emergent issue, the
author was presenting an already established national
concern (Molitor, 1972).*

Results

In the stories analyzed for this phase of the research,
writers explored the potential benefits and problems associ-
ated with technological and institutional innovations
against a common background of stable social and political
values that their readers could identify with. As a result
of this common background, a number of themes and issues
appear in all (or a majority) of the stories analyzed.
These are presented in Table XVI, and are discussed below.

Character. At Level III, personal experience, the one
common factor in all of the stories analyzed is techno-
logical: the personal automobile as a dominant form of
transportation. Clearly, the writers did not expect
Americans or other members of Western society to give up the
"American Dream Machine" within the stories' time frames.
Interestingly enough, in spite of a sixfold increase in fuel
prices and massive efforts by various governments over the
intervening years to make mass transit glamorous and
available, industrial society's love affair with the
automobile shows every sign of continuing well into the

* Parallel indicators exist at the local level. For
example, letters to the editor or phone calls in to "talk"
shows may indicate the possibility of an emerging issue,
while front page coverage in the local newspaper, or
bulletins on the evening news shows are indicative of an
issue's establishment as a major local concern.

TABLE XVI

THEMES SYNTHESIZED FROM EF STORIES, 1940-1980

(* indicates presence in all)

	SOCIAL	TECHNICAL	ECONOMIC	ENVIRONMENTAL	POLITICAL
LEVEL I Philosophical discussion (values, ethics factors)	the prominence of male chauvinism	how many levels of failsafe are sufficient the relationship between technical changes and human values/social constructs	*how the motive of financial gain can determine human behavior	how much shielding is enough, around nuclear piles *the need for and role of privacy	*what happens to the people when nations keep secrets *the role of informal power structures especially in going around formal channels
LEVEL II Setting (socio-cultural parameters)	*women serve or assist *men play dominant roles	*search for alternative power source and communication media (includes parapsychological research)	*cash-based economy *contracts for design/research *government as major source of funds	desert labs with heavy security *offices separate from other spaces home spaces designed for nuclear families and individuals	*security forces as major powers (in nations, organizations) personnel policies as a major source of friction between management and staff *hierarchical power structures
LEVEL III Character's Experience (quality-of-life factors)	women's roles in transition	*personal cars as the major form of transport airplanes handguns		constant vigilence against spreading secrets of radioactive dust	informal actions often taken against formal policies

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1980s. As a primary indicator, the number of new American-
made cars sold in 1981 reached 6,206,296 (Automotive News,
1982) and nearly 125 million automobiles were registered in
the United States that year (U.S. Department of
Transportation, 1982).

Setting. At the system parameters level, Level II, the
authors described the setting for their stories; seven
factors are common to all the stories studied. A consistent
theme in the social sector is that, with notable exceptions,
women act to serve or assist men who play dominant roles.
Many stories have a uniquely gifted, talented, or trained
female protagonist who is placed in contrast to other women.
A few include women as sexual objects. For the most part,
however, women enter the stories as secretaries, nurses,
housewives, or in other supporting roles (in keeping with
the attitudes and expectations of the years in which the
stories were written). Since the early 1970s many projects
have been undertaken to change this state of affairs.
However, a recent issue of Scientific American confirms
that, in 1980, these were still the roles that the majority
of women fill in this country (Scientific American, 1982).*

The common parameter in the technological sector is a
continued search for alternate power sources and communi-
cations media--even including parapsychological research for
techniques in both areas. This kind of drive for techno-
logical progress is an underlying theme in nearly all
futures-oriented fiction of the period, but is particularly

evident in the near-future speculations studied here. It is also evident in the culture as a whole--both in the period the story was written and today. As an indicator of the pace of technological innovation in this country today, over sixty thousand patents were issued in 1980 (U.S. Department of Commerce, 1982).

Two themes dominate the economic sector descriptions. One is the continued use of cash as a medium of exchange (as opposed to barter or some sophisticated computerized accounting system). The assumption on which this theme is based is validated by the large number of bills in circulation today. The other theme is an assumption that the federal government is a major source of contract funds, both for research and for products. Even in the early stories, whose writers had seen the government playing such a role for less than a decade, this parameter remains fixed in their projections. As of 1980, the government was in fact the major purchaser of products in a large number of industries. Moreover, government supported research through the National Science Foundation, the Institutes of Health and Mental Health, and various other agencies and departments totalled close to $30 billion in grants and

*Although nearly all of the stories studied included women as characters, none included clear reference to specific racial minority groups (except the 1940 version of Heinlein's "Blow-Ups Happen", in which the tavenkeeper is clearly a Southern Black, but in the 1946 version--quoted in Chapter Three, above--is identified simply as an immigrant). The analysis described in this chapter, therefore, is restricted to the stories' handling of women, rather than minorities in general.

contracts in 1981 (U.S. Office of Management and Budget, 1980). This comprises some sixty per cent of the total, with private funding of research at a level of approximately $20 billion in the same year (Norman, 1981).

Two factors are consistent in the system parameter descriptions of the built environment: specifically, in the descriptions of structures and land use patterns. Office space is described as separated from other work and living spaces--either as part of a building's design, or more than once, by a plywood partition added where no previous division existed. Home spaces are designed for individuals and nuclear families; no extended families or group homes or dormitories are included in these stories. In those that go into any detail, eating spaces are separate from other living and working spaces except for occasional meals brought in during meetings or rush work periods. Again, present experience conforms, for the most part, to these descriptions.

In the political sector at this level, two main factors emerge across the stories studied. All describe hierarch- ical--typically pyramidal--power structures in whatever type of organization they deal with. At the same time, however, every author points out that the real power lies in the informal power structure, typically dominated by whatever security force is employed by the organization. Frequently, the conflict resolved through the course of the story involves a confrontation with security personnel. The

degree to which these parameters still hold true is not as easily documented as it was for those parameters described above. Yet the management training literature--particularly those in Molitor's "Books" category--has recently included a number of guidelines for and references to the importance of networking and identifying a mentor (a senior manager to support one's efforts and sponsor one's advancement) in an organization if one wants to function effectively in that organization (e.g., Wilson, 1981).

Philosophy. At Level I--values, ethics, and ideas-- the writers whose stories were analyzed have in common four main concerns. In the Economic sector, they all discuss ways in which human actions are driven or determined by the possibility of financial gain. Regarding the physical environment, all of the stories deal, either directly or indirectly, with the need for, role of, and means for acquiring privacy in society. The political question of secrecy and how national or corporate security regulations affect individuals is another consistent concern. Finally, the contrast between the formal power structure and the informal channels that are used by people who want to get things done is another concern that shows up consistently through the stories studied.

The Underlying Scenario. The factors common to the EF stories analyzed are all elements of the authors' own experience. Their presence in the EF stories of this period suggests that, as a group, the authors expected the cultural

context to stay pretty much the same between 1940 and 1980.

A contextual scenario based on these elements would look

something like the following:

> The continued search for alternative power sources
> and communications media is driven by government
> funds. A male-dominated cadre of professionals,
> motivated by the ideal of wealth to reach the top of
> the power pyramid, works in offices separated from
> their female assistants and support staff. Driving
> to individual homes in personal cars, they greet
> wives or girlfriends, who provide emotional relief
> and support, as well as links into the informal power
> structure. These links are doubly important as they
> not only permit the men to get things done, but they
> often make it possible to circumvent the security
> personnel who hold considerable control over who has
> access to what in the system. Privacy is taken for
> granted, except where secrets affecting the nation
> are concerned, where security forces have full
> authority to pry or take control over one's life.

This basic scenario underlies--describes the cultural

context for--all of the stories studied.*

The innovations--nuclear power plants, transportation

technologies, etc.--in all of these stories, then, are

placed in a cultural context that is rather narrowly extra-

polated, but a context that is open to question. The

questions asked in selected stories--and the issues

associated with them--are discussed in some detail in the

next few pages. The issues are then compared to Molitor's

phases in development (see Figure 15, p. 123) in order to

determine whether they have, in fact, emerged as national

concerns since the stories were written.

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*Interestingly, though most stories are set near the writer's current home, the nation as a concept is not present in all of the stories studied. Frequently, the cultural background is assumed to be the whole world.

Nuclear Power Stories. Three stories in the group
selected for this analysis focused on nuclear power plants
as an innovation with fictionally interesting consequences.
These three are: "The Day of the Moron" by H. Beam Piper
(1951), "Counterspy" by K. Edwards (1953), and "Blowups
Happen" by Robert A Heinlein (1940, 1946). Summarized in
Chapter Three, these stories have been analyzed according to
the matrix format described above and the themes and
concerns expressed in them are discussed in detail, below.
Each of them deals with the human actions and responses
associated with operating nuclear reactors, and each of them
illustrates a number of issues that have arisen in the
decades following their publication.

In reading "Blowups Happen" (Heinlein, 1940, 1946),
for example, it is important to realize that Heinlein wrote
it long before the first nuclear power plant was designed.
In fact, the 1940 version of the story preceded the first
"Pile" (in Chicago) by two years. The size and quantity
requirements of a power plant based on a pile similar to the
one described by Heinlein are, therefore, way out of line
with current practice. Nevertheless, the stress of
operating a not-fully-understood, potentially highly
destructive, operated-by-hindsight machine is still very
real. So are the mistakes that occur under such stressful
conditions. "Dismantling the safety interlocks" and using
the wrong wrench--as described in Heinlein's story--are both
highly reminiscent of the problems that led to the Three

Mile Island disaster as described in the Nuclear Regulatory

Commission's analysis (Nuclear Regulatory Commission, 1979--

see also pp 175-185).

All of these stories have dealt with several themes as

important regarding the nuclear power industry in the 1950s

and 1960s. Most of these themes were not being considered

in other forms of media at the time the story was published

but have, since then, either become institutionalized in

this country (through the passage of legislation) or have

passed Molitor's "critical point" as emerging issues of

national concern. The themes described by these stories

include:

(from "The Day of the Moron", (1951))

1. the relative danger of nuclear power plants and the
   need for safeguards

2. the vulnerability of a centralized power grid and
   the consequences of an accident within it

3. the necessity for heavy security around nuclear
   reactors

4. the potential problems of unionized labor in
   critical work areas

5. male chauvinism and resultant difficulties for
   female professionals

6. the requirements for a different kind of training
   to deal with nuclear power plants, given the damage
   potentially resulting from human error.

(from "Counterspy" (1953))

1. the near-impossibility of absolute security

2. the strain placed on those who are responsible for
   maintaining the security of the plant; and, indirectly

    3. the total absence of women from the technical and operational staff of the plants.

(from "Blowups Happen" (1940, 1946))

    1. the relative danger of nuclear power plants and the inadequate understanding we have of what harm they might do

    2. the special personal and training requirements for reactor operators

    3. the expanding need for electricity in this country

    4. the possibility of orbiting power stations

    5. the relative powerlessness of the President, or any Chief Executive to countermand policy in a bureaucracy

    6. the socially irresponsible and blinding effects of profits on decisionmaking.

The following paragraphs trace the evolution of these themes in terms of Molitor's phases. They describe the number of articles published in a variety of journals corresponding to the phases in Molitor's framework, or indicate the degree to which the issue has been accepted and insitutionalized in this country.

Figure 6 shows the number of articles dealing with the safety of nuclear power plants between 1940 and 1980. As demonstrated in that figure, few people in 1951 thought that any real safety problem existed, and concern about nuclear power as actually much less safe than the Atomic Energy Commission had presented it was expressed only occasionally in the journals until the late 1960's and early 1970s. Accidents, safety, and longterm or side effects of radiation exposure became an issue in the professional journals in 1960. It reappeared with the Idaho accidents in 1962 and

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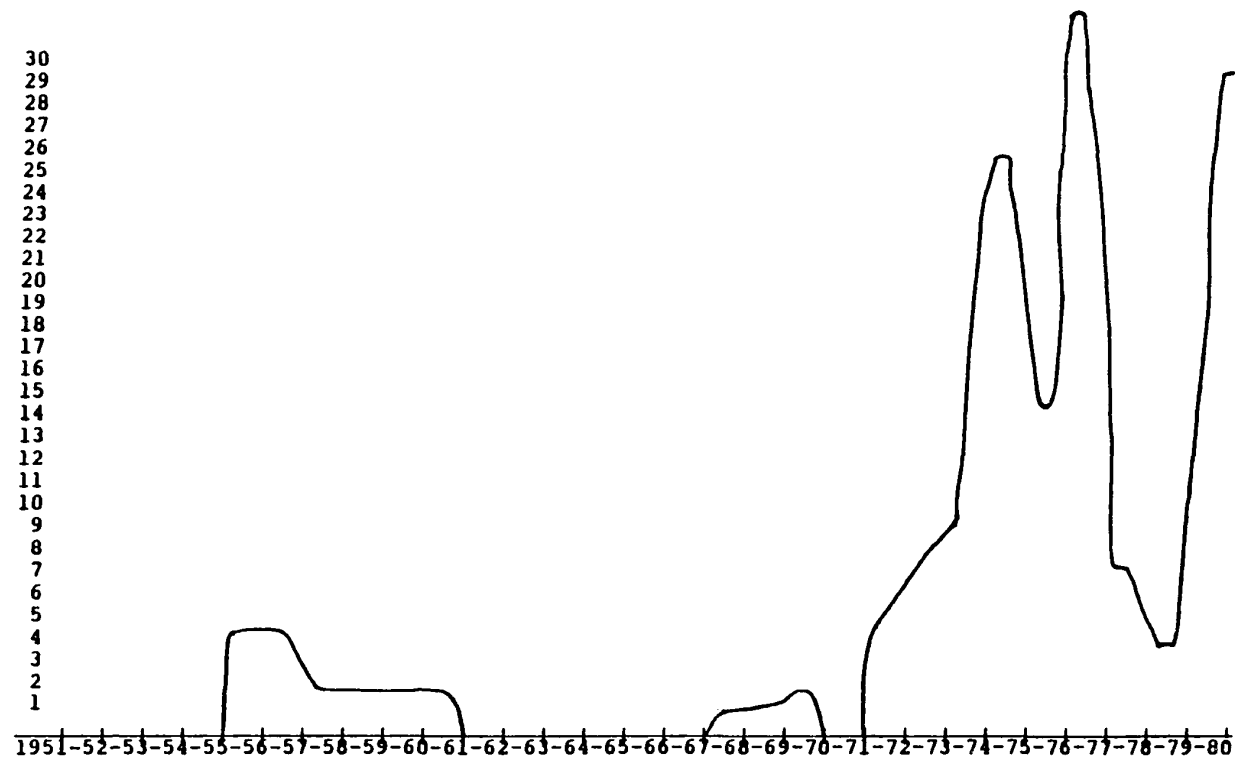
Figure 6. Number of articles dealin with Nuclear Power Plant
Safety. (SOURCE: Reader's Guide to Periodical
Literature)

1965. By 1973, this concern provided material for basic science classes at the undergraduate level (Rulon, 1973; U.S. Atomic Energy Commission, 1973). Interest waned, however, and few publications were concerned about accidents again until 1979, when the Three Mile Island incident once more placed the issue of nuclear accidents in Molitor's General Interest journals and in the public eye.

Figure 7 shows that media interest in electrical power blackouts erupted in 1965 when the Northeast coast (including New York City) experienced its great blackout, just three years before the year in which Piper set his story. As Piper observed, a centralized grid proved too vulnerable, and as in Piper's story, elevators were stopped, people were injured and killed, and stores were looted. The mass media covered the blackout extensively and novels were written based on the event, making the potential for blackouts also an issue of national concern--according to Molitor's schema--through the latter 1960s and into the early 1970s (where no such concern had been previously indexed in the periodical literature). In the aftermath, historical analyses identified the "stupid mistake" that caused the blackout and many dollars were spent in installing cross-connections to other sources so that such a situation could not be repeated--either in New York or anywhere else in the country.

The unionizing of professionals and government employees was an emerging issue when Piper was writing
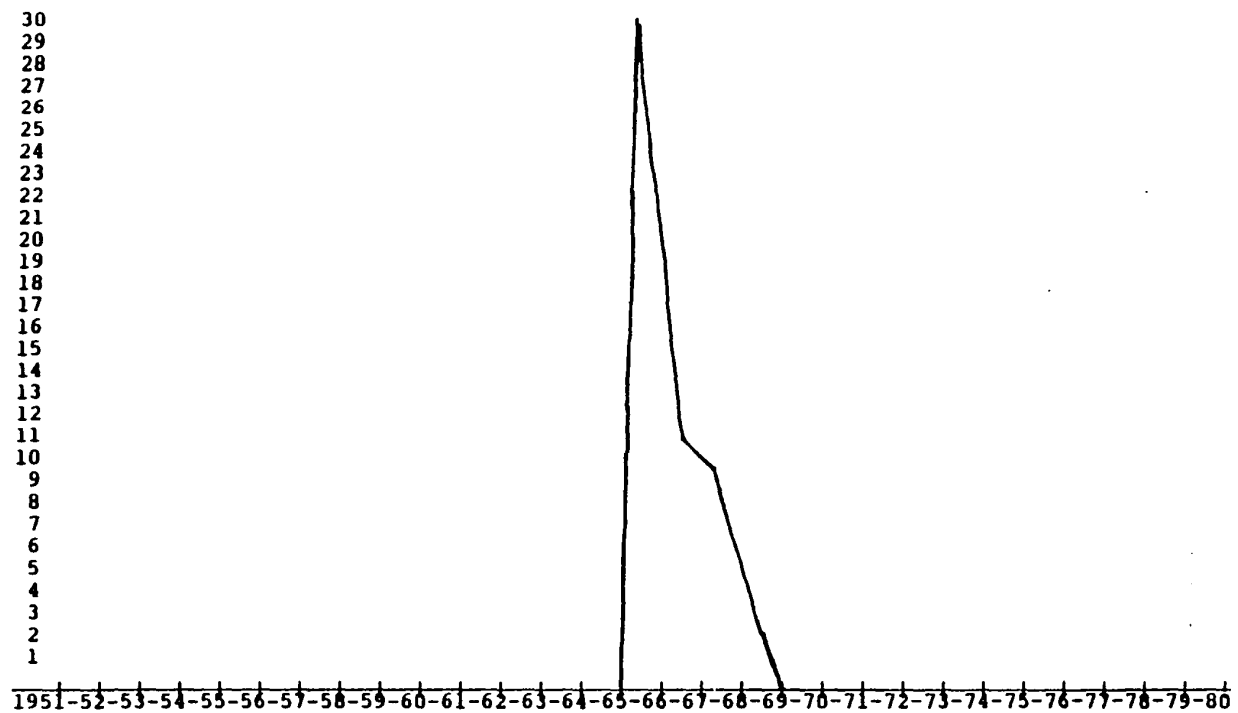
Figure 7. Number of articles dealing with electrical power
blackouts. (SOURCE: Reader's Guide to Periodical
Literature)

"Moron" and became a national issue in the mid-1950s, when instantaneous coverage of teachers and policemen in several cities forming unions and going on strike to demand higher wages and better working conditions became the norm, as shown in Figure 8. Prior to that time, most people had assumed that workers in critical positions--whose absence could have significant negative results in the community beyond their employers--were neither legally nor morally eligible for unions and the capacity for strike that went along with them. Molitor's Narrow-viewpoint publications (e.g., The New Republic) and Popular Intellectual magazines (e.g., Harper's) considered the possibility of the unioniza-tion of professionals and its implications in between events. Some shred of concern remains in these publications the 1980s, but workers in a wider and wider range of professions are forming unions and considering strikes. As an indicator, in 1982, all of California's state university system was organized into a teachers' union. Moreover, paralleling the "Moron" -storyline a strike by workers at Portland General Electric's Trojan nuclear power plant de-layed bringing that plant back on line after repairs in 1979. mass media covered the blackout extensively and novels were written based on the event, making the potential for blackouts also an issue of national concern--according to Molitor's schema--through the latter 1960s and on into the early 1970s (where no such concern had been previously indexed in the periodical literature). In the aftermath,
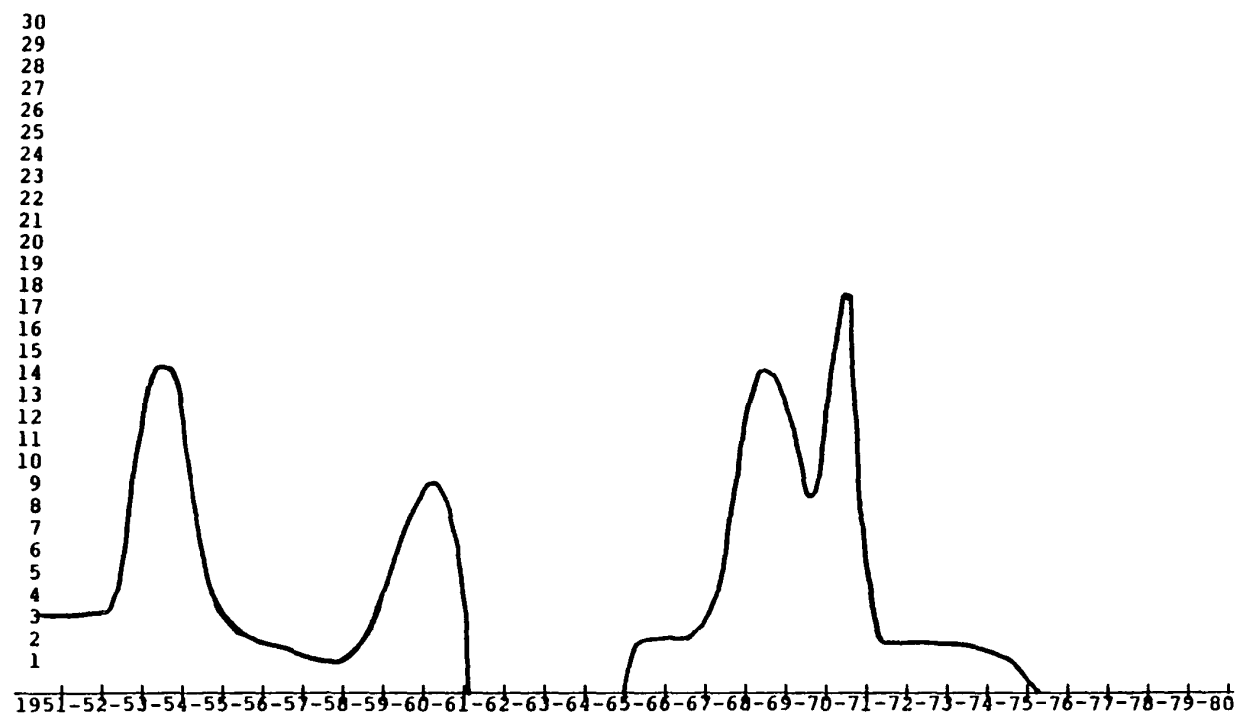
Figure 8. Number of articles dealing with public worker strikes and unions. (SOURCE: Reader's Guide to Periodical Literature)

historical analyses identified the "stupid mistake" that
caused the blackout and many dollars were spent installing
cross-connections to prevent another.

Then, the concern that there was "still a little of
what used to be called male sex-chauvinism" (Piper, 1951)
became a national concern in 1970 with the mass media
coverage of the formation of women's "consciousness-raising
groups" all over the country and the National Organization
for Women (NOW), with three thousand members, publishing its
Women's Bill of Rights (NOW, 1970). In that year, women
receiving Ph.D.s made up 13.4% of the total (compared to
less than 10% in 1950), though women made up less than 10%
of the faculty in psychology and less than 6% of the faculty
at research institutions (Giele, 1978). Since that time,
the number of books, articles, and academic theses on the
subject has continued to increase, with thirteen biblio-
graphies (of more than fifty books and articles in each)
published on "women--employment" between 1970 and 1979
(Ballou, P.K., 1980), compared to twenty articles on the
same subject in 1951-1953 (cf. The Reader's Guide).

The possibility that the United States might not be
able to keep up with demand for electrical power with
current practices was made a popular issue by the "swords
into plowshares" campaign associated with the formation of
the Atomic Energy Commission in the early 1950s. The
assumptions underlying this concern were not questioned
outside of the "fringe" environmentalist journals until the

oil crisis of 1973-74 spawned research into the possibil-
ities of conservation. At that point, government reports
and non-fiction syntheses were published which laid out the
specific growth factors affecting demand and the resource
levels limiting the supply (cf. The Ford Foundation's study
Energy For the Future, and the Department of Energy's
"Monthly Energy Review"). Based on these publications, shifts
in demand for power were covered instantaneously by the
media into the 1980s.

While Heinlein considered the possibility of orbiting
power stations in "Blowups Happen," orbiting satellites
with microwave transmitters beaming power to earth-based
receivers was not presented to the Congressional Sub-
committee on Space and Astronomics until 1975 (U.S. House of
Representatives, 1975). Such power stations are fundamental
to Gerard O'Neil's space colonization strategy, which
reached the point of nonfiction synthesis in 1977
(Heppenheimer, 1977) and newspaper coverage in 1981-82 (The
Oregonian, 1981; 1982)

The Nuclear Regulatory Commission's report on Three
Mile Island (1979) and the President's Commission's Report
on the same incident (1979) point out the need for a
different kind of training for reactor operators than for
traditional power plant engineers and are based on just the
kinds of concerns and problems described here in Heinlein's
story (discussed in greater detail in the following sec-
tion). However, the issue has not yet reached Molitor's

Diffusion stage and so is not yet assured of becoming an issue of national interest and concern.

Philosopher/historian James Ogilvie explained the blocks on a President's actions in 1980, in an article entitled "The Death of the Presidency" (Ogilvie, 1981) in one of Molitor's Egghead journals, but, although there is some discussion of the lack of power of a Chief Executive Officer in bureaucracies among management theorists (e.g., Jay, 1969; Wilson, 1981), the concept has not yet reached the mass media.

The need for corporate social responsibility emerged in the aftermath of the environmentalist movement. This emergence is characterized by Ralph Nader's nonfiction synthesis published in 1973 (Nader, 1973), which year corresponded with Congressional action (96th U.S. Congress, 1973), closing the issue for a time by institutionalizing it.

The possibility of terrorist attack was one of the stated reasons for not selling nuclear power plant tech-nologies to third world countries in the 1960s and was one of the arguments against building new plants presented during the 1970s. The issue reached Molitor's politicizing stage in Oregon with the Pebble Springs decision in 1979 (Oregon Siting Council, 1979).

Although many of the stories of the period in question include nuclear power as part of the context for the story, the three discussed here deal specifically with the problems

and potentials of this particular power technology. As the
preceding tables, graphs, and discussion have indicated,
most of the issues they raise have, in fact, received
attention over subsequent years from both the media and the
government. Some have passed the peak and are no longer
issues to be considered for action, but have been legislated
or regulated and are part of the institutional setting in
our society. Among these issues are equal employment
opportunity for women, corporate social responsibility,
unionization of professionals and public employees,
development of alternative energy sources, and decentraliz-
ation of electrical power grids. Others have yet to pass
the critical point beyond which Molitor has found their
emergence as issues to be assured. This latter group of
issues includes: the specialized training and support needs
of nuclear plant operators, the relative lack of power of a
chief executive officer in a bureaucracy, and the high
levels of stress experienced by those responsible for the
safety and security of nuclear plants.

Research and Development Stories. Several themes were
developed in the stories focusing on innovations in research
and development, including some which have already been
discussed. The stories analysed in this group include:
Piper's "The Mercenaries" (1950) and "What Thin Partitions"
(1953) by Clifton and Apostolides. The themes and concerns
developed in these stories include:

(from "The Mercenaries")

1. the power of security forces and the indignities of
   their searches, especially "strip" searches

2. the potential for women to work as equals on a
   research team

3. the contrast between the expectations held for
   women within the team and those held for them
   outside of it

4. the importance of maintaining independence in order
   to be effective as researchers (both for the team
   and for the individuals--especially women--within
   it)

5. the effects of intercorporate or international
   secrecy and competition on research and
   development

6. the emergence of essentially sovereign entities
   other than nation-states--particularly businesses.

(from "What Thin Partitions")

1. the problems working mothers have and the
   potential effects on the children when childcare is
   not available

2. the benefits to the corporation of readily
   available daycare

3. the subordinate, supporting roles of women in the
   corporation

4. the role of computer research corporations in the
   research and development process

5. the role of government--especially the military--in
   supporting research and promoting new technologies

6. the necessity of informal power structures to get
   things done.

In the area of security, the indignity of searches,

particularly strip searches, reached Parade Magazine in 1981

with a lengthy article and several follow-up stories on the

technique and its misuse/abuse by police and customs

officials in our country. According to Molitor's schema,

such publication means that this issue is past the critical point and is on its way to becoming a national concern.

The contrast between the rare situation of women working as equals and the more normal situation of subordinate roles for women has also been discussed above. As presented in Piper's story, however, this concern illustrates a need to maintain a sense of independence, and is related to the two longterm trends toward increasing independence and individuality in this country. To a large extent this story may be said to be an extrapolation of the theme of scientists' (and scientifically inclined writers'?) need for room to create and explore without the interference of ignorant officials. "The Mercenaries" explores possible consequences and implications of scientists--for example, Norbert Weiner--"refusing to tell the government anything" but what they specifically contract to tell them (Platt, 1980).

The problem of daycare, and the benefits to employers and corporations of making such facilities available to their employees are old and difficult themes. In the 1970s, however, a number of hospitals installed daycare centers for the children of employees. Cities funded daycare information and referral centers for concerned parents, and by the 1980s, some companies began to franchise daycare centers, while others offered daycare as one of the benefits employees could choose from. Smaller companies have found the costs of maintaining such facilities--especially for

insurance--too high to be feasible for them. These companies are looking at the alternatives contracting out the service to a nearby facility (Strain, 1983).

Computer Research, Inc. is the name of the research firm the authors describe in "Partitions". It is the equivalent of numerous small firms now scattered throughout the country--for example, Columbia Research, Inc. in the Portland, Oregon, area. At the time they were writing about this fictional firm, however, the RAND (Research ANd Development) Corporation was newly founded, Stanford Research Institute (now SRI International) had not yet broken off from the University, and computers were room-sized calculators. Yet World War II, and then Korea, had taught the United States military to rely on mathematicians and other scientists to convert their raw data (e.g., observations of enemy activities) into meaningful information (e.g., patterns from which policy decisions might be made). The scientists, in their turn, found they enjoyed tackling "real world" problems and, throughout the 1950s and 1960s, were forming a variety of organizations that might enable them to do so on a per-contract basis. By 1980, RAND and SRI had become the model contract research organizations for several countries, and most metropolitan areas with universities or a population over half a million had a smaller version or two.

Together, the stories discussed in this section raise some interesting issues regarding research and development

in this country. Both of them continue the concern about the role of women that was expressed in the nuclear power stories--taking that issue a little further by pointing out the problems of childcare and professional independence when a married woman continues to work outside the home. The stories also point out the ubiquitous role of the federal government as the major sponsor of research and purchaser of the results, as well as the effects of intercorporation or intergovernment competition on the individuals who must live with it.

Transportation Stories. Innovations in transportation technologies are present in nearly all speculative stories. In extrapolative fiction, the trick is to develop alternatives that might be implemented within a fairly short timespan (remembering that it takes about thirty years for a highway to be built). The other trick is to consider not only the immediate effects of the transportation technology, but also the secondary, tertiary, and seemingly unrelated effects (e.g., the effect of the automobile on American social and sexual mores).

The stories published between 1940 and 1975 and focusing on transportation innovations to occur before the 1980s are, then, particularly constrained. They include: "Historical Note" by Murray Leinster (1951), Robert Heinlein's "The Roads Must Roll" (1946), and the novel Under Pressure by Frank Herbert (1956).

The lightly farcical "Historical Note" illustrates
these constraints. Written in 1951, when the Cold
War was beginning to be institutionalized in this country,
and before the Berlin Wall was built, in many ways, the
story describes the various behaviors that led to the
building of the Wall—even as it shows how the Wall could be
rendered useless. The process Leinster describes whereby
the fliers move from being military tools to unique and
expensive toys to the mainstay of a redefined cultural
pattern parallels that of a number of similar innovations.
Among these are: television in the fifties, stereos in the
sixties, calculators in the seventies, and (apparently)
microcomputers in the eighties. In all of these cases, a
technology that was introduced with an apparently limited
usefulness and market, became, for a number of reasons,
incredibly popular. Each was used for a substantially
broader range of activities than expected, and led to the
creation of a whole new subculture within the larger society
around those uses. Meanwhile, each technology affected
numerous unforeseen aspects of everyone else's life, in much
the same way as Leinster has illustrated.

Herbert wrote Under Pressure (1956) in the early years
of the Cold War, when limited nuclear war still seemed
possible and ongoing hostilities between East and West
seemed inevitable. With this story, he extrapolated then-
current political and environmental trends and used a number
of not-yet-existent technologies to create the setting for

this examination of human actions and responses under over-whelmingly stressful conditions.

These stories present a number of themes that have emerged as issues in this country since the stories' publication. These issues include:

(from "Historical Note")

1. new technologies assumed and developed by the military

2. the tendency of governments to adopt new technologies without considering the full range of consequences

3. the degree to which our lives and social systems are determined by our transportation technologies

4. scientists as a national resource, to be protected from other nations

5. the role of the free market in establishing an innovation.

(from "The Roads Must Roll")

1. development of strip cities along transportation corridors

2. service requirements for complex transportation systems and the subculture growing around it

3. unionization of critical or public service personnel

4. supporting roles of women in a men's lives

5. the stress associated with too much power and responsibility

6. the need for careful testing and monitoring of key personnel.

(from Under Pressure)

1. the relative powerlessness of a junior officer in the military--and of his wife

2. the need for formal power structures in the larger
society and for informal ones in small working
groups

3. the need for some spiritual base under stressful
conditions

4. the high level of stress associated with working
under water and around radioactives

5. the effects of secrecy on individuals and their
relationships

6. the power of security forces.

Most of these themes have been discussed above, in the
analyses of the other groups of works. Two remain to be
considered: the transportation subculture of "Roads," and
the relative powerlessness of junior officers in the
military hierarchy. The theme central to "Roads" is the
highly structured service system needed to maintain a
complex transportation system and the tendency for a
subculture to form around that system. Perhaps the most
obvious example of this phenomenon in this country today is
the "trucker" culture that has grown up on the Interstate
freeway system. These drivers and their service providers
now handle a substantial portion of the goods hauled between
cities in the United States. Like Heinlein's Road Crews,
they have their own dress code, jargon, communication and
maintenance technologies, and social structures. What's
more, as is the case with Heinlein's crew, only those who
have been brought up in the culture are really a part of it.
The result is a striking parallel between life on freeway
strip cities and on Heinlein's Road Cities. The theme of a
junior officer's relative powerlessness is so fundamental to

the military organization as to make it unlikely to emerge as an issue in our society in the near future, given the maintenance of the military tradition.

The three stories presented here deal with three very different forms of transportation: air, land, and submarine. They also focus on very different levels of concern: the global effects of individual transporters, the social structures evolving around fixed-surface transport-ation systems, and the adaptation of individuals to a high-pressure, manmade, enclosed environment. All three stories raise issues concerning the relationship between designed transportation systems and social systems. All of them present hierarchical organizational structures and show how informal structures evolve within them. Finally, all portray women as supportive of men (who are the actors in these stories) and as putting up with the consequences of men's actions.

In each of the sets of stories studied, the idea-gem being presented was the answer to a "what if . . . ?" question. In the nuclear power stories, the authors explored the possible consequences of installing and operating nuclear power plants. In the transportation stories, they explored alternative systems and the possible effects their alternat-ives might have on the culture. In the research and development stories, they examined the process of research in a changing organizational context. Many of the themes these authors have developed have emerged

as issues in the popular literature in the years following their publication. Some stories have been almost predictive. In this analysis, all of the stories examined have been shown to have provided insights into characteristics of specific innovations and their consequences that would be relevant to decisionmakers concerned with popular responses to those innovations.

COMPARISON OF SPECIFIC IMPACTS DESCRIBED

The next level of detail in these analyses is an individual comparison of EF stories and IA reports that describe one particular technology. This section describes a comparison of the sets of EF stories focusing on transportation innovations and nuclear power plants analysed in the preceding section with historically significant IA reports describing the same technologies. For both the reports and the stories, the individual works were analyzed and the impacts described were listed. Then the two sets of results were compared and discussed.

Transportation Systems

Two type of transportation systems were described by the EF stories summarized in Chapter III. Heinlein's "The Roads Must Roll" (1942; in Heinlein, 1980) focused on highspeed automated conveyer systems, running between major cities. Herbert's Under Pressure (1956) focused on small-scale submarines as underwater tugs. Other stories have focused on these themes, as well. Harlan Ellison describes

the role of conveyer-belt transportation system in an highly
mechanized society in "Repent Harlequin! Said the Ticktock-
man" (1968; in Greenberg and Warrick, 1974). Arthur C.
Clarke describes the use of small submarines as "scout-subs"
for whale herders in his The Deep Range (1957). These four
stories are compared here to TAs of transportation techno-
logies prepared for the federal government in the late
1970s.

IA Reports: Transportation. A technology assessment
of "future intercity transport-ation systems" through A.D.
2025 was prepared for the National Aeronautics and Space
Administration and the U.S. Department of Transportation in
1976 by the consulting firm of Peat, Marwick, Mitchell and
Co.. This assessment consisted of four volumes, the fourth
of which presents background (context) and transportation
scenarios and presents the impacts derived from those
scenarios. In the assessment four types of transportation
systems are described: air systems, including conventional
aircraft, SST, airbus, short runway aircraft, short-haul
services, and air traffic control; rail/fixed guideway
systems, including AMTRAK service (improved or curtailed),
improved passenger trains (IPT), and tracked levitated
vehicle systems; bus systems, including improved service
(cost/speed/comfort) and small vans; automotive systems,
including improved fuel efficiency, higher speed service,
and electric-powered vehicles. Neither automated conveyer
systems nor marine systems were considered in this IA report

as being of interest to national intercity transportation
policies. However, the report did point out that improved
speeds, convenience, and efficiency along high-density
traffic corridors--such as those created by freeways or
passenger trains--would increase traffic in those corridors
by about forty per cent (Peat, Marwick and Mitchell, 1976).

About the time that Peat and Co. were completing their
report, SRI International began work on "Transportation in
America's Future" (1977).* This report includes reference
to the "widely accepted" understanding that "improvements in
personal mobility lead to greater freedom of choice for
living and working arrangements" (pointing out that Lewis
Mumford (1958) was one of very few who accepted this postion
even in the late 1950s), and suggested a constant commuter
travel time of 1.1 hours as the critical boundary on that
development (SRI, 1977). The report also points out that
high travel costs tend to reduce commuting to the urban core
and encourage job-seeking in suburban areas.

The SRI report describes technologies for A.D. 2025 in
the areas listed in Table XVII. Included in the innovative
urban systems, Accelerated Pedestrian Conveyers are the same
general technology as Heinlein and Ellison have described.
SRI's conveyer ranges in speed from 4.5 to 9 miles per hour,
most often built in elevated and underground structures.
The impacts projected for the conveyers they describe are

*Further references to this report and some description
of the methodology employed are included in Chapter V,
following.

limited, due to their small scale and limited application:
downtown cores, shopping centers, and airports. These
impacts include:

1. low labor costs for operating them due to
   automation and continuous process operations

2. possible high maintenance costs

3. low capital costs for small structures, partially
   offset by co-construction activities

4. reduced land requirements and fuel consumption
   for transportation in the downtown core

5. increased attraction to the core because of the
   innovative systems

6. possible longterm effects on urban renewal and
   new community designs--similar to the elevator's

These impacts provide some indication of the extent to which
the SRI team saw the technology advancing in the next fifty
years.

The SRI study also describes submarines, largescale,
for carrying bulk liquid or slurry cargo. The report
suggests that such subs would be designed to offload at mid-
ocean and offshore mining, manufacturing, and energy
stations, due to the difficulties of surface loading.
Larger submarines are expected in SRI's "success" future
(with rapid technological and economic growth), and medium-
sized ones are expected in less affluent circumstances.

EF Stories: Automated Roadways. In comparing
Heinlein's "Roads" to IA reports, two major points are worth
noting. First, the kinds of problems associated with heavy
commuter traffic (e.g., strip cities, rush hour peak loads)
are, in fact, major problems of concern to transportation

TABLE XVII

TRANSPORTATION TECHNOLOGIES DESCRIBED IN THE SRI REPORT*

SYSTEM	TYPE
AIR	VTOL/STOL aircraft, all-cargo aircraft, and improvements in design, materials and production, avionics, airtraffic control, and airports;
SHIPPING	submarines (bulk carriers), bulk cargo vessels, barges, small supply craft, tugs, air cushion vehicles, hydrofoils, and changes in power plants, navigation systems, construction materials, and ports;
PIPELINES AND TUNNELS	undersea, slurry, and recycling pipelines, and tunnel construction methods;
RAILROADS	tracks, control systems, yards, cars and loading, new systems (e.g.,levitated), and motive power (electrical, deisel, nuclear);
AUTOMOBILES	speeds, power plants, emissions, and parking;
INNOVATIVE URBAN SYSTEMS	urban rail, commuter rail, automated guideway transit, charter buses, auto rentals;
PARATRANSIT	limousines, taxis, jitneys, pooling and cooperatives, and hitchiking;

* Stanford Research Institute (1977)

and landuse planners today, even though, as the SRI report pointed out (SRI, 1978), few people saw the potential as late as the 1950s. This concern is expressed in the Peat and Co. study in their description of "High Density Travel Corridors," specifically including Chicago-St. Louis, Portland-Seattle, and Boston-Washington (1976). Several analyses of highway design and EISs for highway improvements have raised these issues, as well (e.g., Federal Highway Administration, 1974). Both of the assessments agree with Heinlein that a highly successful "work in the city--live in the country" economy, with extensive available energy is at once necessary to maintain such corridors and is encouraged by them.

The second major consideration is the fact that, while the SRI study limits their assessment to the type of "slidewalks" used in airports today, and the Peat and Co. study ignores them completely, Heinlein is talking about massive, highspeed belts. Heinlein's "Roads" are far more like freeways than "slidewalks", offering gradated speeds from twenty to one hundred miles per hour, and including restaurants and other services on the belts. This difference in scale suggests that a comparison to the impacts (already felt)* of freeways may be in some respects more appropriate than to the impacts of APCs. However, a major point of the story is that the "roads" are vulnerable,

*Such a comparison is made in the Retrospective Thematic Analysis section, pp 113-151.

and that an operator strike in such a centralized system can cripple large sections of the economy--as well as cause great harm to life and property--necessitating a special, paramilitary, training program for such operators and their managers.

Ellison's automated roadways (1968) are part of a society which is ruled by the clock, and the steady, standardized pace of the roadways ensures that everybody gets to his or her appointed place at precisely the proper moment. In the story, the protagonist dresses up as a clown (Harlequin) and dumps a ton or so of jelly beans on a central intersection, causing the roadways to stop and a large number of people to be considerably delayed. Since the roadways are more like SRIs APCs than Heinlein's "roads", few people are injured, but still, the economy suffers from the ripple effect. In addition to offering some biting commentary on certain social trends, this story, like Heinlein's, points out the relative vulnerability of such a transportation system and the broad impacts a breakdown can have.

IA Reports and EF Stories: Automated Roadways. Table XVIII lists the impacts of automated roadways as described by the Peat and Co. report (1976) the SRI report (1977), Heinlein's "Roads" (1942) and Ellison's "Harlequin" (1968). Both the IA reports and the EF stories studied talked about the relationship between commuter transportation systems and the development of High Density Traffic Corridors. Both

TABLE XVIII

COMPARISON OF IMPACTS DESCRIBED IN EF STORIES AND IA

REPORTS: AUTOMATED ROADWAYS

EF Stories*	IA Reports**
High Density Traffic Corridors	High Density Traffic Corridors
Energy Usage	Energy Usage
"work in the city-- live in the country"	"work in the city-- live in the country"
increased use with increased speed, efficiency, convenience	increased use with increased speed, efficiency, convenience
system-oriented merchandizing, restaurants	comparative labor costs for operation and maintenance
crippling effects of strikes by service or operator crew	comparative labor use for operation and maintenance
disastrous effects of accidents	possible increased attraction to downtown core
need for special training and "socialization"	
role of men as actors, women as supportive of men	

*Heinlein (1946), Ellison (1968)
**Peat, Marwick, Mitchell, and Co. (1976), SRI (1977)

talked about the high energy usage associated with moving such masses of people and the need for an economy whose production level could sustain that usage. Both also talked about the increased use of such systems as their speed, efficiency, and convenience increases. The IA reports also discussed the comparative labor usage and costs associated with the APCs and the possible increased attraction for the downtown core, should such systems be placed there.

The EF stories also described the emergence of system-oriented merchants (i.e., chain restaurants) and a system-oriented subculture centered around the service personnel for the system. They described the crippling effect of operator strikes and accidents, and the need for specialized training and "socialization" for operator personnel. In addition they presented men as the main actors in the system, with women serving and supporting them as secretaries, wives, and waitresses.

EF Stories, Small-scale Submarines. Herbert's Under Pressure (1956) has been summarized in Chapter Three and analyzed in the Retrospective Thematic Analysis, above. The possible use of small subs as underwater tugboats towing bags full of liquid or slurry cargo is the major innovation focus of that novel. Navy-owned and operated subs are used to haul bags full of oil from undersea wells for use in military applications. With four-member crews and nuclear power plants, these subs are designed for relatively short trips of four to six weeks, providing quick and silent

undersea travel when unfettered, and steady hauling power
when loaded down.

Arthur Clarke's The Deep Range (1957) focuses on
mariculture as a potential solution to world food problems.
In the story, whales are herded as a source of protein and
oil. They are systematically bred and slaughtered to
maximize protein production. In addition, they are
protected from marauders such as people on whaling boats,
sharks, and orcas. In order to effectively meet the needs
of the herds, the "whaleboys" ride in one- and two-man subs
that are loaded with highly sophisticated communications
and navigation equipment as well as the various "tools of
the trade" (i.e., tranquilizer harpoons, electrified
harpoons, remote control manipulators, etc.).

In these stories, the impacts described for this
transportation mode are limited to those experienced by the
crews of the subs, their immediate families and their
superiors. These include:

1. high pressure on and corresponding stress for
   operators and crew

2. high correlation with development of undersea
   resource-based technologies (e.g., in mining, food
   production)

3. development of special technologies to support
   the submarines' and crews' needs

4. close relationship with the military

5. redefined conception of oceans by operators

6. special training, psychological preparation for
   operators

7. use limited to professional operators and crew

8. long, often unexpected absences from home for
   operators and crew

9. overlap with space technologies

10. development of system-oriented subcultures

11. modification of bureaucratic structures to
    support the technology.

These impacts overlap considerably with those of the trans-
portation stories; one author is present in both groups and
the writers were in communication with each other periodi-
cally over the years during which the stories were written.
Yet the impacts described for both forms clearly are related
to the technologies which they derive from, suggesting the
possibility that there are some constants in human responses
to system innovations.

IA Reports: Small Subs. Of the two IA reports on
transportation systems, only one mentioned submarine
transport and that was limited to large cargo subs (SRI,
1978). No discussion of the impacts of such a transporta-
tion mode was included in the report. Further, in a
technology assessment of mariculture (Mitre, 1973), no
mention was made of such vehicles in overseeing or managing
the crops. Therefore, no comparison can be made with IA
reports on this subject.

Nuclear Power Plants

The stories analyzed in this section were written in
the years when nuclear power plant technology was in its
infancy. They describe the plants from the point of view of
individuals working in them and as a result, offer a unique,

individual perspective on the problems and potentials of the technology. The IA reports analyzed here were selected as models of the state-of-the-art for the IA process, and because of the important role they played in the decision-making process regarding the implementation of nuclear power plant technologies in this country.

Impacts in IA Reports. Many of the longest and best-known environmental impact statements produced in this country are the results of assessments of nuclear power plants. This section describes a critical environmental assessment and an early (pre-TA legislation) technology assessment, listing the impacts described in them. These two reports were chosen on the grounds that they were, in fact, the critical assessments leading to the current national policy with regard to nuclear power, and that they represent the most complete examples of the state-of-the-art following the period in which the EF stories analyzed were written, thus typifying the results likely to be achieved with any other assessments.

The Seaborg Report. The 1962 decision to implement the commercialization of nuclear power was made pursuant to legislative guidelines set in amendments to the Atomic Energy Act, on the basis of a report from the AEC to President Kennedy (Seaborg, 1962). The President had requested the report from the Director of the Atomic Energy Commission to describe the potential for commercializing

nuclear power. Specifically, he asked the chairman of that
commission to

> identify the objectives, scope, and content of a
> nuclear power development program . . . [to] recom-
> mend appropriate steps to assure the proper timing
> of development and construction . . . [to evaluate]
> the extent to which our nuclear power program will
> further our international objectives in the peace-
> ful uses of atomic energy. (Seaborg, 1962: iii)

In addition, the President called for "realistic forecasts
of the future of economically competitive nuclear power in
this country" (Seaborg, 1962: iii).

The chairman of the AEC at that time, Dr. Glenn T.
Seaborg, replied eight months later with a sixty-seven page
document whose table of contents is listed in Table XIX.
In keeping with the tone of the President's request, Dr.
Seaborg provided information concerning the current status
of electrical power generation and of nuclear power, out-
lined a set of objectives for the immediate, intermediate,
and long-range futures, and briefly described (in less than
ten pages) programs in place to deal with construction
problems, siting problems, waste handling problems, a number
of policy issues concerning the processing and ownership of
nuclear materials, and the expected impacts of nuclear power
on the coal and transportation industries. The report
stated that while there had been some problems in bringing
experimental plants on line, nuclear power was clearly cost-
effective and could bring relatively cheap electricity to
those parts of the country where other fuels were becoming
increasingly expensive.

TABLE XIX

THE SEABORG REPORT: TABLE OF CONTENTS

SOURCE: Seaborg, G.T., "Civilian Nuclear Power, A
Report to the President" Atomic Energy Com-
mission, WAshington ,D.C., 1962.

In the Introduction to the report, Seaborg pointed out that after building six plants,

> sufficient developmental and operational experience has been accumulated to permit a reasonably accurate assessment of future possibilities. Nuclear electric power has been shown to be technically feasible, indeed readily achieved. Power reactors can be reliably and safely operated. However, contrary to eariler optimism, the economic requirements have led to many problems. . . . Attempts to optimize the economics by working at the outer fringes of technical experience, together with the difficulties always experienced in a new and rapidly advancing technology, have led to many disappointments and frustrations. . . . Many construction projects have experienced delays and financial overruns (Seaborg, 1962: 4).

Nonetheless, Seaborg concludes

> Nuclear power is believed to be on the threshold of competitiveness with commercial power for large plants, in areas of the country where fossil fuel costs are high (Seaborg, 1962: 5).

Table XX lists the impacts of nuclear power plants described in the AEC report. Clearly, the focus of concern is at a much higher level of generality than in an environmental assessment for a single plant (as described below), making this report one of the first technology assessments.* That it was the basis for President Kennedy's decision to support a program for commercializing nuclear power in this country makes this report doubly important for consideration here.

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*Even though written before the TA legislation was passed, this is the only published assessment of the technology per se, and was intended to fill the role of a technology assessment--that of informing federal-level decisionmakers concerning the impacts of implementing a nationwide program or policy.

TABLE XX

SUMMARY OF IMPACTS IN THE SEABORG REPORT*

. . . The above projected use of nuclear power would
result in . . . annual savings . . . between
$4 billion and $5 billion . . .

High cost power areas would no longer exist . . .

. . . would add to the health and vigor of our industrial
and general economy . . .

The Technical program would assist the space and military
programs . . .

Our international leadership in the field would be
maintained with benefits to our prestige and
foreign trade . . .

. . . would not burden the transportations system during
national emergencies . . .

*Seaborg (1962)

The Three Mile Island Assessment. In 1976, the Nuclear

Regulatory Commission (NRC) published the final draft of the

Three Mile Island (TMI) environmental impact statement (NRC,

1976). Unlike many of its predecessors (e.g., the report on

the Hudson River plant--14 volumes--or the San Onofre plant

report--7 volumes), this statement was relatively brief

(eleven chapters). Much of the length common in earlier

reports was avoided by effective use of references to

related analyses. In this way the TMI assessment clearly

reflects the growing body of knowledge and expertise about

nuclear power plants and their effects. And, in fact, at

the time of publication, it was considered a "model"

assessment.

Chapter Seven of the TMI IA report deals with the

impacts of postulated accidents at the TMI plant. Table

XXI describes the classes of accidents from which the

accidents whose impacts were analyzed were chosen. Of these

classes, impacts for all but Class Nine were analyzed.

Regarding Class Nine, the report states:

> The postulated occurrences in Class 9 involve
> sequences of successive failures more severe than
> those required to be considered in the design bases
> of protection systems and engineered safety features.
> Their consequences could be severe. However, the
> probability of their occurrence is judged so small
> that their environmental risk is extremely low. (NRC,
> 1976: 7-1).

Such a refusal is not unusual in NRC assessments, and is

permitted by the Code of Federal Regulations (10 CFR, part

51) in a paragraph that describes "negative declarations"

(10 CFR, 51.7). This section requires that the declaration

TABLE XXI

CLASSIFICATION OF POSTULATED ACCIDENTS IN

THE THREE-MILE ISLAND REPORT*

Class	AEC Description	Accident's Example(s)
1	Trivial Incidents	None
2	Small Releases Outside Containment	Spill in Sample Hood
3	Radwaste System Failure	Inadvertent Release of Waste Gas Decay Tank
4	Fission Products to Primary System (BWR)	Not applicable
5	Fission Products to Primary and Secondary Systems (PWR)	One day Operation with Primary System Leak to Reactor Building Normal Operation with Steam Generator - Tube Leak and Release from Condenser
6	Refueling Accidents	Drop of Fuel Assembly or Drop of Heavy Object on Fuel Assembly
7	Spent Fuel Handling Accident	Drop of Fuel Assembly
8	Accident Initiation Events Considered in Design Basis Evaluation in the Safety Analysis Report	Uncompensated Operating Reactivity Changes Startup Accident Rod Withdrawal Accident Moderator Dilution Accident Cold Water Accident Loss of Coolant Flow Accident Stuck-Out, Stuck-In, or Dropped Control Rod Accident Loss of Electric Load Accident Steam Line Failure Steam Line Leakage Steam Generator Tube Failure Rod Ejection Accident Loss of Coolant Accident Waste Gas Tank Rupture
9	Hypothetical Sequences of Failures More Severe Than Class 8.	None

*Nuclear Regulatory Commission (1976)

will state that the Commission has decided not to
prepare an environmental impact statement for the
particular action and that an environmental impact
appraisal setting forth the basis for that deter-
mination is available for public inspection (10 CFR
51.7).

For this report, then, as for many NRC reports, the commis-

sion decided not to describe impacts except for those of

accidents less than Class Nine in intensity, and used their

standard paragraph referring the reader to an appraisal that

explains the minimal probability that such an accident could

occur. As a result, in the Final Draft version of the EIS

that includes comments by reviewers and responses by the pre-

parers, the Department of Interior requested an analysis of

Class Nine accidents, but the NRC staff disagreed--once

again on the grounds that the probability of such an

accident was "acceptably low, and that generic discussion of

these events are adequate" (NRC, 1976: 11-6). Moreover, as

a result of these refusals to perform such an analysis, the

TMI assessment does not include descriptions of the impacts

of an accident such as those described in the stories

describing this technology (i.e.,"Blowups Happen" where over-

stressed operators made errors adjusting coolant valves and

moderators (Heinlein, 1940; 1946), and "Day of the Moron"

where inadequately prepared operators started up the reactor

with fuel "stuck in" and caused it to reach critical mass

(Piper, 1951)) that are analyzed later in this chapter.*

_____

    *"Counterspy," where loss of primary coolant flow was
presented as a way to destroy a nuclear reactor (Edwards,
1953), would be considered a Class Eight accident.

The missing analysis is an especially unfortunate lack in light of the fact that the accident that occurred at Three Mile Island in 1979 was the result of a sequence of failures described by Class Nine, whose environmental risk was deemed "acceptably low" in the IA process and so was not planned for (Nuclear Regulatory Commission, 1979; The President's Commission on Three Mile Island, 1979). In that accident, according to later investigations,

> The plant experienced a total loss of feedwater, initiated by a loss of condensate flow with an almost simultaneous trip of the main turbine. Reactor coolant system (RCS) temperature and pressure increased. The PORV [pilot-operated relief valve] opened as designed . . . The PORV failed to close when its lower set point was reached . . . This failure of the PORV to close when the pressure decreased, followed by early operator action that throttled the flow from the HPI [high pressure intake] pumps, initiated an abnormal sequence of events that led to this severe accident. (President's Commission on Three Mile Island, 1979: 176)

The report goes on to state that

> the absence of this [PORV] signal in the control room added to the confusion of the operators during the TMI-2 accident. . . . The PORV was not classed as a safety-related component . . . There have been 11 failures of PWR [pressurized water reactor] PORVs failing in the open position before TMI-2 . . . The NRC has not highlighted PORV problems as an unresolved safety issue . . . (President's Commission on Three Mile Island, 1979: 209)

During the "confusion in the control room" the operators made three critical errors, one of which has already been alluded to. According to the NRC investigation of the accident,

> At the time of the initiating event, loss of feedwater, both of the auxiliary feedwater trains were valved out of service . . .

> Subsequently the high pressure injection system was
> intermittently operated . . .
> Tripping of reactor coolant pumps during the course of
> the transient, to protect against pump damage due to
> pump vibration, led to fuel damage . . .
> (Nuclear Regulatory Commission, 1979)

Clearly the events at Three Mile Island are precisely of the type described in the nuclear power plant stories, as well as of the Class deemed too unlikely to be included in an IA report.

Table XXII lists the impacts described by these critical, state-of-the-art IA reports. In the area of accidents, the table shows that the TMI assessment described radiation exposures for surrounding populations for four types of accidents. No impacts on personnel were described for the plant's normal operation. Economic impacts included expected annual savings for the nation as a whole from implementing the technology, cost overruns resulting from trying to build the latest (not necessarily proven) designs, and the expectation that discrepencies in the cost of electricity in different areas of the country would be reduced as high-cost areas were provided nuclear power. Impacts on related technologies included assistance for space and military programs, reduced strain on existing transportation systems during national emergencies, and an expectation of no significant effect on coal technologies from the introduction of nuclear fuels (because of expected increases in demand for electricity). Impacts on related corporate or governmental structures and organizations were not described.

TABLE XXII

IMPACTS DESCRIBED IN THE IA REPORTS ON NUCLEAR POWER PLANTS*

Regarding	Impacts
Accidents	Estimated dosage to population in 50-mile limit and at site boundary
	Annual potential radiation exposure from accidents
	Environmental risk from transport accidents
Economics	Attempts to optimize lead to cost over runs
	Annual energy savings
	Elimination of high-cost power areas
Related Technologies	Technical development assists space, military programs
	Few effects on coal technology
	Reduced strain on transport facilities during emergencies

*Seaborg (1962), Nuclear Regulatory Commission (1976)

Impacts in Extrapolative Fiction. Through the 1940s and 1950s, most science fiction writers made use of nuclear technologies in their stories. A few of these writers became fascinated with the technology itself and wrote extrapolative stories exploring the consequences of its largescale implementation. Because they were fiction, these stories had to have two important ingredients: (1) a focus on individual human beings and their responses and (2) a crisis. As a result, the writers who produced the stories were compelled to examine the technology for potential human problems. When they found one (or more) that appealed to their own imaginations and their models of social change processes, they developed stories to present the problem(s). (See Chapter III for further discussion of this production process.)

Three stories, in particular, written in the years 1940-1955, focus on the impacts of nuclear power plant construction and operation and are relevant to any discussion of the consequences of implementing nuclear power-generation technologies.* "Blowups Happen" is the earliest, written by Robert A. Heinlein in 1940 and updated in 1946. The technological description is limited by what was known at the time, but his presentation of the human problems--affecting operator efficiency and policymaking capabilities

*These stories are summarized in Chapter III, and are analyzed in terms of the issues they raise in the preceding section (pp 120-148).

--associated with operating nuclear power plants has been shown (by the experiences at Three Mile Island and of the Washington Public Power Supply System, among others) to be relatively accurate. Its focus is on the individual and organizational consequences of building and operating large-scale nuclear power plants as Heinlein saw them in 1940 and 1946. "The Day of the Moron" was written by H. Beam Piper in 1953, when the United States government was installing some of the first nuclear power plants and the "atoms for peace" movement was emerging. His story, like Heinlein's, deals with the personnel problems in building and operating such a plant and, again, presents the technology as it was understood at the time of his writing, although with an insider's awareness of the potential dangers. "Moron" describes a set of problems stemming from a situation that has since been shown (at Three Mile Island) to be a major source of concern: inadequate training and testing of those whose job it is to work with a highly dangerous and poorly understood technology. Finally, "Counterspy," by K. Edwards (1951), is the third story to be examined here. The focus is a weapons research plant that is only incidentally a power plant, but the story graphically portrays the ways and means terrorists might use to cause a breakdown in the operation of a nuclear reactor.

These three stories explain nuclear power plant technology and raise a number of important issues regarding its implementation. As Table XXIII shows, they portray a set

TABLE XXIII

CONCERNS ABOUT NUCLEAR POWER PLANT TECHNOLOGIES AS DESCRIBED

IN EF STORIES*

-The relative danger of nuclear power plant accidents
(compare to other technologies)

-The special training and character requirements for
nuclear reactor operators

-The role of nuclear power plants in meeting the growing
demand for electricity in this country

-The effects on decisionmaking of the heavy capital
investments required

-The need for decisions concerning the plants that cannot
be made by a Chief Executive Officer in a bureaucracy

-The personal danger for those who work in nuclear power
plants

-The strain on management, operators, and security people
responsible for preventing accidents

-The vulnerability of large, centralized power systems
based on nuclear power plants

-The necessity for heavy security around nuclear reactors

-The potential problems of dealing with unions in critical
work areas

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* Heinlein, 1946; Piper, 1953; Edwards, 1951

of problems and consequences associated with implementing

nuclear power-generation technologies that have emerged as

important to decision-makers concerned with the impacts of

such plants on our society and its environment. However, as

was made clear in the discussion of impacts described in

assessments, these concerns were not included in some of the

critical IA reports on nuclear power that were produced in

the period following the publication of these stories.*

Comparison of Impacts. Clearly, there are substantial

differences between the types of impacts described in the EF

stories and those described in the IA reports. Table XXIV

presents those differences. Both the AEC (Seaborg) and the

NRC reports have followed the pattern identified in the

statistical content analysis (pp. 101-112). They have

emphasized quantitative ecological, economic, and demo-

graphic impacts, while ignoring the personal and

institutional impacts resulting from the implementation of

the innovation. The EF stories have similarly followed the

pattern of the stories analyzed in that section, identifying

a broader range of possible impacts and emphasizing social

and quality-of-life factors such as emotional well-being and

personnel management problems.

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*It is worth noting here that an IA report prepared by
the Office of Technology Assessment (1983), did describe the
effects of detonating a nuclear weapon in a U.S. city.
Although this report provided the impetus for the highly
controversial television film "The Day After" (American
Broadcasting Corporation, 1983), it still does not deal with
the human concerns associated with nuclear power plants.

TABLE XXIV

COMPARISON OF IMPACTS DESCRIBED IN IA REPORTS

AND EF STORIES: NUCLEAR POWER PLANTS

Regarding	Fiction	Assessments
INDIVIDUALS AND GROUPS		
- Accidents	No electrical power for large segments of the country	Estimated fraction of 10 CFR Part 20 limit at site boundary of .001 to 1.2
	Many people injured or killed	Estimated dose to Population in 50-mile radius/man-rem .25 to 1100
		Annual potential radiation exposure from accidents is well within normal variations of background
		Environmental risk from transport accidents: 1 fatal injury in 10; $475 property damage/yr
-Personnel	High stress for operators managers and technical personnel	
	Heavy burden from need for security	
	Need for special training and character in plant workers	
ECONOMICS	Substantial capital investment in plants	Attempts to optimize by working at the technology's edge leads to cost overruns
	Local economy grows around plant workers	Annual savings of $4-5 billion
		High cost power areas no longer exist
RELATED TECHNOLOGIES	New cybernetic controls development	Technical development will assist space and military programs
	Reduced use of coal-fire technologies	No significant effect on coal technologies
	Use of radio-isotopes in medicine, military, transportation	Reduced strain on transportation system during national emergencies
CORPORATE/ GOVERNMENT STRUCTURES	Increased need for security means increased power for security personnel	
	Heavy government involvement and regulation of nuclear power industry	
	Need for decisions that can't be made by a Chief Executive Officer because of redtape and policy overrides	

The results of these comparisons between EF stories and IA reports--especially in light of the results of the analyses described above--demonstrate the complementarity of the two approaches to considering the consequences of innovation and suggest a strong need for some integration of extrapolative fiction into the IA process if all the relevent impacts for a given innovation are to be described by a given impact assessment.

CHAPTER V

USING EXTRAPOLATIVE FICTION IN IMPACT ASSESSMENT

The previous chapters described analyses of both EF
stories and IA reports in terms of their differences and
similarities in content. The results of those chapters
suggest that the use of extrapolative fiction has some
potential utility for assisting decisionmakers considering
the consequences of current actions. This chapter explores
ways that EF stories and IA reports can be combined to
provide a more effective tool for that purpose. The first
sections of this chapter provide a framework for doing so,
building on the results of previous chapters and outlining
an expanded approach to impact assessment that makes such a
synthesis possible. Later sections describe alternative
formats within that approach and provide illustrative
examples of two of the alternatives suggested.

A SYNTHESIZED APPROACH

An approach that combines extrapolative fiction and
impact assessment would include an iterative sequence of
activities based on the steps in Table III (p.32). It would
start with a description of the innovation--technology, dam,
federal land management program, etc.--being studied in the
context of the human--social, techno-economic, and physical

--environment in which it will be placed. That description
may include alternative actions being considered, and would
definitely include an analysis of the implementation
process. In short, this description would provide the
information regarding the innovation on the basis of which
the impact analysis may be developed. It would be followed
by a forecast of the relevant aspects of the innovation. In
an EIS, that might be a description of new construction
techniques as they affect a building project under study.
In a TA, forecasts of related technologies or of expected
changes in the technology being assessed would be described
here--as, for example, the development of graphic terminals
would be an important determinant of the rate and level of
impact of graphics-based production control systems. In a
social impact assessment, both the new techniques for
implementing the innovation and expected changes in related
areas would be included, along with any other expected
changes in the implementation of the innovation for the
period of study.

This process views impact assessment as based on a new
definition of purpose--a driving question that differs from
that driving the current IA process. The history and
criticisms of impact assessment described in Chapter II,
combined with the absence of certain impact areas found in
the statistical content analysis, provide the bases for an
enlarged definition. Rather than asking:

>What are the likely short- and long-term impacts
>of such-and-such an innovation on a society or com-
>munity and its environment ?

the new process asks a new kind of question, tentatively

stated as:

>What are the agencies, actors, and systems which
>will most strongly affect or be affected by this
>innovation and how can the key actors be led to
>understand--ultimately to be able to act on the
>understanding of--the effects?

This question focuses on the individuals and organizations

likely to be involved in the implementation of the

innovation as well as the social, physical, and other

systems and environments.

As a new kind of problem statement this question

requires new kinds of information for its answer--much of it

nonquantifiable. Moreover, the new information would be

gathered and synthesized within a framework designed for a

specific assessment, and new techniques would permit the

synthesis of a gestalt as well as the analysis of the parts.

The resultant product would, in turn, fulfill the objectives

for which impact assessment was originally conceived (as

described in Chapter II).

Collecting Information

An enhanced IA process, asking for new kinds of

information, requires new techniques for collecting that

information. In the traditional IA process, both primary

and secondary sources are used to develop a data base. The

use of questionnaires, hearings, and literature reviews is

traditional, along with numerical indicators from a variety of secondary sources, which are then analysed as data points using quantitative methods. An expanded process uses these, and adds the investigative reporters' sources--interviews, internal documents, and informal communication media--for information that may be useful in conjunction with the results of traditional data manipulation. Moreover, such an approach emphasizes the need for personal, anecdotal information as potential sources for useful insights and intuitively comprehendable images.

It emphasizes as well, the iterative nature of the research and analysis process. The use of a "first-cut," or "scoping," phase is encouraged,* along with the use of EF stories as a way to develop that gestalt. Second and third cycles through the process, again using the models and devices of extrapolative fiction--along with the more traditional analytical techniques--increase the likelihood that the necessary information is included.

Developing Models

In an enhanced IA process, assessors recognize the importance of mental and verbal models as well as dynamic and structural models in assessment methodologies (see

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* In such a phase, the team works through the whole project once quickly to generate a "gestalt"--an intuitive sense of the nature of the system-under-study--before proceeding with the analysis in a more rigourous fashion. Typically, key actors are identified and major issues are defined in the scoping or first-cut analysis. (see Porter et al., 1980; Armstrong and Harman, 1978)

Figure 9). They recognize that clarifying their mental models provides them with (and depends on) an intuitive understanding of the system. This may be generated by a verbal model, and is followed by a verbal model that provides the initial parameters of the study and the system. A structural model at this point may illustrate the elements of the system and their relationships in a simple graphic form. The resulting diagram may be (though not necessarily, depending on the study) translated into a set of equations which may then become one or more dynamic models, describing the relationships between the elements over time. This dynamic model, then, is used along with other kinds of information to form a new set of mental models. Using the new mental model, the assessors then produce new verbal models to communicate their understanding to others.

With this process assessors can address the new objectives. Moving from one modelform to another through the analysis and research, emphasizing the important mental and verbal models, they can begin to deemphasize structural and dynamic models.* Shifting their focus from the tools of assessment to the innovation and its effects, these assessors can identify the strongly affected parties and systems, as well as the key actors and agencies likely to affect the innovation. Then, having done so, they can

*Armstrong and Harman (1978) and Linstone et al. (1978) recommend that structural and dynamic models should play an ancillary role in the assessment process, rather than the central role which they currently play in most assessments.
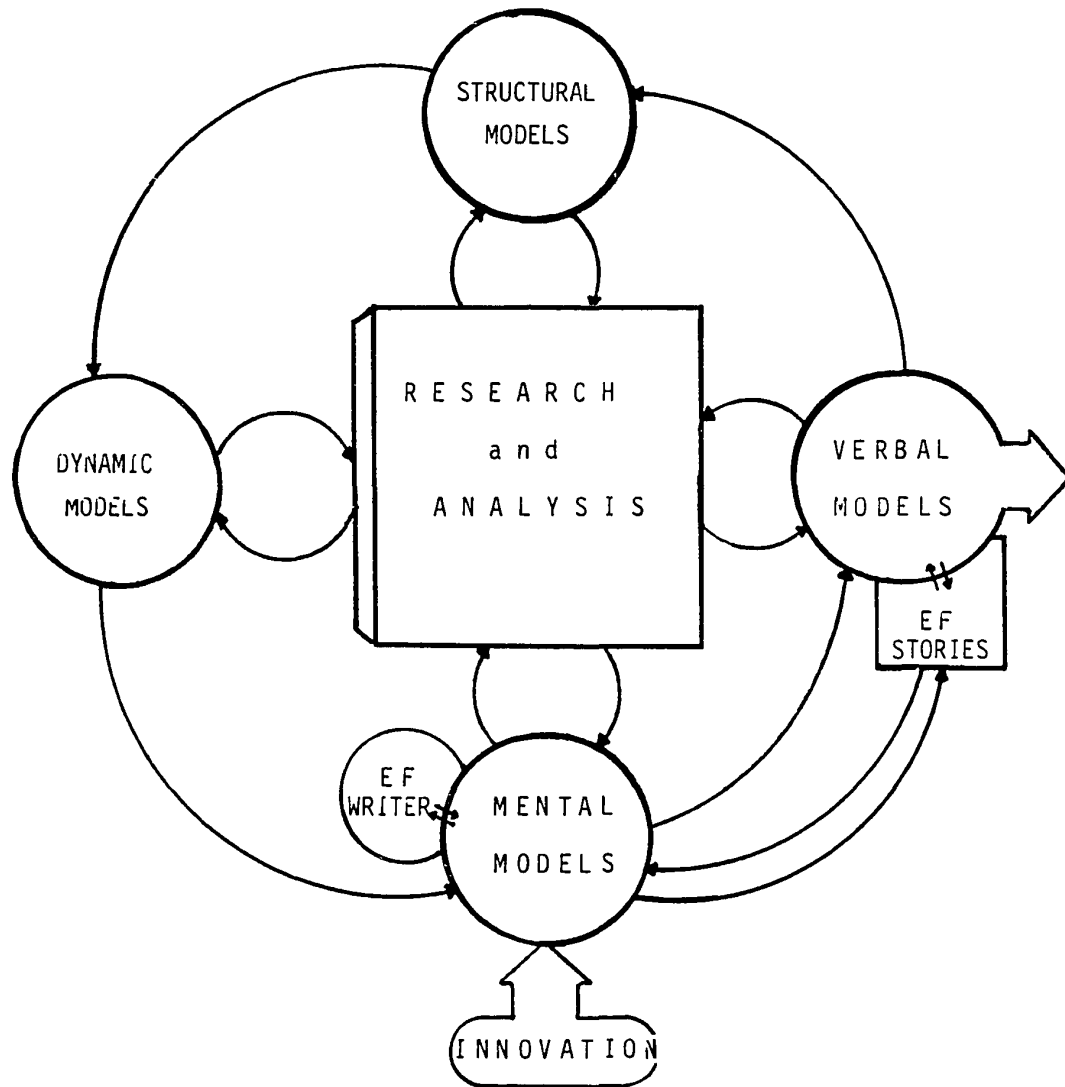
Figure 9.   The pattern of modelforms in
a synthesized approach, with
its emphasis on mental and
verbal models.

address the results of their efforts to the appropriate
audience.

Modeling the system-under-study becomes much more
complex in this enhanced IA process than was apparent in the
traditional process. By consciously including nonquanti-
fiable impacts on the society as a whole, the community, and
other programs within the problem definition, assessors may
no longer rely on structural of dynamic computer models as
the primary method for testing their alternatives. Porter
and his colleagues recognize this when they state that
"common sense, insight, and intuition are still the
assessor's best guides" to developing and describing
possible futures (Porter et al., 1980: 157). The contri-
bution of extrapolative fiction may be most strongly felt in
this activity.

Communicating the Results

This enhanced IA process shifts the focus of assessment
activities toward sharing information about the innovation
with the appropriate actors and away from gathering data and
applying quantitative analytical techniques. Reports of
results are therefore seen as providing decisionmakers with
information that is about the impacts of an innovation on a
community or society and the responses available to them
within the framework of their organizations' policies and
procedures. The report is also seen as communicating a
gestalt of the system--shifting the decisionmaker's image of

the nature of the innovation and its impacts toward a wider, more inclusive view.

The concerns described in Chapter II indicate that this perception of the IA report has not been the norm in the past. Impact assessment traditionally has been seen as a primarily analytical process, assuming that the rigor and scientific objectivity necessary to meet its objectives were possible only by emphasizing the techniques of quantitative analysis. To a large extent this assumption reflects the assumptions of the field's immediate precursors--operations research and systems engineering--and the "technical" perspective (Linstone, 1983) from which practitioners in those fields operate. According to Linstone and his colleagues, this perspective tends to treat all kinds of situations and systems as problems amenable to data-oriented modeling techniques and their inherent reductionism. The characteristics of the technical perspective contribute to an impact assessment methodology in which analysis is emphasized and synthesis is misunderstood or avoided, in which generalizations are sought and idiosyncrasies eliminated, and in which the need for objectivity requires that the human subjectivity of the investigator be (at best) downplayed or (at worst) rationalized away (Linstone, 1983).

However, the users of these assessments must make an intuitively acceptable decision about implementing an innovation. The assessors who wish to have their results used, therefore, "should not only know who the readers are,

but also should estimate what sort of interest and attitudes and how much understanding they will bring" to the presentation (Haemer, 1965: 16). Their report should reflect the fact that their audience--the decisionmakers-- must make judgements, create new alternatives, or at the least understand the nature of the system-under-study based on the material presented. Moreover, the report should assist decisionmakers to make effective use of their intuitive sense--or mental models--in the decisionmaking process, helping them overcome the notion of subject-vs.- object long enough to perceive the system with which they are concerned as part of themselves.

The form in which information about the system is communicated has a substantial effect on decisionmakers' ability to achieve this realization and to change their mental model or image of that system. Kenneth Boulding addresses this problem in his study of communication and mental images (1977). He states, "changes in the image as a result of symbolic intercourse (language) would depend, of course, on the skill of the communicators" as well as the capacity of the medium used (Boulding, 1977:55).

The effective communicator, according to Boulding, is one who chooses to send a message using the particular combination of elements from a common symbol set that the recipient can absorb and respond to with a minimum of filtering and translating. This means that the effective communicator of an innovation's effects must choose from

several types of verbal models, ranging from highly
imagistic poetry, novels, and short stories, through
journalistic reports, to the technical articles and reports
that Root had in mind when he presented the model-forms
described above (p. 196). Each of these verbal models has
its own set of language (i.e., artistic or technical),
guidelines (e.g., structured, verifiable, aesthetically
pleasing), and audiences. Each draws on a rich history and
tradition that tends to dictate the style and perspective of
the author. In general, it may be said that choice of type
"requires identification of the potential assessment users
and of the sorts of information and forms of presentation
they require" (Porter, et al., 1980:400]. If the goal is to
change the image of the decisionmaker so that it includes
the range of effects and options associated with an
innovation, then the model chosen must reflect that goal.

In this synthesized approach, with such goals, the use
of such alternative verbal models such as EF stories and
well-written scenarios becomes increasingly important.
These new verbal models can include both specific individual
and broadscale societal or organizational information about
innovations and their impacts. They provide alternative
images and encouraging an intuitive understanding, thereby
facilitating the decisionmaking process as they report
assessors' results.

Including Extrapolative Fiction
_____

By now it should be clear that meeting the objectives

of impact assessment becomes more likely with an approach

that includes the kinds of models and techniques that make

up extrapolative fiction. The discussion so far does not

explain, however, precisely how such EF models and tech-

niques can be merged effectively with the more formal and

quantitative IA approaches. That question is the focus of

this section. The following pages explore ways and means of

including such models and techniques in the IA process as

currently practiced.

Two basic alternatives for incorporating extrapolative

fiction into an impact assessment methodology are considered

here. In the first alternative, the fiction is appended to

a completed process as a means for illustrating the results.

In the second, the fiction contributes to the research and

analysis process: the assessment team uses already pub-

lished stories that deal with the technology or policy in

question in their research process, or includes one or more

members who can write one or more new stories in conjunction

with an ongoing study.

APPENDING EF STORIES TO IA REPORTS:

ALTERNATIVE FORMATS

At least four interesting possibilities exist for the

use of previously published EF stories in or alongside an IA

report. (1) The report could actually include one or more

short stories as scenarios of possible futures (along the lines suggested by Porter et al., 1980). Or, an anthology could be put together--either (2) in place of the report, but with extensive editorial comments and technical appendices, or (3) along with the report, to exemplify some of the impacts and issues raised in the report. Finally, (4) passages from relevant stories could be included in the report to clarify or demonstrate the extent of specific issues and impacts.

Stories as Scenarios in the Report

One possible outline for including stories as alternative scenarios in an IA report is presented in Table XXV. This outline presents the assessment findings in a brief summary, places the stories early in the report as imagistic models of the results of alternative actions on the part of decisionmakers, and includes the analytical, methodological, and technical support descriptions at the end of the report. In such an outline, the stories serve to provide the reader with clear images of the possible effects of the innovation and of the potential results from the decision options that are available. The more technical material, describing the basis for the stories, are placed after these imagistic summaries in increasingly detailed sections, where they can be used but need not be waded through to discover the meaning of the report.

TABLE XXV

POSSIBLE OUTLINE FOR AN IA REPORT
THAT INCLUDES EF STORIES

Summary of Conclusions, Recommendations

Alternative Scenario #1 ("story title")

Alternative Scenario #2 ("story title")

.

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.

Issues and Policy Options

Summary of Analysis and Results

Methodology

Data Base

Background Paper #1 (detailed report of
    analysis)

Background Paper #2

.

.

.

References

Index

A good index is essential to a report organized in this way, so that information about points raised in the stories and summary material at the beginning can easily be located elsewhere in the text as questions come up or the reader's interest is piqued.

Anthologies

A collection of stories, or anthology, could be organized around themes such as important policy issues, institutional changes, and communities or groups affected, or could be organized by their sequence in time. Such an anthology would include commentary and technical information supporting the issues and policy options, again in a journalistic style to facilitate the reader's understanding of the content. Table XXV provided an example of the table of contents for an anthology of this type, describing life-extending technologies, and Chapter VI includes a detailed description of that anthology.

One tool for structuring a time-based anthology is the Divergence Map, developed by Miller, Schwartz, and their colleagues at the Pacific House (Pacific House, 1972). Figure 10 illustrates this framework, showing the ranks of cells into which stories (or scenarios) may be placed according to whether they are likely to occur "sooner" or "later" or somewhere in between. Table XXVI provides a sample table of contents for an anthology in which short stories and excerpts from novels describing life-extending technologies are clustered into near future, middle-range
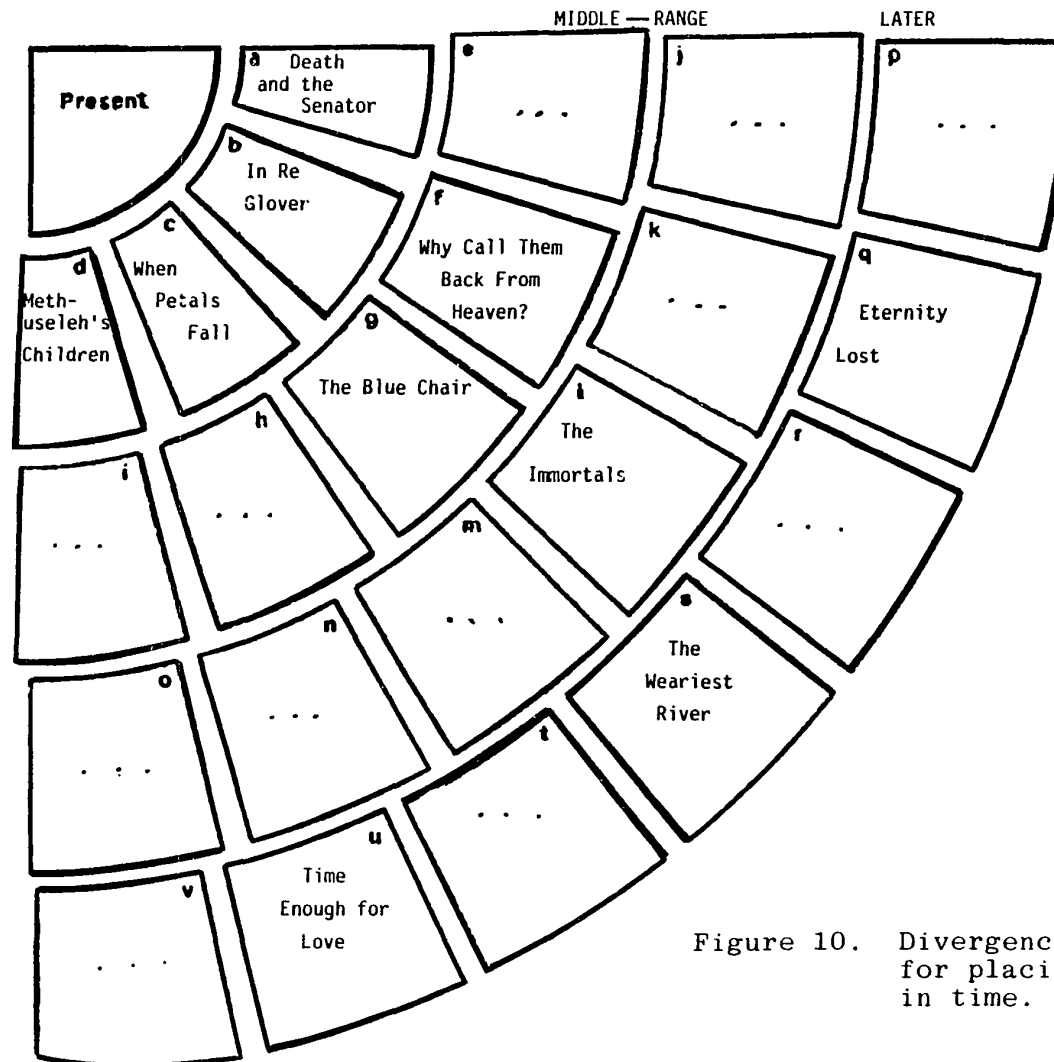
Figure 10.   Divergence map framework
for placing EF stories
in time.

TABLE XXVI

TIME-BASED TABLE OF CONTENTS FOR AN ANTHOLOGY

ON LIFE-EXTENDING TECHNOLOGIES

INTRODUCTION TO LETs

THE NEXT DECADE

Introducing the Technologies
"Death and the Senator" Arthur C. Clarke
"In Re Glover", Leonard Tushnet
"When Petals Fall", Sydney J. van Scyoc
"Methuseleh's Children", Robert Heinlein
Summary of Near-Future Possibilities

THE NEXT CENTURY

Extrapolating the Effects
Why Call Them Back from Heaven?. Clifford Simak
"The Immortals" James Gunn
The Blue Chair, Joyce Thompson
Summary of Mid-future Possibilities

THE FAR FUTURE

"Eternity Lost" Clifford Simak
"The Weariest River" Thomas N. Scortia
Time Enough for Love, Robert Heinlein

Considering LETs and their Implications

AFTERWORD

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future and distant-future sections, according to their position on the "map." Each of these sections would include appropriate editorial comments, using a journalistic style, to describe the technologies being considered in each story and to suggest questions to be kept in mind while reading them.* The comments would also mark divisions between time periods and provide transitions. Then, in conformance with the original design for Divergence Maps, the reader could be asked in an afterword to consider some alternative pathways through the futures described by the stories--choosing an ideal, an expected, and perhaps a to-be-avoided pathway for the society. Readers might also be asked to consider other alternatives suggested but not described by the material in the collection.

Quotes and References

The fourth technique for using pre-published stories is to include passages from such stories in an otherwise technical report. This technique is most appropriate where relevant stories are easily available and the report requirements prohibit the inclusion of whole stories or the relevant stories are either too long to be included or may not be reprinted because copyright releases are unavailable. In such cases, a brief summary, possibly including a passage

*Greenberg and Warrick's Political Science Fiction (1974) provides a useful example of this style of commentary.

or two, can stand in place of the story, with a footnote referring the reader to the story itself as a useful adjunct to the report. The summaries used for the Thematic Analysis section of Chapter IV may be useful examples for this approach.

EXTRAPOLATIVE FICTION IN THE RESEARCH PROCESS

A second alternative for introducing extrapolative fiction into impact assessment is to include the techniques and products of extrapolative fiction in the IA research process. This alternative has the potential for leading to a coherent final product in which the insights to be gained from the fiction are clearly incorporated into the analysis.

There are two main approaches to including extrapolative fiction in the IA process. Team members may read EF stories early on in the research process to provide a gestalt of the system and to raise individual and quality-of-life issues, or they may include a fiction-oriented team member in the IA research activities to introduce EF techniques and ask the questions necessary for fiction's human orientation during the research process. Limitations of this alternative vary with the approach used.

Having team members read selected stories early in the research process can potentially increase communication within the team, across discipline lines. The images in the stories can provide a common basis for discussion outside of the usual disciplinary concerns. More, such a

process can, as does the scoping process (or "first cut" analysis) provide an initial set of options, issues, and impacts to be explored and expanded upon in the IA process.

The results of the comparison of nuclear power stories and IA reports described in the previous chapter are indicative of the effect the use of EF stories as part of the scoping process might have on the assessment of the impacts of those technologies. Both of the reports analyzed in that chapter could be expected to have included a wider range of impacts if the assessment teams had used these stories early in the research process as part of the basis on which they identified significant issues or impact areas to be studied. The teams might have discussed possible personnel problems as well as potential outcomes of highly unlikely but serious accidents that might result from such problems. They might also have considered the issues of control of operation under hazardous conditions, and the effect of the profit motive on the safe design, construction, and operation of such plants.

The systematic use in the IA process of published EF stories that include such issues and impacts could lead to IA reports that reflect consideration of the potential emotion-charged issues that may emerge concerning the technology, as well as the rational expectations of the assessors. Further, such an approach to combining extra-polative fiction and impact assessment would provide an alternative "outsider" perspective on the innovation.

One of the limitations of using stories in the research process is the present lack of topical bibliographies. Most bibliographies of science fiction are listed by author rather than by topic or story-type. Consequently, locating appropriate works may be a tedious process at first.

There are, however, numerous fans and collectors of science fiction who can be approached for references, as well as a fair number of librarians, bookstore keepers, and information specialists who are familiar with such works and would be delighted to search for out-of-print or archival material on topics that interest them. In addition, many "closet" fans are currently associated with futures-oriented research institutions and engineering firms that might be undertaking IA studies. Any of these people would be able to locate works that relate to a given study. In the meantime, Appendix A includes a list of works, by topic, that deal with the time frame and setting required of the IA process and may be a useful starting point.

Including a Fiction-Oriented Team Member

The inclusion of a fiction-oriented team member on the IA team is limited by the skill of the writer, the team's openness to alternative approaches, and the capacity of the subject to capture the writer's imagination and lead to a story which is more than anecdotal material. While a roadway lined with motels may provide the basis for a story, an individual building might not. Robots do; toilets (even

composting ones) generally do not. Destruction and disrup-
tion of communities do; a building on the corner does not
(except when it symbolizes a greater issue, as in Disch's
334, which describes the lives of three generations in a
public housing building). In general, it may be said that
the subject matter has to be something a writer can envision
people experiencing and must hold the potential for
conflict.

Including a fiction-oriented person on the team is
also limited by the acceptance by the team of the fiction-
writer's humanistic--as opposed to analytic--orientation.
Because writers of fiction are concerned with human actions
and human responses to those actions, they will ask new
questions at the level of particulars, rather than at the
general level of statistical analysis which is the norm in
impact assessment. Because fiction writers depend on their
own intuitive understanding and on images of the whole for
their material, they will seem to leap to conclusions before
the rest of the IA team has completed the analysis--which
may cause some friction among team members.

In spite of these potential difficulties, Lipinsky and
his colleagues at the Institute for the Future found
including fiction in their report a useful attention-getter
(Lipinsky, 1978; 1980). They were completing a study of the
potential effects of electronic funds transfer systems for
a large banking corporation. There was some difficulty
communicating, so members of the team finally wrote a report

that was a novel, circulated the manuscript informally, then held the formal briefing as planned. This method was declared effective when the bank executives arrived at the briefing with specific questions--for the first time in the history of the project (Lipinsky, 1980).

In another study, researchers at SRI International's Center for the Study of Social Policy included anecdotal material alongside more formal scenarios in their final report (SRI, 1977). These anecdotal sidebars were developed by the forecasting team (and written by those of its members with aspirations to become authors of fiction) to present aspects of a series of alternative societal contexts in which to embed potential transportation innovations over the next fifty years. The sidebars presenting each alternative societal future described "a day in the life" of characters in each alternative as they moved from place to place using the transportation systems available to them there and then. Figure 11 illustrates the format of that report.

Other possible ways a person with fictive skills could enhance the IA process include the methods described in the previous section for incorporating previously published EF into the assessment. A story could be written (or gleaned from the literature) and used as part of the scoping, or "first-cut," assessment process. A collection of alternative stories could be put together, like those described earlier, by appealing to professional authors (through the science fiction authors' networks and

History and Description

The economic disappointment of the 1980s and
the United States entered the 21st century. The
sabotaged by weather worse than anyone could re
intensified the strains on the American way of
towards codperative attempts to combat agricu
dislocations.

The drift towards cooler and more v
world in full force by the 1990s and co
descended on parts of the world and f
late winter snows, unexpectedly viol
weather patterns were all commonpl
relatively small shift in mean co
cations in crop weather and spre
productive regions.

VIGNETTE

Changing Jobs In Fou

Anne Garrison awoke with a start, shivering
been dreaming of endless expanses of swirling snow
sk... Obscured by distance in the blizzard, great mach
shredding the earth in search of coal. Anne shook her he
was a reflection of her reassignment to the company's Powder
She had to leave soon and began to hurry into her clothes. The
grinned. Today was the day her promotion to maintenance engineer
official. She'd been working for this day ever since she'd returned
from Western Energy's Management Development Program two years earlier.
At Powder River, Anne would be supervising 12 male assistants. On this
day she became the highest ranked woman at Western Energy. She didn't
want to be late for her plane.
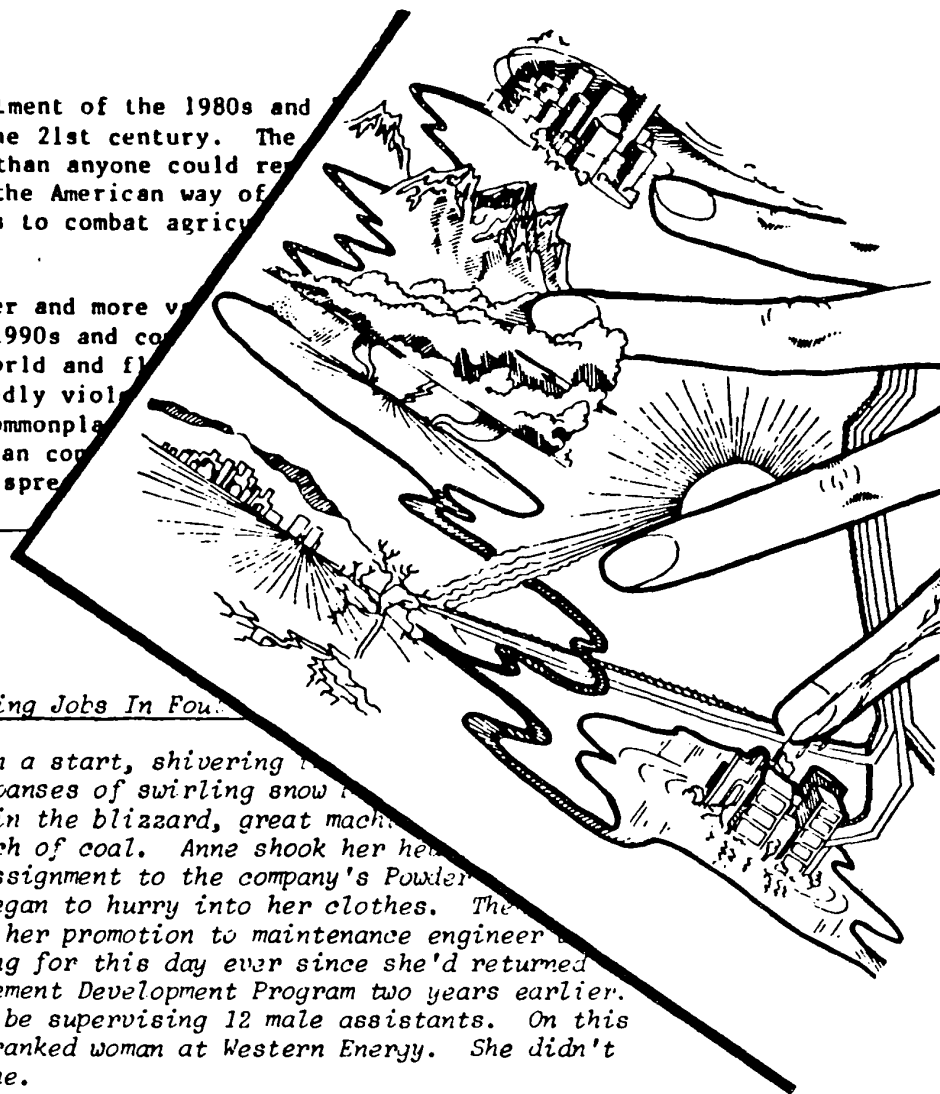
199

publications) to participate in a writers' workshop based on a draft IA report, by asking the team's writer to develop a few sketches, or by having team members cooperatively pull something together (as is typically the case for scenario development and occurred in the Institute for the Future and SRI examples, cited above). Or, as is described in Chapter VI and exemplified in Appendix B, a story could be written to synthesize and illustrate some of the major problems and potentials for the problem under study.

The inclusion of extrapolative fiction in the IA process is clearly a possibility. Further, each of these alternatives has the potential for enhancing the IA process, that is, meeting the objectives of that process more effectively. The task remains, however, to attempt the synthesis.

CHAPTER VI

ILLUSTRATIVE CASE STUDIES

In the preceding chapter a number of alternative formats
were proposed for incorporating extrapolative fiction into
the IA process. The results of the analyses presented in
Chapter IV suggest that each of these has the potential for
improving the process and results of impact assessment by
expanding the types and variety of impacts described in the
final report, but that potential has not yet been tested.
This chapter develops two of the suggested alternatives into
case illustrations of the integration of the two forms to
explore the potential of those alternatives and provide
substantive support for the proposal which this dissertation
presents.

AN ANTHOLOGY DESCRIBING LIFE-EXTENDING TECHNOLOGIES

This section of this chapter explores one of the
alternative formats described in Chapter V: the development
of an anthology of EF stories to go along with an IA report.
The anthology developed here is made up of stories selected
from a number of science fiction journals and anthologies
and of excerpts from various novels. The report that it is
designed to complement was prepared by The Futures Group for
the National Science Foundation (Gordon et al., 1979).

The topic of both the report and the anthology is life-extending technologies. It is a particularly appropriate topic for an example including EF stories in an IA report, since the possibility of immortality has long fascinated artists in our culture and has been an innovation assumed to be part of the ever-closer technological future by a number of authors. The number of EF stories to choose from is relatively large, therefore, and the potential for complementing the report is enhanced.

The Futures Group Assessment

Theodore Gordon and his colleagues at The Futures Group (Glastonbury, Connecticut) received a grant in 1975 from the National Science Foundation to perform a technology assessment of life-extending technologies (LETs). The stated purpose of the study was to

> identify prospects for life extension, a spectrum of impacts which may follow these technologies, and policy options open to public and private decision makers to amend these impacts. (Gordon et al., 1979: xvii)

Specific objectives of the research were

> 1. To identify the potential for and forecast the emergence of life-extending technologies in the next 25 years
>
> 2. To form plausible scenarios from these forecasts that depict not only the sequence of technologies that might be expected but also demographic, economic, political, social, and ethical considerations
>
> 3. . . . to identify the various groups at interest;

4. . . . to identify a spectrum of impacts, both
favorable and unfavorable, which flow logically from
the scenarios

5. To contribute to the methodology of impact
assessment . . . (Gordon et al., 1979: xvii-xviii).

These objectives are similar to those described in Chapter

II for impact assessment (pp.42), except for the lack of a

discussion of the impacts on the physical and natural

environment.

Gordon and his colleagues began their study with a

Delphi questionnaire designed to establish the experts'

opinions and forecasts for the development of a range of

LETs.* The individual technologies identified from the

questionnaires were then clustered into two groups: life-

span-extending and curve-squaring technologies. The first

group, the span-extending techniques, are those which

increase the number of years a person might hope to live,

while curve-squaring** techniques increase the likelihood

for an individual to reach the expected age at death for the

population as a whole.

Dynamic computer simulation models used population data

collected for 1900-1975 and projected the survival curve of

the population to the year 2100 based on scenarios

---

*The Delphi Method involves a series of questionnaires
sent to a group of experts, analysed, then sent again until
some consensus is reached. M. Turoff and H. Linstone
describe its appplication in The Delphi Method, 1975.

** These techniques are called "curve-squaring" because
they squared-off the peak of the graph showing age at death
for the population.

portraying the estimated effects of different combinations of LETs and of expected work- and consumption-oriented behaviors on the part of the population (Gordon et al., 1979). These scenarios assume a range of possibilities, from no change in life span or use of life-extending technologies, to a doubled expectancy with square-curving due to the use of disease control, artificial organs, organ anti-aging techniques, genetic and cellular anti-aging techniques, and the "cure" of senile dementia.

The demographic scenarios which resulted from the models were then used to compute impacts on the labor force and the economy. These impacts were used in turn, along with interview results, as the basis for computing impacts on social security, pension funds, insurance, and healthcare costs. The initial impacts were also used to identify social impacts and as the basis for a discussion of values and LETs.

Results of the Futures Group study were documented in a seven-volume report of which six volumes are divided into topical areas--e.g., Social Aspects, Demographic and Economic Aspects, and so on--and one is a summary of the others. The following paragraphs summarize the impacts described in those volumes according to the structure of that report.

Economic and Demographic Impacts

Most of the impacts described in this study were
developed, in part, on the basis of the economic and
demographic impacts projected by computer models developed
at The Futures Group. In the summary volume of their
report, Gordon et al. describe the demographic impacts in
considerable detail (in twenty-six pages of graphs, tables,
and text). Economic impacts are described in similar detail
(twenty-one pages of text and supporting graphics). Of the
seven volumes in the full report, the fourth volume
describes the demographic and economic impacts and the
models used to generate them.

These impacts consist primarily of projections of
population and labor force structures, based on the seven
technology combinations and possible shifts in retirement
age. They indicate that the size of the population in A.D.
2000 would range from 267 million to 275 million, with a
labor force ranging from 123 million to 135 million and an
average age of from 34.5 years to 36.5 years, depending on
the combination implemented. Similar results are shown for
the year A.D. 2025--though the population is larger and its
members older--and both sets are summarized in Table XXVII.

In addition, Gordon and his colleagues considered the
effects of LETs on the insurance industry, listing the
expected impacts of LETs on pensions and social security,
life insurance, and health insurance, respectively. These
lists reflect not only the high level of uncertainty

TABLE XXVII

SUMMARY OF ECONOMIC AND DEMOGRAPHIC IMPACTS OF LETs
AS DESCRIBED IN THE FUTURES GROUP STUDY

Scenario	Labor Force[a]		Consumers[a]		Population[a]		Average Age		Over 65	
	2000	2025	2000	2025	2000	2025	2000	2025	2000	2025
Normal Aging	123	138-150	225	275	275	328	34.5	36.3	12%	14%
Curve-Squaring			220	265	267	325	36.5	42	14	22
same retirement	"	"			267	325	36.5	42	14	22
delayed ret.	135	185								
Squared & extended			225	275	267	325	36.5	42	14	22
same retirement	123	138-150								
delayed	135	185								
Doubled (no Curve-squaring)	123	138-150	220	265	275	328	34.5	36.3	12	14
delayed retirement	135	185								

SOURCE: Gordon, T. et al., Life Extending Technologies; A Technology Assessment, Report
to the National Science Foundation, 1977, Summary volume by Pergamon, 1979.

a. expressed in millions.

associated with LETs at the time of reporting, but also the effects of such technologies on the earning capacity, healthcare needs, and support requirements of a population with a substantially increased number of senior citizens.

Social Impacts

Social impacts were identified in a symposium held by the American Council of Life Insurance and in interviews with sociologists and social gerontologists (referred to in the study as "interest group panelists"). Both groups were asked to review a prepared taxonomy of possible social impacts, to add other impacts to that taxonomy, and to assess "which of these they felt were most significant in terms of the degree of change they would bring to society" (Gordon et al., 1980: 159). The resulting social impacts are described in four pages of text in the summary volume, the bulk of which deals with the social security system and pension plans. In the full study, Volume Three includes both the description of the current state-of-society with regard to the elderly and the forecasted social impacts. The primary impacts are summarized as follows:

1. The aged will have more political clout, but will probably remain divided along traditional political lines and hold a variety of points of view

2. The nuclear family will continue to decline in importance, with institutions taking over more child-raising functions--but surrogate families for "orphaned" elderly may increase

3. Intergenerational marriages will increase, as will intergenerational tensions

4. New communications technologies will make mass entertainment, education, and information available to the homebound or bedridden

5. The extended, multigenerational family will be reinvigorated. (Gordon et al., 1979: 20)

In addition, the research team identified the following

potential impacts:

1. LETs will cause shifts in definition of retirement age from a specific age to capacity for work.

2. LETs will mean more consumers with fewer incentives for saving for old age and more need for social services such as housing support, healthcare, and entertainment

3. Lifelong learning may or may not become the norm with LETs, depending on the types of LETs and the capacity for educational institutions to change

4. LETs may lead to a decline in emphasis on the child-parent dependency relationship

5. Mass-entertainment media and special entertainment packages may play an important role in helping the elderly wile away the time

6. Crimes that target the elderly may increase as more people become vulnerable (through increasing life span or expectancy) or may decrease if LETs enhance the vigor and alertness of older people

7. LETs may become the scapegoat, blamed for a variety of changes that may have occurred regardless of their use.

The apparent contradictions between the first (the aged have

political clout) and last (LETs become the scapegoat) of

the primary social impacts and the uncertainty expressed

in some of the impacts listed in this latter group are

indicative of the lack of knowledge and high degree of

uncertainty associated with the development pattern of life-

extending technologies at this time.

Values Impacts

A series of essays, presented in Chapter Seven of the
summary volume and Volume Six of the full report, deal with
the values questions associated with LETs. The essays,
prepared by the Institute of Society, Ethics, and the Life
Sciences, point out some of the differences between the two
main forms of LETs: curve-squaring having generally less
effect on values than span-extending technologies. The
potential impacts on values resulting from the use of LETs,
which analysis of the essays suggest that the authors have
assumed, are summarized below.

> 1. Lifespan extension would delay the debilitating
> effects of aging without eliminating them and so would
> encourage the current attitude that aging is not a
> disease
>
> 2. The development of specific ways of life to minimize
> the physical debilitation associated with aging would
> encourage an attitude that those who age
> involuntarily are diseased while those who choose not
> to live in those ways are deemed irrational
>
> 3. New understandings of the aging process may radically
> change current attitudes regarding privileges,
> rights, benefits, and status accorded those who
> exhibit symptoms of aging
>
> 4. Advances in understandings and technologies would
> continue to challenge conceptions of the nature of
> humanness
>
> 5. Increases in life expectancy would have little effect
> on the family, but increases in lifespan would
> hasten the deterioration of the extended family,
> incurring resistance to LETs by certain cultural and
> religious groups
>
> 6. Increased expectancy means increased likelihood that
> one will live into the retirement years, and could
> increase the attention devote
> ndertaken beyond the "productive" years; extended
> lifespans may lead to an increased value on

schooling, skill development, second careers, and sabbaticals

7. Use of prosthetic devices may change concepts of the body and of wholeness or integrity

8. If LETs are scarce or are distributed unevenly, there is the possibility of social upheaval

9. If LETs must be purchased by coercive controls on fertility, lifestyle choices, or pollution levels, concepts of personal freedom may be radically altered

10. If LETs depend on actions taken during childhood years, then current attitudes regarding the freedom of parents or doctors to "decide what's best" will shift

11. LETs will have an effect on assumptions about knowledge, with curve-squaring technologies decreasing uncertainty about one's personal future (as one is more certain about the likely time of death), and span-extending technologies increasing uncertainty about appropriate allocation of resources

12. Some LETs will have impacts on assumptions of rights and responsibilities regarding suicide, euthanasia, the right to refuse treatment, and decisions about required vs. expendable care.

These potential values impacts, gleaned from the set of essays in the Futures Group study, raise some fascinating policy questions.

Policy Issues

The policy issues identified in the Futures Group IA report are summarized in the following list:

1. whether programs designed to implement life extension should encompass attitudes and perceptions about old people as well as biomedical components

2. whether alternative policies concerning resource allocations for such programs should be seen as strictly competitive or whether policies should be

favored which contribute to the achievement of the
goals of other policies as well

3. the level of support for basic research, for
facilities, and for training good, young, biomedical
researchers;

4. the division of responsibility among agencies with
programs related to life extension;

5. the need to confront emotional reactions to aging
control and rejuvenation technologies;

6. the presence in our society of values regarding
death which may undermine interest in life extension;

7. whether LETs will increase or decrease the quality
of life or whether they will simply lengthen
existence

8. the rights, privileges, benefits, and status of the
aged

9. the relative importance of our obligations to
future generations, especially in terms of resources

10. how to distribute LETs, especially if they are
scarce or if people feel entitled to them.

These issues are presented in the Summary volume of the

report (Gordon et al., 1979: 22-33). Although they are not

discussed at length in this impact assessment, these issues

do provide the basis for a set of recommendations which are

also listed in the Summary volume. These recommendations

include suggestions for government-sponsored studies on:

retirement age (with regard to the nature of work and the

ratio of dependents to producers in our economy), inter-

national impacts, and the secondary costs involved with

producing and distributing LETs.

Clearly, many of the issues raised in the report are

not dealt with in the analysis of impacts or in the recom-

mendations. Some of the issues neglected by Gordon and his colleagues have, however, been considered in the EF stories published on the subject of life extension. A set that focus on the same timespan are summarized below.

An EF Anthology

The EF literature contains a number of short stories and novels that explore the possibilities of extended life spans. Some of these focus on cryogenics and the possibilities and problems associated with suspending the life processes by keeping the body at very low temperatures. Others consider rejuvenation techniques. Still others examine the possibility of genetic selection combined with transplantation. Table XXVIII provides a list of stories dealing with LETs by type of technology.

Many of these stories deal with issues that are raised in the Futures Group assessment described above. The following pages describe a set of stories that might be included in an anthology complementing that assessment. Set within the next several decades, these stories offer glimpses of what it might be like to live with and cope with some of the issues and impacts that Gordon and his colleagues have described.

"Death and the Senator", by Arthur C. Clarke, (in Greenberg and Warrick, 1974) describes an early stage in the process of the development of life extension when a critical operation at a critical point in life can renew vigor and

TABLE XXVIII

EF STORIES DESCRIBING LETs

Technology	EF Story
Cryogenic maintenance of a suspended body	The Door Into Summer, Robert Heinlein
	Why Call Them Back From Heaven? , Clifford D. Simak
	"In Re Glover", Leonard Tushnet
Non-cryogenic maintenance of aged bodies	"When Petals Fall", Sydney J. Van Scyoc
Pills or Treatments at Maturity	"The Immortals", James Gunn
	"Eternity Lost", Clifford Simak
	"The Weariest River", Thomas N. Scortia
	The Blue Chair, Joyce Thompson
Breeding	"Methuselah's Children" Robert Heinlein

restore lost capacities, extending one's productive years
considerably--if one has access to it.

The story opens as the Senator comes to terms with the
fact that he has a terminal condition, one that may not
permit him to live more than another year. His hopes for
the Presidency crushed, he realizes how "much he had missed
. . . in his relentless pursuit of power" (Clarke, in
Greenberg and Warrick, 1974: 160), that even though his
wife and children are lost to him, his grandchildren love
him. He resolves to see them while they still do, canceling
other appointments to make the time.

The conflict is established when the head of NASA shows
him that a technique, developed by Soviet scientists in
their space station, could possibly restore his heart and
save his life. The Senator considers this opportunity--and
the irony that it should only be available from the Soviets,
since he was the one who had--in spite of NASA's attempts to
point out the medical advantages--shut down the U.S. program.
Now only the Soviets had a zero-gravity laboratory in which
to develop the techniques that might prolong his life and
make it possible for him to become the next U.S. Presi-
dent. Moreover, through the very agency the Senator had
cut, the Soviet Space Program Director was offering
those techniques to him.

However, it becomes obvious that only a select few can
be treated in this facility, and that treating him would
mean refusing others. The Senator considers the old problem

of too little good for too many needy. He also considers

his own role in creating the current situation, as the one

who had made an American space hospital impossible, denying

others the help he was now being offered. "Could he accept

the help he had denied to others? Once he might have done

so--but not now" (Clarke, in Greenberg and Warrick, 1974:

166).

Having accepted the reality of his own death, the

Senator has found a new set of values. He refuses for

himself the life-extending technology which he has denied to

other Americans through his actions. He chooses not the

sure nomination for the Presidency, but a few months of love

and peace with his family as the next--and last--phase in

his life, and so illustrates Clarke's point that values and

behaviors are affected by the certainty of death and that

limited availability of technologies will have even greater

effects.

"When Petals Fall," by S. J. Van Scyoc (1973; in Carr,

1980) goes beyond Clarke's focus and addresses the issue of

life-extension versus life-enhancement in the context of the

issue of one generation's responsibility to future

generations.

The protagonist, Kelta West, is a Federal Inspector

responsible for ensuring that the nursing homes in her

district obey regulations and take adequate care of the

"hundreds of thousands" of elderly who

> lay in their cradles swaddled in senility, entubed at
> every orifice, gaping eyes deserted, lax mouths
> wordless, . . . doggedly fighting out the last moments
> of personal existence; blood circulated by machinery,
> minds erased by age, they waited for the miracle that
> could restore them to function, however minimal.
> (Van Scyoc, in Carr, 1980: 117)

Kelta's work is complicated by an organization called the
Messengers who periodically work their way into the homes,
disentube whole wards (holding as many as one hundred
patients) and let them die. Besides being illegal, these
"messengers" raise public awareness of the homes and the
role they play in the society, requiring that the federal
agencies responsible for them deal with the media as well as
the homes' managers.

Her work is also complicated by researchers who need to
experiment on the patients (but can't do so legally) to test
the potential "immortality" drugs which the patients are
waiting for. Discovering that a number of patients have
survived a Messenger's visit because of such research, she
questions the researcher responsible for their survival. He
indicates that he has developed a serum, but that "all it
does is enable the body to survive as a body, not as a
viable personality. . . . They are helpless. Hopeless. But
alive." (Van Scyoc, in Carr, 1980: 126). He requests her
assistance in getting the drug to market. Her response is
unequivocal

> . . . You're not asking just for moral support.
> You're asking for our drinking water, our oxygen, our
> children playing. I say no. You've had your roses,

> Doctor. I hope you enjoyed them. You've had your
> time on Earth too. Now it's our turn. (Van Scyoc, in
> Carr, 1980: 127)

Having made this statement, she delivers an ultimatum: the

researcher and his sponsors can be prosecuted or they can

shut down the project.

In response, they argue that their results will put

public sentiment on their side. Contending that they are

wrong, that the public resents maintaining corpses, the

inspector restates her ultimatum and leaves, to secure the

tape of the conversation, and to use the last of her water

tokens for a shower, hoping that the flowing water can

cleanse her of the whole affair--and the knowledge that she

herself can never have a child in this world of limited

resources, pollution, and a too-rapidly growing population.

As she goes, the inspector reflects on the fact that

changing public sentiment is leading to changed attitudes

about death and, particularly, about euthanasia. So--after

providing glimpses into the nature and scope of the issues

of responsibility to future generations, and of life-exten-

sion without life-enhancement--the story closes on the con-

sideration of the definition of rights and responsibilities

regarding euthanasia, and of expendable care.

"In Re Glover," by Leonard Tushnet (1968, in Sargent,

1977: 39-48) deals with the legal implications of maintain-

ing the body of a person whose mind is inactive, but who is

not yet dead, to be revived at some future point in time.

The technology in this story is not one considered in the

Futures Group study, but is one being considered today for some terminally-ill patients who have the finances to arrange life extension and the determination to be cured. Based on the principles of cryogenics, this technology involves suspending the body's processes by lowering its temperature and keeping it in cold storage until such time as a breakthrough will permit curing the disease. The process is still experimental, but has been used successfully on a number of mammals, and has captured the imaginations of a number of journalists. It also is a recurrent theme in science fiction.

"In Re Glover" describes the court case surrounding the suspension of life for a very well known and well-to-do entrepreneur with a number of heirs.

> Ralph Glover, the brilliant and dynamic founder of the many-sided business empire bearing his name had died--or had he? If he were dead, his four sons by his first wife and his two daughters by his second (both wives having predeceased him--if that term could be used without prejudice) were due to inherit the entire estate, share and share alike, after a number of relatively minor bequests had been paid; the great Glover Foundation, the internationally known medical research institution, was to get nothing, having been the recipient of munificent gifts during the founder's lifetime; the federal government and the states of residence of the heirs were eagerly anticipating the considerable inheritance taxes. If he were not dead, the trustees of the tax-free Glover Foundation would continue to receive, as they had for five years now, all revenues from the many corporations constituting the Glover enterprizes; the children were to fend for themselves, meaning that the sons and sons-in-law would have to find jobs, and the federal and state governments would have to wait until Glover's actual demise to collect. (Tushnet, 1968, in Sargent, 1977: 43-44)

Court was prepared to take it on, recognizing that the case

> would set landmarks in law, in a new field of law as
> well as in the laws of wills, mortmain, trusts, and
> homicide, with overtones . . . on euthanasia and
> medical and legal malpractice. (Tushnet, 1968, in
> Sargent, 1977: 43)

As the story unfolds, the case is even more complex than it

seems at first glance. It involves more than the question

of what constitutes death. Numerous twists and turns in the

plot and in the relationships between the people involved

carry the reader through the case while the legal issues

involved in this particular form of life extension are made

dramatically clear, along with the issues associated with

current attitudes about death in our society and the effect

of extended lifespans on the family and on retirement.

Why Call Them Back From Heaven?, a novel by Clfford

Simak (1967), focuses on the nature of a life lived in the

expectation that one will get a second chance--that, having

died, one will wake up having had one's body preserved and

treated so that it is now immortal. Simak describes a

number of interesting personal, social, and economic impacts

as resulting from this state of affairs.

For one, people become extremely careful not to be hurt

before they reach the second life:

> A man had to live, this first life, as long as
> he was able. It was the only opportunity he had to
> lay away a competence for his second life. . . .[I]t
> would never do to let a piece of carelessness . . .
> rob him of the years needed to tuck away the capital
> he would need in the life to come. (Simak, 1967: 12-
> 13)

As well, many inconveniences are accepted to "tuck away" the
necessary capital. Simak's protagonist, a public relations
specialist for the organization responsible for maintaining
the bodies--the Forever Center--enters his room after
turning down a large bribe to undermine the Forever Center

> . . . for the first time in his life, the poverty
> and squalor of it struck him across the face.
>   The bed stood in one corner and in another corner a
> time stove and a keeper for his stock of food. A
> mangy carpet, with holes worn here and there made an
> ignoble effort to cover the bareness of the floor. . .
>   This is the way we live, he thought. Not myself
> alone, but many billion others. Not because we want
> to, not because we like it. But because it is a
> wretched way of life we've imposed upon ourselves, a
> meanness and a poverty, a down payment on a second
> life . . . (Simak, 1967: 45)

This effort to minimize current expenditures in order to
maximize later spending capacity is encouraged by the
society and by the Forever Center, who will hold the saved
funds in trust. Yet once the savings are built up, new
problems emerge: people who are not earning money in this
life are spending the capital put away for the next.

> James worked so hard all his life and we scrimped
> and saved. Now that he can't work any more, we have
> time to just sit and take it easy and do a little
> talking and go visiting and such. But we're getting
> behind, financially, every blessed day. We are using
> up the little that we've saved . . . (Simak, 1967: 28)

Not surprisingly, a new counter-culture emerges. Based
on the fundamentalist Christian tradition, these outcasts
are called the Holies. Non-conformists in an age of self-
imposed conformity, they insist on the right to believe in
something beyond physical existence. They preach on street
corners and ask "Why should people . . . believe in anything

at all if they have the legal--not the spiritual mind you,
but the legal--promise of immortality?" (Simak, 1967: 90).
These people, living on the fringes of the culture, maintain
their right to die, and insist on witnessing the Bible and
God's law as expressed therein to everybody in spite of the
police's determined efforts to eliminate them.

Another major impact of this LET is demonstrated when
the protagonist is declared outcast on charges trumped up by
the security chief and leaves the heavily populated coastal
area. He finds vast stretches of land unpopulated and
unfarmed, with houses and barns left empty by people who
have gone to the cities to get jobs to build the capital
necessary for happiness in the second life. With the
majority of people living as close as possible to the
Forever Centers so that their bodies may be immediately
preserved and living on virtually nothing that is not
produced in the cities, farming becomes an antiquated and
useless art.

Finally, Simak raises some interesting issues
concerning the state of the economy. He points out how the
once small, charitable foundation

> . . . had become the biggest thing the world had ever
> known.
>   Big in many ways. Big in the hold it had on the
> public imagination. . . . Big in the participation in
> the program, . . . And, perhaps most important of
> all, big in its assets and investments.
>   For all those millions . . . had left their funds
> in trust with Forever Center. And one day the world
> woke to find that Forever Center was the largest

stockholder of the world and that in many instances
it had gained control of vast industrial complexes.
(Simak, 1967: 47)

Through such characterizations, Simak takes the possibil-

ities and extrapolates them to the point where the absurd

extremes no longer seem quite so absurd.

Issues and Impacts in the EF LET Stories

A number of issues raised in the Futures Group's

assessment are dealt with in these stories. These include:

1. the problems associated with uneven distribution
    of LETs

2. the importance of the multigenerational extended
    family for aging seniors

3. those who choose not to use LETs may be deemed
    irrational by their neighbors

4. the effect of LETs on assumptions about knowledge--
    and the effect of certainty regarding one's time of
    death on one's way of life and values

5. the effect of LETs on assumptions about the right to
    refuse treatment

6. the increased political clout of the aged

7. increased intergenerational tensions

8. the relationship between expectations about old age
    and consumer behaviors

9. the role of entertainment in helping the elderly
    while away the time

10. the blame placed on LETs for negative social or
    environmental changes

11. changes in status and benefits for the aged

12. changes in lifestyles that reduce personal freedoms
    resulting from the desire to purchase LETs

13. the possibility of changes in assumptions regarding
    euthanasia

14. the potential effects of resource allocation patterns for developing LETs

15. whether LETs will increase or decrease the quality of life or whether they will simply lengthen existence.

Through the experiences of people living, working, and dying in a world which includes the possibility of greatly extended lifespans, these four authors present half of the issues and impacts that the Futures Group study have included in their report, in a way that illustrates and clarifies the nature and scope of those effects. They have also presented a number of impacts and issues that were not dealt with in that report. The following list summarizes this latter group:

1. the desire of people who expect to live lengthy lives (or eternal ones) to avoid accidental injury or death

2. the need to avoid spending money while earning if one expects to live a long time with no new source of income

3. the potential for a successful producer or distributor of LETs to become a significant economic--hence political--power, especially if people's life savings are held in trust by that distributor

4. the possibility of significant shifts in population toward medical-technical centers--especially if there is a time factor involved in making LETs work

5. the use of forfeiture of access to LETs as a punishment for offenses against the distributor or the state.

These issues, as well as the impacts leading to and flowing from them, bring the possibility of LETs to a new level of concern and point out possible areas of study for future, more specific impact assessments on the subject.

Excerpts from the stories described in this section, then, could be combined with others to form a topical anthology that provides vicarious experiences and clear images of the consequences associated with the issues and impacts raised in the Futures Group report. Moreover, such an anthology would extend the results of that assessment, offering new insights and possible areas of study for follow-on assessments. Prepared as a companion volume to the Futures Group Summary volume, an anthology including these stories could have introductions and afterwords that related the stories to the material in that volume--might perhaps even be cross-indexed with that volume to ensure maximum utility for decisionmakers.

THE GUAYULE RUBBER STUDIES

This section describes an alternative approach to integrating extrapolative fiction and impact assessment-- that of including a fiction-oriented member on the IA team. In this section the original assessment process is described along with that of a sample synthesis of extrapolative fiction and impact assessment techniques. The synthesis is presented as a summary, a story, and an outline for a full report (these are included as Appendix B to this dissertation). The IA reports described here are concerned with the commercialization of guayule, a desert shrub with a latex-like substance in its cells.

Guayule first became a subject of interest in the United States during World War II when the source of rubber, hevea trees in Southeast Asia, became inaccessible. In 1948, concern about the future of guayule diminished when oil discoveries in the Middle East, combined with U.S. farmers' demands for resumption of their rights to plant other crops on their lands, caused the Department of Agriculture to halt the guayule program. Interest in guayule surfaced again when the OPEC oil embargo of 1973-74 created an awareness of how dependent on outside sources this country had become for many of its basic needs--including oil for synthetic rubber production--and how undependable those sources were. Responding to that interest, the National Academy of Sciences issued a statement that research into the development of guayule as a domestic source of rubber should be supported (National Academy of Sciences, 1977), and Congress passed the Native Latex Act of 1978, establishing the Joint Commission on Guayule Research and Commercialization, co-chaired by the Deputy Secretaries of Agriculture and Commerce.

As one part of the research effort resulting from the commission's work, a technology assessment was funded by the National Science Foundation to identify the impacts of and suggest policy options for the commercialization of guayule. The University of Arizona proposed jointly with the Midwest Research Institute to extend the agronomics research effort already underway at the University into the policy and

business implications of the potential new crop (Foster et
al., 1980a; 1908b).

Shortly after that project was funded, Portland State
University was asked by the National Science Foundation and
agreed to include the Arizona assessment as one which they
would study and expand on as part of a project developing
the multiple perspectives concept (Linstone et al., 1980).
I was part of Dr. Linstone's team and used the results of
both projects to develop the synthesis described in this
chapter.

The University of Arizona Assessment

The first assessment of guayule commercialization was
undertaken by a group of scientists whose primary interest
was in finding a "solution" to the "problem" of how the best
policy alternatives could be isolated and implemented. The
University of Arizona's Office of Arid Lands Studies (U of
A) research team included agronomists, social scientists,
and desert ecologists who were to work with researchers
experienced in policy analysis from the Midwest Research
Institute (MRI) of Kansas City, Missouri, to complete the
study. The two groups divided up the work and proceeded
separately and then together to complete the assessment. An
interim report was published in April, 1980 (Foster et al.,
1980a), with final results released in the summer of that
year (Foster et al., 1980b).

Methodology. The U of A team spent considerable effort analyzing the state-of-the-art for guayule, including developments in agronomic research, the economics of guayule production, and environmental constraints. In the process, they interviewed people from many interest groups in the rubber community and in the southwestern (United States) farming community. Using dynamic and econometric models, they projected rubber demand and supply into the year A.D. 2000, and developed two scenarios--one based on "laissez-faire" policies and the other on "strong federal involvement"--for guayule's development.

These two scenarios were compared in terms of the rubber demand and supply, economics, and environmental constraints which the team had identified. Econometric models were used to provide statistics on needed acreage, seed production, and processing facilities for each scenario. Simple extrapolation techniques were used to scale impacts over time based on these statistics.

Based on their comparison of the two scenarios and the impacts identified for each, the U of A team defined the main goals for commercializing guayule and, with the help of people from MRI, listed what they considered to be the relevant impacts and policy issues. The policy issues identified were classified as "strategic" or "non-strategic" "social," "economic," or "other." Out of this list of policy issues, and based on the team's interviews and experience, the team then identified and listed a set of

policy conflicts, institutional failures, and resolution
mechanisms likely to be encountered in or needed for the
full commercialization of guayule.

Results. The U of A assessment predicted a shortfall
of natural rubber in the United States of from 2.4 to 4.9
million metric tons by A.D. 2000. The team assumed a
doubling of the rubber content of guayule (to twenty per
cent) in five to ten years, a base yield of five hundred
pounds per acre per year, and an available acreage of from
1.5 to 2.0 million acres by the year A.D. 2000. They
pointed out continued rises in the costs of both natural
and synthetic rubbers over recent decades and the current,
depressed state of the rubber industry as factors to be
considered.

Given this context, the U of A team went on to develop
the two scenarios for the development of guayule. According
to Scenario A ("laissez-faire"): 1.5 million acres would be
planted in A.D. 2000 (42% in California, 32% in Texas, 19%
in Arizona, and 6% in New Mexico); and the cost of guayule
would range from $.60 to $1.50 per pound of rubber produced.
In this scenario, then, the United States would meet one
hundred percent of its predicted shortfall of natural rubber
by 1991 (Foster et al., 1980a; 1980b).

In Scenario B, heavy government involvement would
result from a reduction in rubber imports to one-half of
current levels. This crisis situation would increase
federal funding and support for guayule development and lead

to: heavy research and development emphasis, increasing
yield per acre by 73 percent over Scenario A; 2.0 million
acres in production in A.D. 2000, requiring sixteen
processing plants and close to twenty-five million pounds of
seeds; a quasi-governmental corporation coordinating and
managing the program; and half of the natural rubber demand
being met by 1990.

Impacts on the human environment were identified and
evaluated by the team for both scenarios and were seen as
relatively minor. This evaluation was based on the assump-
tions that guayule would replace other crops in water-short
areas rather than be extensively grown on previously uncult-
ivated lands, and that processing plants would be placed in
urban areas. Substantial social impacts--described as
increased employment--were identified for the alternative
assumption of a processing plant located in a more rural,
less populated region.

Policy issues for the "laissez faire' scenario (A)
were found to center around: the scale of production and
the benefits received by interest groups (e.g., rubber
companies, farmers); the different risks and investment
tradeoffs experienced by private developers compared to
government agencies; and the tradeoffs between allocation
and development of various resources (e.g., water for crops
or industry; land for food, fiber, or housing). For the
"heavy federal involvement" scenario (B), conflicts over
international relations, antitrust regulations, and

strategic materials stockpiling policies were expected, in addition to those issues identified in Scenario A (Foster et al., 1980a; 1980b).

Presentation. The U of A study follows the traditional IA report format. The nature of guayule and the state-of-the-art for its development introduce and dominate the body of the written report. The development of the two scenarios--their requirements and the limited potential impacts--follows that section. Discussion of policy issues and options make up a few pages at the end of the report. Tables and graphs are used frequently to supplement the text, often without any explanation tying them into the written report.

In addition to the formal draft and final written reports, the U of A team presented their results at the Third International Guayule Conference and to the annual meetings of the Guayule Rubber Society over the period the study was being conducted. These were formal presentations, making substantial use of tables and graphs reproduced from the written report. The reports were well presented, clearly stating the methods used in the study and the results achieved.

Comments and Concerns. The U of A study has been criticized for its lack of scope and the relative weight placed on the technology compared to the impacts and policy issues in the presentation (Linstone, 1981). When the results were presented at the Third International Guayule

Conference (Taylor, 1980a), a number of questions were raised during the discussions concerning the reliability of the numbers and the utility of the conclusions.

An evaluation of the U of A report in terms of the objectives set for impact assessment (described in Chapter II) gives the following results. The report's emphasis is on the technology rather than on the desired focus, the technology's effects. Those impacts discussed relate primarily to the interest groups involved and only secondarily to the natural or physical environment. For example, there was no analysis of impacts resulting from extensive planting on previously uncultivated lands. The effects of guayule commercialization on related technologies and on the national economy are included as assumptions rather than identified and evaluated as impacts, and impacts on local economies are discussed minimally. When impacts are discussed, their extent is described only as either "limited" or "significant." The alternatives--"laissez-faire" and "strong federal involvement"--are based on single anticipated changes in the political environment and assume no change in the physical or social environment. Long-term or indirect effects are not discussed, even though there is some attempt at a cost-benefit analysis. Moreover, there is little relationship between the forecasts and the identified impacts, except as implied in a table describing "policy conflicts" and their resolution. Overall, there was little improvement in methodology over previous studies, in large

part because of a lack of experience in impact assessment on the part of the majority of U of A team members and their resultant dependence on policy-oriented MRI analysts for guidance.

However, while many members of the guayule research community are not convinced that the study results are credible, they are using those results (e.g., Flynn, 1981; Perry and Hanson, 1981). As indicated in interviews with members of that community, there are a number of reasons for their use of these questionable results. The forecasts are broad enough to ensure some degree of congruence with what may actually occur. The report is clearly written and was released at a time when decisions were just beginning to be made by the Guayule Commission concerning implementation. Moreover, the community was involved in the process (through interviews and comments on draft versions of the reports) and feels some ownership in the results--although their involvement is not very visible in the final report.

These comments on the U of A assessment reflect, to a large extent, the fact that the report was prepared by an inexperienced team to meet the expectations of the funder, the National Science Foundation and the co-contractor, the Midwest Research Institute rather than the needs of the users--rubber company executives, government officials, other researchers, and citizen groups.

Developing an Alternative Model
=====

In April, 1980, Dr. Harold A. Linstone asked this author to join a research team at the Third International Guayule Conference to assist in interviewing key actors in the guayule programs as part of his research on the use of multiple perspectives in technology assessment. From this experience came the idea of developing a report on guayule as an illustrative example of this dissertation's thesis. The topic was an interesting one, in part because it included elements of environmental, social, and national policy concerns. Moreover, there was an opportunity for the kinds of research necessary to implement the approach to impact assessment suggested by this dissertation.

Methodology. The research began with a review of the U of A interim report (Foster et al., 1980a) and the National Academy of Sciences statement (1977). The team then attended the Third International Guayule Conference—a four-day event that permitted a participant-observer approach to the research. Since most of the sessions were made up of technical paper presentations that could be monitored by others, I emphasized meeting and interviewing those actors not met by the other members of the team and following up on details or new information. Those interviewed (listed in Table XXIX) include rubber company executives, members of the U of A team, farmers and local bankers, and government officials associated with guayule's development.

TABLE XXIX

KEY ACTORS INTERVIEWED FOR THE GUAYULE RUBBER STUDY

NAME	POSITION
Don Weihe, Joe Neivert	Firestone International Division (includes guayule)
Jack Reidl	Goodyear International Division
Earl Gregg	B.F. Goodrich; also chairman of Rubber Division American Chemical Society
Pasquale (Pat) Gallioto	Anderson Mfg., Guayule Processing
Alex Mercuri	Chairman Guayule Commission, also Dep. Sec. Dept of Agriculture
Francis Wolleck	Co-chairman Guayule Commission, Dep Sec., Dept. of Commerce
Isi Siddiqui	Director of Guayule Program State of California Dept of Agric.
H. T. Huang	National Science Foundation, polymer research program monitor
Ed Flynn	"Mr. Guayule Rubber News",
Dan Bragg	"Mr. Guayule of Texas" directed feasibility study at Texas A&M
Jonathon Taylor	Member Technology Assessment team, Office of Arid Lands Stud. UofA
David Rubis	Agronomist, U of A, also convenor of joint meeting between the rubber companies and Commission
Wayne Whitworth	Agronomist, New Mexico State U
Jimmy Tipton	Agronomist, Texas A&M University
Robert Heckler	President, Farmers and Merchants Bank Las Cruces, New Mexico

The questions listed in Table XXX were used as interview guidelines, although such questions as "How do you feel about guayule and its development?" and "What do you get out of its success?" were usually added. Additional insights were gained by participating in informal group discussions and events, and in the more formal Guayule Commission Hearings held in conjunction with the Conference.

I maintained the participant-observer role through the rest of the Linstone team's efforts, attending several meetings at which their results were discussed and working papers were exchanged, and contributing to their report (Linstone et al., 1981). Finally, at the end of the study period, I made a series of site visits--to Southwest Texas, New Mexico, and the rubber companies' offices in Akron, Ohio. Information gained from these visits was shared with other team members on their request and provided the final pieces of information needed to complete this illustration.

A synthesized report was drafted based on all of these experiences and some additional analysis of the organizations, institutions, and communities involved. Several attempts were made to draft a report that would demonstrate the major issues and impacts of guayule commercialization while being interesting and entertaining reading. These attempts were based on the premise that different forms of verbal models were appropriate for different kinds of insights needed by different groups of readers. A technical discussion of data bases and analysis was extracted from the

TABLE XXX

QUESTIONS USED FOR INTERVIEWING THE GUAYULE ACTORS

---

1. Why haven't the rubber companies moved further? USDA? other agencies?
2. How will entrpreneurs proceed?
3. What key people are not at this meeting?[a]
4. How did you get involved with guayule?
5. Are new organizational arrangements needed?
6. What is the impact of a rubber cutoff for the rubber co's?
7. Who are the key people for action?
8. What is the connection between guayule and jojoba?
9. Who would stand to make the most money?
10. Who would suffer most?
11. Who is the biggest help? hindrance?
12. What has been the dumbest decision?
13. What questions do you have? puzzles about guayule development?
14. What role could NSF play? BIA? Texas?
15. What existing agency would you give temporary responsibility for guayule's development to?
16. (What is wrong with the U.S. program? what is your country doing?)[b]
17. What are some other uses for guayule besides latex?

---

a. The Third International Guayule Conference, Pasadena, California, April, 1980
b. directed to representatives from other countries (researchers attended from Mexico, French West Africa, Australia, and Southeast Asia)

U of A material and developed to provide supplementary material for the synthesized report. A report on organizations and processes used a journalistic style to summarize the U of A and Linstone teams' results in those areas. A story presented the relevant images and permits an intuitive understanding of the nature of the technology and its effects on the people who will live with it.

The writing of such a story required that I be sufficiently immersed in the material to "see" clearly what guayule's cultivation would look like, to "feel" what the people working with it might feel, and to "take part in" their activities with regard to its development. The story line and characters must make it possible for the reader to share those "experiences" and to identify with the people who might be involved. Most of all, the story must be sufficiently engrossing to hold the readers' attention and ensure sharing of the "experience," so they might become familiar with the problems and possibilities likely to emerge from the development of guayule in the United States.

A number of outlines were drafted to meet these requirements. Table XXXI illustrates one outline considered. It plots a story that focuses--as did the studies on which it was based--on how guayule could be developed. A key character or prime mover dominates this approach, with a single hero focusing on a key decision point--in this case, the environmental problems associated with guayule's processing--and working out a technical

TABLE XXXI

ONE OUTLINE CONSIDERED FOR THE GUAYULE EF STORY

SETTING

> The President's pro-military stance creates the need for more equipment
>
> -leads to an increased need for natural rubber
>
> Unrest in Africa, combined with a swing to the left in southeast Asia (preference sales to China) virtually cut off U.S. access to hevea
>
> Rubber companies ar panicked
>
> -they've contracted to sell but have no raw materials
>
> -they've dawdled and been bogged down in the EIS process for guayule

STORYLINE

> Hero designs a processing plant that mitigates most environmental impacts.
> >   (SKETCH: Heinlein-style hero-type, raised on SW farm, chemical engineering degree, just out of Air Force, refuses to work for big companies)
>
> He forms a company, working with independent guayule activists to contract with Mexican ejidos, for 3-yrs worth of wild guayule.
> >   (SKETCH: Langley-type trying to convince ejidos that they can benefit by giving her the crop as well as seed)
>
> He contracts with American farmers to supply seedlings and buy all production in 4 years
> >   (SKETCH: visit to hometown, parents, neighbors, schoolchums)
>
> In the process of getting licenses, etc., his intentions become clear to the rubber companies. At first it gets rough, as they think they have to bully him out of his plans. Then, with the help of a particularly persuasive lawyer (female), he convinces them its to their advantage to sell him their military contracts for the interim, in return for his processing design
> >   (SKETCH: dealing with rubber company exec's)
> >   (SKETCH: rubber company and military meeting where the need--and potential longterm market is spelled out)
> >   (SKETCH: hero coming to admire his lawyer's professional --later personal--qualities)
> >   (SKETCH: celebration of victory over companies)

CRISIS AND DENOUEMENT

> Each permit/contract process is a minor crisis, building up to the final one--there is not 50,000 acres (minimum needed) worth of seed! Comic relief as everybody involved gets into the act looking for guayule seed stashes. They come in one-by-one until the last moment, when it looks as if the thing just can't be dc.ie after all--and the last needed stash is found (by accident) in a Rubis-type character's file drawer.
> >   (SKETCHES: each character's experience trying to find seed)

CLOSING SCENE

> Hero and lawyer-friend cement a longterm personal--as well as professional--partnership in the office of the built and operating plant.

solution. This plot parallels that of Heinlein's "Let There Be Light." In true romantic fiction style, and with the help of a female ally, the hero overcomes the bureaucratic problems that threaten his technical solution. The advantage of such a storyline is that it tends to be fast-paced and can point out many of the problems and potentials of the innovation. The disadvantage in this situation became evident when the story was partly drafted and clearly would have to be novel-length to encompass so much action and background detail.

Another outline was selected, focusing on one piece of the earlier story, and a story, along with a summary of the full report were drafted. Presented in Appendix C, the summary and story (entitled "Synthesis") are placed in the framework of a full report, with placeholders for the more detailed technical information (much of which is included in Linstone et al., 1980).

Results. The nature of the methodology employed for this illustration led to some different conclusions about the nature of the effects of guayule's development from those were reached in the other studies (Foster et al., 1980; Linstone et al., 1981). Yet, to a large extent, the results (presented in Appendix B) are dependent on the other studies' findings--combining the interviewees' comments, the papers presented at the guayule conference, and the Guayule Rubber Society Newsletters with the U of A and Linstone teams' reports.

Briefly, their reports present either-or situations. That is, the U of A and Linstone teams identified distinct courses of action in which each actor/agency is expected to do just one thing, without taking into consideration the effects of cross-fertilization among them. Alternative scenarios in those reports present extremes resulting from single policy stances on the part of individual decision-makers. Impacts derived from those scenarios, therefore, are (as described above for the U of A report) fairly limited in scope and extent. Resulting from a single action (or set of actions), the impacts are described in terms of that action set rather than the whole context.

The results presented in Appendix B, using the tools of fiction* suggest a different range of possibilities. They lead to the expectation that a multi-pronged approach to guayule's development is more likely, given the actors involved. At least one rubber company can be expected to forge ahead with a vertically controlled production system (including their own processing plant and company-owned or leased plantations), possibly by 1985. In the meantime, talks are likely to continue among federal agencies to establish a mechanism for federal access to domestic rubber, possibly leading to an agreement (by the end of 1984) to

*As was indicated in Chapter III, some of the tools of fiction are those of the historian or investigative reporter, as well. Therefore a number of the results presented here could well have emerged from the efforts of such researchers.

stockpile guayule. The National Science Foundation can be expected to switch their funding interest from agronomics and polymer research to engineering (i.e., processing) research, while other agencies--in the Departments of Commerce, Energy, and Agriculture--may be persuaded to fund some guayule-related projects over the next few years.

As a result of these actions on the part of decision-makers, the synthesized report also suggests that beyond 1985, the first environmental impacts of large-scale cultivation and smallscale processing should be felt--mostly around Fort Stockton, Arizona, where Firestone has a test plant and is likely to build a fullscale facility. The diversion of cotton-growing and sorghum-producing lands to guayule would decrease water use and shift agricultural market patterns for the area, while the possible use of previously uncultivated marginal lands--encouraged by the four-year wait for a return on investment--may increase erosion problems. In addition, haze problems from intensive planting of the resinous shrub would begin to be apparent, as would any air and water quality problems resulting from a small- to medium-scale commercial processing plant.

It is clear that these impacts--and the measures necessary to mitigate them--will play a significant role in determining the scale of development in the years to follow. In terms of the scenarios developed by the U of A team, should the federal government decide that guayule is a strategic resource that should be stockpiled, then these

effects may play a lesser deciding role than if development continues on a laissez-faire basis with local governments making regulatory decisions. In either case, however, the results of this synthesized approach indicate that conflicts over water use (already a major problem in the Southwest), land use (agricultural vs. residential or industrial), agricultural emphasis (food or fiber), and regulatory authority (e.g., environmental protection) would emerge and need to be dealt with as guayule became an increasingly important crop in that region.

Results from interviews indicate that the mechanisms called for in the Linstone team report (1980) for resolving these conflicts seem to be emerging in the forum for information exchange that is the Guayule Rubber Society. As more people outside of the research community become involved in that society and its meetings, some of these conflicts can be dealt with before they become emotional and political issues. Useful exchanges occur during Society meetings, where different interest groups can share concerns and ideas on an informal basis, prior to more formal statements or negotiations.* The society's newsletter, "El Guayulero," also has made it possible for researchers and government officials to express concerns and to keep each other

*For example, at the International Guayule Conference in Pasadena, one informal group consisted of the Chairman and co-Chairman of the Guayule Commission, the major political activist, two agronomists, and the executive in charge of guayule for one of the large rubber companies.

informed on progress in dealing with them (cf Flynn, 1981; Hanson, 1981; Siddiqui, 1981). At present, however, observations from the synthesized approach indicate that only a few interest groups are involved in the Guayule Rubber Society. This means that farmers, local officials, Indian tribes, and local labor are left out of the exchange, increasing the likelihood that their concerns will become significant issues, as these groups become aware of potential problems, but have no informal mechanism for dealing with them.

Presentation. As discussed earlier in this dissertation, dynamic models such as those used by the U of A are appropriate in only limited situations and the technical report is a useful form for sharing some, but not all, kinds of information. Structural models such as those used by Linstone's team are appropriate in clarifying problems and relationships, and the verbal models of journalists are useful for sharing the kinds of information that result from interpreting those models or summarizing other reports. But, as the analyses of EF stories (Chapter IV) have demonstrated, fiction most often describes the social and quality-of-life impacts that reflect the hopes and fears of the people involved with the innovation to the reader outside of the community.

Clearly, all three modes are necessary to effectively communicate the results of this research: the technical report for data and analysis, the journal article for

summarizing results and organizational concerns, and the fiction for bringing forth human issues from the generalized analysis. In the synthesis presented in Appendix B a story points out some of the most important processes, issues, and impacts associated with the implementation of the policies currently being considered. It is followed by a journalistic summary that provides an overview of the information available in the U of A and Linstone assessments. In a complete version (too lengthy to be attached to this dissertation) a more detailed technical report, including results and descriptions of the methodologies used to obtain the results would follow these, with data and analytical discussions evaluating potential impacts and policy issues or considerations placed in appendices.

In their final form, the summary and the story are combined in a report that emphasizes the effects of the commercialization process. The focus of the results is shifted away from the technology per se (as in the U of A report) and from the organizational processes necessary to the technology's implementation (as in the Linstone report) to the technology's effects on the people dealing with it.

A sense of what the issues, options, and needs will be in developing the technology is provided early on in the synthesis. The reader is given a feel for the elements of the problem through the story, then an overview of the important policy concerns in the summary. This suggests

that the more technical analyses which follow them can be more readily understood and utilized by the report's users.

To that end, the story is written as an allegory (see Suvin's and Campbell's comments on science fiction as allegorical, in Chapter III). Its characters are symbolic: an attempt to typify the various groups--the Mexicans, the Americans, the researchers, the engineers, the administrators, and the farmers--involved in guayule's development. Less attention was paid to the government and its role than in the IA reports, and more to the people doing the work.

Since the emphasis in all of the reports was on cooperation and the forming of coalitions, the working marriages of research with development, Mexican with American, and agronomy with process-engineering are the focus of the story. The main characters' move from the Southwest U.S. to Akron, Ohio represents the needed shift in focus when the time comes to make a final commitment to fullscale development. At the same time, the story is written to present some of the issues and conflicts emerging from the development process.

The opening scene illustrates the possible environmental and economic effects of largescale cultivation.

> The air rose, hot and odorous, above the rows of
> cactus-like bushes. The haze made it difficult to
> see, as in the distance, a tractor turned and headed
> back down between the rows. Behind the tractor,
> cultivator hooks turned the sandy soil around the
> bushes to ensure that no other plants would consume
> the precious water allotted to the crop. The man

> driving the tractor adjusted the scarf over his face
> to better keep out the dust and the fumes . . .
> (Appendix B)

The memories of Mexico point up the need for continued

cooperation with that country.

> Then the scene shifted, and she was . . . a girl on
> her uncle's ejido across the border, going out with
> the rest of the family to gather the wild guayule. . .
> Each day, during harvest time, they would fill up the
> truck's bed with the prickly plants--roots and all on
> some--and haul their harvest to the cooperativa where
> it would be chopped and baled and set to the
> processing plant in Saltillo. (Appendix B)

The possible racial issues (Mexican and Caucasian) and the

conflicts over land and water use (food or fiber, the

cultivation of marginal lands, the ejidos) are touched on,

as well.

The need for rubber and its decreasing availability are

in the story, as they are in the rubber community, driving

forces in guayule's development.

> "Gentlemen," he said, "We have come to the point of
> decision. Either we accept that guayule is and must
> be our major source of natural rubber in the future,
> committing ourselves to its full development as a
> resource, or we continue to rely on an increasingly
> unstable and decreasingly productive supply of hevea.
> We believe that the best interest of the company lies
> in the sure, steady, local supply. (Appendix B)

And, as in the story, decisions will be made far away from

the fields and processing plants, in another world of board

rooms and briefings, based on logical arguments and

forecasts combined with descriptions of procedures and

personal benefits.

> "If this corporation chooses to develop guayule
> according to its present policies, you can see that,
> in either scenario, we will have a significant short

fall in our supply. . . . If, however, the corporation
makes a full commitment to the development of this
resource, we can expect to meet both the shortfall of
natural rubber and any deficit in synthetics resulting
from the unavailability or high cost of petroleum."
. . . He described in glowing terms the position the
company would occupy in a world short of rubber but
depending on it for everything from tires to surgical
tubing. He played on each Board member's personal
concerns. . . . Patiently and steadily he worked to
convince them . . .

Gradually Consuela could see each one buy into the
idea. Guayule was becoming important to them. A
major source of income. A steady source of supply.
One by one they accepted it. (Appendix B).

In this way the need to include the full range of incentives

and effects is illustrated and the potential mechanisms for

cooperation are described.

This synthesized report is designed to enhance the

existing IA reports by going beyond them to include

information and conclusions that are not included in those

reports, and by using more effective verbal models for

communicating the results. The hope was that the objectives

for impact assessment would be more effectively met by

including several different modelforms. The fear is that

lack of skill or presence of unrecognized biases may limit

the utility of the synthesized report unnecessarily. To

minimize the basis for that fear, great care was taken to

ensure that the story was well-founded in the data and

information gleaned by other researchers as well as myself

and portions of the manuscript have been reviewed by members

of the assessment teams in early draft stages.

Limitations. The story and summary report presented in Appendix B are designed to provide insights into and facilitate the communication of the process and initial effects of guayule's commercialization. They do not deal with a number of the isses which have been raised concerning long-term impacts. Another report, including a story dealing with local Indian tribes' access to land, water, and processing facilities in a water-starved Southwest, might be used to deal with these long-term effects, as guayule commercialization gets underway and a new, updated IA report is needed.

These examples illustrate ways to integrate extrapolative fiction with impact assessment, thereby including a broader range of insights, impacts, and issues in the IA report than has otherwise been included. They are intended to illustrate the possibilities, but they lend substantive support to the proposal presented in this dissertation, as well. Insofar as they clarify and illustrate impacts and issues, and insofar as they introduce new insights and impacts, they contribute to the evidence that extrapolative fiction can enhance impact assessment by introducing new techniques and models into the IA process.

CHAPTER VII

CONCLUSIONS AND IMPLICATIONS

The preceding chapters have examined the proposal that
extrapolative fiction can provide insights otherwise missing
from impact assessments and communicate a more complete
understanding of the results of those assessments. This
chapter summarizes the results of the preceding chapters,
discusses possible reasons for those results, and suggests
some potential implications. It also delineates the
limitations of the research and recommends some possible
follow-on activities.

SUMMARY OF RESULTS

A review of the literature concerning impact assessment
results and methods disclosed that reviewers and practi-
tioners have a number of concerns about the effectiveness of
that field in fulfilling its function as an aid to decision-
makers. A number of criticisms have been leveled against IA
reports regarding their lack of clarity, lack of discussions
of social and quality-of-life impacts, and their heavy
reliance on quantitative methods and presentations. Practi-
tioners viewing the IA process have expressed concerns about
the lack of interdisciplinary cohesion, the ineffectiveness
of impact analysis and evaluation techniques, and the need

for methodological enhancement. These criticisms and concerns suggest that some radically new approaches to impact assessment are in order.

A review of the literature concerning futuristic fiction suggested that such fiction may be useful to those teaching or practicing the policy sciences. Further review provided a set of parameters for a subset of futuristic fiction that meets the special needs and requirements of impact assessment as a field within those sciences. Called here extrapolative fiction, this subset deals with time-frames, locations, and scopes of concern regarding the impacts of innovations that are equivalent to those of impact assessment.

A comparative statistical content analysis demonstrated that EF stories discuss an innovation's impacts in emotional well-being and other quality-of-life and social areas with significantly greater frequency than IA reports. This analysis also demonstrated that, compared to the descriptions of impacts in the IA reports studied, EF stories consistently discuss a wider range of impact categories and provide specific, rather than general descriptions of those impacts.

A thematic analysis of early (1940 - 1960) EF stories showed that many of the themes and concerns expressed in the stories studied have emerged as issues of national concern in the decades following those stories' publication. That analysis also showed that natural or physical environmental

impacts are described in the setting in which the story takes place, while impacts on individuals and groups are communicated through the experiences of the characters acting in the story. Impacts on the economy, related technologies, social institutions and politics were shown to be described as they contribute to the development of the plot and conflict in the story. That these impacts are tied to required story elements means that all EF stories can be expected to contain some description of most of these impact areas.

A comparison of individual EF stories with IA reports dealing with the same topics--nuclear power plants, automated "slidewalks" or roads, and smallscale submarines--showed that the EF stories address potentially critical issues regarding human responses to and operation of innovations that are not included in IA reports. In the most compelling case, the stories' focus on human response, combined with the fictional requirement for crises led to a clear illustration of the effects of operating nuclear power plants on inadequately prepared personnel and the effects of large capital investment on policymakers. In contrast, the IA reports studied--critical reports in the decisions to implement this technology--focused on impacts at the level of measurable radiation exposure and expected construction costs. The events at Three Mile Island and Washington Public Power Supply, anticipated by the fiction but not by the assessments, underscore the point.

These results provide substantive support for the proposal that one way to remedy some of the weaknesses in the IA process described in the literature is through the inclusion of EF stories. There are, however, some significant methodological considerations. The perspectives and methods associated with the two fields differ almost to the point of complementing each other. Necessarily, these differences must be taken into account in any attempt to synthesize the two approaches.

Two alternative configurations were illustrated in this dissertation for incorporating extrapolative fiction in the IA process. The first appended EF stories to a completed IA report as a means for illustrating the IA results. This approach is effective insofar as two sets of conditions are met: (1) stories can be found that deal with the innovation assessed in the report, and (2) the available stories deal with the impacts or policy options described by the report. In the assessment of life-extending technologies, an anthology of stories focusing on the same time period was shown to illustrate and extend the report results.

The second illustration in this dissertation was the use of extrapolative fiction in the IA process. Two approaches were suggested for this configuration, and one was developed as a case study. The first approach was the use of EF stories by IA practitioners early in the research and analysis process as a means for establishing a holistic perception of the system and innovation under study,

including the hopes and fears of those who may be living
with that innovation. Again, this approach is effective
only to the extent that relevant stories can be found in the
literature. Avoiding this potential limitation, the second
approach includes a person on the IA team with skills in
writing, researching for, and drawing on related works of,
extrapolative fiction. This latter approach has a further
advantage since it ensures that the questions asked in the
IA research process include those asked for fiction-oriented
processes. It is limited, however, by the skill of the new
team member and by the other team members' acceptance of
that member's research style--which may be apparently quite
different, since it is based in different models and
perspectives. The inclusion of this author on a team
investigating guayule's commercialization led to
substantially different results and an alternative format
for presenting those results.

DISCUSSION OF RESULTS

In this dissertation, one subset of futuristic fiction
has been proposed as a tool to enhance a subset of the
policy sciences: the futures-oriented systems practice of
impact assessment. The results of the literature reviews
and the analyses summarized in the preceding section support
that proposal and suggest some possible explanations for its
effectiveness.

One potential reason for these results may be found in the plotting, setting, and character development requirements for fiction itself. In order to be a work of fiction, a story must have a character, conflict (either internal or with the environment, or in the best works, both), action, a crisis, and a resolution (see, e.g., Elkins, 1979; Bova, 1982). In order to be a work of speculative fiction, these ingredients must be placed in a setting that is logically developed from the current here-and-now of the author and his or her readers (see Heinlein, 1969). In order to fit within the realm of futuristic fiction, that setting must be clearly located in a time some years after here-and-now (Clarke, 1979). Finally, in order to fit the definition suggested here for extrapolative fiction, that setting must be a logical extrapolation of current trends placed within the next fifty years--the timeframe for most impact assessments--and located on this planet. Each of these restrictions on the elements of which the story is composed increases the likelihood that there will be some overlap in concern between a story and an assessment. At the same time they require that the focus of the story be at a level of personal experience which has typically been well outside of the realm of impact assessment, and so lead the story to provide very different, though related, descriptions of possible impacts.

Another way to understand these results is to look at the process by which the assessments and the stories are

developed. Many of the stated and implied criticisms of IA

reports that are discussed in Chapter III derive from an

assessment process that is oriented to the academic

disciplines of the assessors and which depends on

traditional, reductionistic, and quantitative methods to

solve clearly defined problems. That process is very

effective for dealing with isolated events in a controlled

environment or with very large numbers of elements in a

well-understood environment (see, e.g., Waddington, 1977).

Such a process, however, is ill-suited to dealing with what

Checkland (1981) has called human activity systems--

organizations, institutions, and societies made up of human

beings that use technologies to interact with the physical

environment. Extrapolative fiction, on the other hand,

depends on a process that involves the research techniques

of investigative reporting (see Heinlein, 1969; Bova, 1982)

and the modeling techniques of the arts (see LeGuin, 1979;

Elkins, 1979), both of which have evolved over the years to

understand and portray the activities and responses of

individual and collected human beings. Cutting across the

disciplines, this process emphasizes synthetic, qualitative

methods to clarify not-very-well-understood relationships.

Clearly, for impact assessment to achieve the objec-

tives with which it has been institutionalized, both kinds

of processes are needed. The analyses and illustrative

syntheses presented in this dissertation demonstrate the

degree to which there is both overlap and complementarity in

the two kinds of results. Where the IA reports described quantitatively measurable impacts, the EF stories described qualitative impacts. Where the EF stories focused on the users and operators of the innovation, the IA reports focused on the society or region in which the innovation would be placed. Where the two were combined, a much broader range of impacts were described, at much more meaningful levels of detail.

IMPLICATIONS OF A SYNTHESIS

The implications of implementing these results and incorporating extrapolative fiction in impact assessment may be considered at three levels. The first is the process whereby IA reports are completed. As the Discussion section above suggested, the two processes complement each other and including the fiction process may lead to some interesting developments in the IA process. The second level is the content of those IA reports. To the extent that the fiction is included in IA reports, those reports will include some very different kinds of descriptions of impacts. Finally, the context of systems research, in which impact assessment methodology is developed, is the focus at the third level of implication.

Process

At the level of process, integrating these two fields suggests severl implications. The results described here

validate what many IA practitioners have begun to express--
that social forecasting is as much art as science, and that
creativity and intuition are as important to the process as
good trend extrapolation and cross-impact techniques. The
experience of a decade has led these practitioners to
recognize where their tools are lacking, and the results of
this research provide the grounds for those practitioners to
look at a new set of tools--those of extrapolative fiction--
to use when known tools fail or need an assist. The tools
of fiction, combined with the known techniques of impact
assessment, permit the inclusion of intuitive, creative
activities in the IA process and bring that process into the
context of the new systems thinking.

The scope of the effects of such a synthesis is related
to the method chosen for the synthesis. If the IA team
chooses to use previously published EF stories, they may be
limited by the lack of topical bibliographies in that area,
by the time, resources, and staff available to perform the
assessment, and by the difference in focus between many
early EF stories and the majority of IA reports. The first
of these difficulties may be ameliorated by adding new steps
in the literature review phase: polling known fans of the
genre or relying on information specialists or librarians.
The second, however, must be addressed on a project-by-
project basis: the project manager must weigh the availa-
bility of resources against the availability of appropriate
story material. Should the manager decide that enough

stories appropriate to the project-at-hand are readily available, then the initial literature review phase can include the half-hour to three hours that it may take to read a story or novel. Should the team decide to develop an anthology, then letters to previous publishers and perhaps the authors will be necessary to gain permission to do so.*

Alternatively, the limitations imposed by the nature of stories that have already been published can be circumvented by including writers with fictive skills on the team. The experience described in this dissertation of including a fiction-oriented member on an IA team demonstrates that the synthesis of extrapolative fiction with impact assessment leads to the inclusion of new kinds of research and new ways of thinking in completing assessments. The inclusion of a fiction-oriented team member means the inclusion of a humanist in a techno-scientific environment. The writer of fiction, concerned first and foremost with human characters and their human problems, will ask new questions and analyze data in new ways, affecting the assessment team's forecasting and analysis processes. While this addition to the process may add to the assessment team's early meeting time, the reduction of frustration, wasted time, and other problems associated with lack of integration should compensate for that delay as the project approaches completion.

*Although these contacts may sound difficult, in fact, re-publication of works is considered by most authors to be indicative of the author's standing in the field, so gaining permission is generally straightforward.

While including a technical writer on the team has been recommended elsewhere (Porter et al., 1980; Arnstein and Christakis, 1975) to ensure coherence and clarity in the technical report (see Chapter II), including a writer of fiction may be somewhat more difficult. However, it is fairly easy to find good technical writers who are also interested in writing fiction, and who may be trained (through reading and through writers' workshops) in the techniques of extrapolative fiction. If finding such a writer is not possible, then holding a writers' workshop as part of the assessment process may be possible, reaching writers through professional associations and newsletters and providing facilities for them to work together for a few days (usually five to nine). The writers could use a draft report as a source of ideas, and would, through the workshop process, develop a set of mutually acceptable stories based on the assessment results.

In either case, the assessment team has been changed. Reading the fiction provides the members with an alternative (albeit vicarious) experience of the possibilities, and including a fiction-oriented team member changes the balance and orientation of the team as a whole. In the long run, the effects of that change may be compounded and may, in time, lead to significant changes in the formal IA methodology.

Content

At the level of content, the inclusion of fiction as part of the IA report not only enhances the presentation of quality-of-life and other qualitative impacts, but may contribute to a new conceptualization of the function and nature of such reports--and of social analysis in general. By setting a precedent for the inclusion of emotional and aesthetic aspects of human life in policy documents, the synthesized approach described in Chapter V of this dissertation could contribute to the emerging recognition that a wider range of factors are significant in the policymaking process than has traditionally been assumed. Making a decision may begin to be seen as more than making a rational choice between clearly defined alternatives.

In the short term, the synthesized approach may lead to one or more "best-selling" reports. Reports that catch the attention and interest of the citizens involved in a project or program should encourage those citizens' participation in the decisionmaking process, thus contributing to the accomplishment of another, process-oriented, objective for impact assessment: active citizen involvement. A particularly effective document could also be used to extend and enhance the role of impact assessment in the bureaucratic decision-making process.

Context

In the context of an evolving systems science, the
synthesis suggested here represents an initial step toward a
new extension of the practice of that science by going
beyond the inclusion of social scientists in policy studies
to include humanists. Including students and creators of
the literature of the future opens the door for other
writers and literary critics to contribute to the field and
may be seen as another small step in the move to integrate
the new systems thinking with systems practice. Incorpor-
ating extrapolative fiction into the impact assessment
process may contribute to an understanding of the role that
intuitive and imaginative capacities play in the analysis-
synthesis processes of systems science, and encourage the
inclusion of other humanistic writings (e.g., historical
theories, formal essays, and philosophical studies) in that
discipline. Rather than continuing the separation of the
humanities from systems and futures research, the inclusion
of extrapolative fiction in the impact assessment process
encourages the participation of intuitive, imagistic, and
humanistic scholars in social systems analysis and design.

At another contextual level, these results--of the
literature reviews, the analyses, and the illustrative
syntheses--may be seen as reflecting a new approach to sys-
tems research. Recent shifts in systems thinking, charac-
terized by the work of Churchman (1968, 1977), Checkland
(1981), Linstone (1977, 1983), Jantsch (1976, 1981), and

others, have moved the field away from the quantitative, objective, analytical approaches of operations research and dynamic modeling which have been traditional. The new systems practice addresses human (or sociotechnical) systems as "fuzzy" systems, whose purpose and boundaries are observer-dependent, whose evolution requires coping with unsolvable "problems," and whose elements are recognized as individual human beings with feelings and fears that lead to apparently "irrational" actions and decisions when observed by those outside the system. Models are seen, in this new systems approach, as assisting understanding rather than predicting behavior. Analysis is seen as the first step in design--inseparable from the creative, intuitive design process. Research is seen as the process of discovering what is known rather than of proving an hypothesis.

Within this framework, the inclusion of the verbal models of fiction in a systems process is entirely appropriate. The fiction provides another way to discover what is known, offering models that complement quantitative dynamic models. The fiction also emphasizes the subjective nature of the observer and the participants in the system being studied, illustrating their feeling-based behaviors as well as the rational decisions. Moreover, since the fiction is clearly as much about the author as about the subject being described, the epistemological problem of social systems research (i.e., the impossibility of separating the observer from the system) is at the minimum underscored, and

may, in some cases, be made clear to the citizenry and
decisionmakers who are likely to use the report.*

At the same time, including the intuitive and imagina-
tive process of extrapolative fiction in the analytical
impact assessment process may bring together again the
several streams of futuristic writing--utopias, futures
essays, social change theory, etc.--described by I.F. Clarke
(1979; discussed in Chapter II). Rather than maintaining
the disciplinary boundaries that have grown between these
forms of writing, this synthesis could strengthen the links
still present between them and, possibly, contribute to the
development of the emerging discipline of futures research.

Finally, the synthesis of extrapolative fiction with
impact assessment can be considered an initial attempt to
apply a theory of imagery to the policy sciences. The
consideration of fiction as a form of communication that
through its encouragement of the formation of mental images
has significant potential for communicating decision-support
information suggests a wide range of applications in the
policy sciences. It may even eventually contribute to new
developments in cybernetic theory, as the concept of sharing
images becomes a part of the definition of communication and

*Heinz vonFoerster clarifies this problem in his
discussions of "observing systems", summarized in Linstone
and Simmonds (1977), and detailed in his Observing Systems
(1981). He points out that, as cognitive beings, what we
perceive are descriptions of reality that we create for
ourselves, rather than anything outside of ourselves.

extends the traditional notion of communication as an inces-
sant stream of bits flowing from transmitter to receiver.

LIMITATIONS OF THE RESEARCH

This dissertation represents the culmination of a
degree program in applied systems science with an emphasis
in futures research. As such it is intended as a methodo-
logical contribution, offering the possibility of enhancing
--rather than supplanting--existing models and approaches.
It demonstrates that the field of extrapolative fiction can
be used to enhance the practice of impact assessment without
attempting to prove that EF stories, alone, can replace or
supplant IA reports.

When this research was initiated (in 1979), it was seen
as a necessary step into what was then uncharted territory:
the integration of various forms of impact assessment and
the collection and analysis of works of science fiction as
possible contributors to that field. Since then, others--
most of whom have been referred to in these pages--have
published work along those lines, and the research has
evolved to take into account their efforts.

Partly because of those others' efforts, a number of
interesting problems and related study questions have
emerged over the years. These questions, relating to how
the decisionmaking process works, what the role of citizen
participation should be in the impact assessment process,
and what the potential role of estranged science fiction may

be in clarifying perceptions of current cultural issues for
decisionmakers, were unfortunately beyond the scope of this
present work. Such questions, along with any stories or
authors that may have been missed, will have to wait to be
dealt with until the next project.

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APPENDIX A

TOPICAL BIBLIOGRAPHY OF
EXTRAPOLATIVE FICTION

(selected works)

TOPICAL BIBLIOGRAPHY OF EXTRAPOLATIVE FICTION

Space Colonies

Bova, B., Millenium, Colony
two books describing the colonization of near space by
corporate conglomerates. Deals with earth-colony
relationships, starting with Milennium.

Clarke, A. Fountains of Paradise
A space elevator is built in Sri Lanka

Heinlein, R., The Man Who Sold the Moon
collection of short stories describing how an entre-
preneur collects the capital and creates a moon colony

_____, The Menace From Earth
collection of short stories describing life in near-
space colonies, including the Moon

Pohl, F. Man Plus
Colonizing some places may take reshaping human beings
for the first wave.

Pournelle, J. High Justice
Corporate control of power sources leads to corporate
development of space stations

Reynolds, M., LaGrange Five
Part of a series of books on A. D. 2000, describing
formation and development of a colony at a LaGrange
point

Sheffield, C., "The Man Who Stole the Moon"
a young engineer, frustrated by redtape in his attempts
to test his rocket fuel, joins the mafia to build the
resources to get to the moon

Submarine development

Clarke, A. The Deep Range, Dolphin Island
mariculture leads to new tools and new ways of reaching
the ocean's resources

Herbert, F. Under Pressure
the need for oil drives the U.S. to drill undersea
wells

McLaughlin, D. Dome World
undersea mining leads to undersea cities and wars

Pohl, F. and J. Williamson, Undersea Quest
    cities develop around mines and wells

Pournelle, J., "The Enforcer"
    story in High Justice describing ocean thermal-electric
    plant and related production/housing facilities

Artificial Intelligence

Asimov, I. "Evidence"
    short story describing the election of an android to
    mayor, explains the First Law of Robotics.

_____, "Satisfaction Guaranteed"
    a housewife falls in love with her robot

Gerrold, D. When Harlie Was One
    a very large computer becomes self-aware

Heinlein, R., The Moon is a Harsh Mistress
    another large computer becomes self-aware and helps
    bring about a revolution

Keller, D. H., "The Psychophonic Nurse"
    a baby is tended by a robot nurse

Production/Distribution Systems and Economics

Bova, B. The Weathermakers
    one segment of the population controls the weather
    control systems

Clarke, A., The Deep Range
    whales are herded to provide protein for a hungry world

Coulsen, J., Tomorrow's Heritage
    the multinational corporations divide up the world to
    maximize profits, set up satellite stations and operate
    weather control facilities

Miller, W.M., "The Darfstellar"
    specialistic society in which creativity is harnessed
    to create new specialities

Pournelle, J. High Justice
    corporations develop massive integrated agro-industrial
    complexes based on nuclear power

Reynolds, M., Commune: 2000 A.D., Equality in the Year 2000
    Guaranteed Annual Income leads to new social units as
    production systems require fewer and fewer workers

_____, "Freedom"
in a planned economy is personal freedom a disease or a
cure?

Scheckley, R. "Cost of Living"
Keeping up with the latest gadgets puts children in
debt for parents' purchases

Changing Social Roles

Disch, T. 334
interwoven stories of three women living in public
housing in New York--one a middle-aged mother, one a
lesbian, and one whose husband nurses their child.

Heinlein, R. Friday
in a north america made up of many sovereign nations,
an "artifically enhanced" woman makes her way as a
courier for a revolutionary organization

Felice, C. "No One Said Forever"
a career woman comes to terms with the fact that this
transfer will separate her from her child for at least
two years

Rimmer, R. Proposition 31,
two couples decide to pool their resources in a
"corporate marriage" and pass a referendum in
California to make it legal

Psychological Enhancements

Anderson, P. Brain Wave
intelligence is suddenly doubled

Anvil, C. "The Great Intellect Boom"
a pill to improve the intellect backfires, leads to the
need for an antidote

Heard, H. F. Doppelgangers
The fourth, psychological, revolution leads to a world
state

McCaffery, A. To Ride Pegasus
A group of people with psi potential are brought
together in an institute

McDonald, J. D. "Trojan Horse Laugh"
a drug puts peoples emotions in synch--and a positive
feedback loop goes into effect

Phillips, P. "P-Plus"
    a personality enhancer used by a few creates a new
    elite; used by all, resumes business as usual

Reynolds, M. Ability Quotient
    scores on a super "I.Q." test determine one's life
    pattern

Sturgeon, T. More Than Human
    the next evolutionary step begins when a group of
    people come together to form a synergistic personality

Life-Extending Technologies

    (see tables in Chapter VI)

Biomedical Technologies

Banks, R. E. , "The Happiness Effect"
    brain surgery provides "social adjustment" by removing
    "bad" synapses

Harrison, H. "The Ghoul Squad"
    transplants become the norm, and people have to state
    that they don't want their bodies used for parts

Heinlein, R. I Will Fear No Evil
    corporate chief arranges to have his brain transplanted
    into another person's body

McIntyre, V. "Spectra"
    a girl is made into a cyborg

APPENDIX   B

Proposed Report Format for Including a Story in an Assessment

of the Impacts of Guayule's Commercialization

CONTENTS

"SYNTHESIS: A SCENARIO FOR 1987"

The air rose, hot and odorous, above the rows of
cactus-like bushes. The haze made it difficult to see, as
in the distance, a tractor turned and made its way back
between the rows. Behind the tractor, cultivator hooks
turned the sandy soil around the bushes to ensure that no
other plants would consume the precious water allotted to
the crop. The man driving the tractor adjusted the scarf
over his face to better keep out the dust and the fumes. He
looked up and saw a pick-up truck parked at the end of the
row. Waving, he acknowledged its presence, then proceeded
to finish cultivating the row.

When he came to the end, he switched off the engine and
jumped down.

"Ho, David! What brings you out here?"

"Just checking on your crop, Al. Tryin' to get a sense
of how much to plan for, when, at the plant."

"Well, this field's been in three years and's ready for
topping. That one," he pointed across the road, "was topped
last year, and I'm planning to pull it up next month."

"Sounds good. Looks good, too. Should be a pretty
good harvest."

"Yeh, I think so. It should be a good year. Better
be, the bank'll be looking for their money." The farmer

wiped his forehead with the scarf and started to put it back on. "It's a good thing the Ag people backed up my loan, otherwise I don't think I'd have been able to try this stuff. Of course, we're all counting on you guys at the plant to pay us enough to make it worth our while."

The man called David smiled, his blue eyes crinkling around the edges as he did so. "Well, right now it looks okay. The price of oil is pretty high and we've got a process that does a pretty good job of extracting the latex from these things. The company's even backing the building of a fullscale plant in town, so we ought to be able to give you a worthwhile price." He turned toward his truck. "Better let you get back to it, then. Have a good day!"

David Archer swung up into the cab of the truck, his sandy hair falling into his eyes with the movement. As he started the engine, he thought about Al, and the other farmers like him. They were all taking a chance on an experimental crop, based on his promises and on the Department of Agriculture's backing. Good farmers all, they had set aside a portion of their marginal lands to try a crop that was supposed to use less of that scarcest of resources--water--than any other marketable crop, and come back with a return at least as good.

His brow furrowed for a moment as he once more considered the risk they were taking. What if the company backed out now? Then he remembered this morning's phone call and relaxed. He smiled, and his ruddy cheeks glowed.

If that call was any indicator, then, well, it looked as it they were going to win--at least in the short run. He swung the truck back onto the roadway and headed up into the hills.

At a break in the fence David turned the truck off the road onto a dirt track. He wound his way bst corn and cotton fields and, following an arroyo, headed toward a metal shack at the base of a shrub-covered hill. There he stopped and hopped out.

"Consuela!"

"Ola, David! Over here!"

Following the sound of the voice, David looked up the hill. There, halfway up the slope, was a bright patch of color he identified as his wife. He waved and started up through the cactus-like shrubs.

As he climbed, he found himself comparing the plants with those he had just seen in the field. Where those had been planted in neat rows, these seemed scattered all over the hilside. Where those were all the same stage of growth, these varied--some were ready to harvest. Most obviously, though, where the other field had been laced with irrigation lines, here there were none. To the casual observer, he was sure, this hillside would not look at all like the same sort of crop. Yet, to him, not only was it the same, but it was evident that the harvesters would be through here shortly, pulling out the mature plants and leaving the young ones behind to hold the soil. Moreover, he thought, this crop

was likely to yield very nearly as much as the farmer's
field below--with considerably less energy expended and soil
damaged to produce it.

By now he had almost reached the spot where his wife
was working. He paused a moment, ostensibly to catch his
breath, but really to enjoy the sight of her. Her always
lovely skin and shining black hair were even more attractive
to him, clad as they were in a scarlet shirt and scarf.

She looked at him and smiled, "What brings you here,
today, amigo?"

"Well, besides a chance to spend a few minutes with my
favorite wife, some business and some news." As he talked,
he closed the gap between them.

"The business is a crop check I'm making to see what
kind of schedule we'll be running at the plant. I just came
by Al's place and talked with him a bit. He's out
cultivating that field, nearly suffocating from the dust and
fumes."

Consuela nodded. "Yes, when they're planted that
densely and all at the same growth stage, it does get pretty
bad. The resins are pretty volatile . . . But what's the
news?"

Once more, David's eyes began to sparkle. "Frank
called today." He paused.

"Yes?"

"He says he needs to beef up his staff a bit." Another
pause.

"Yes, so?"

"Well," he drawled, "he wants both of use to move to headquarters in Akron--you to take over the guayule development program and me to manage the production."

"Really? . . . Why, David! That's wonderful!" Both of us--together!"

"Yes, both of us. Together." He reached out and took her hand. Pulling her towards him, he felt the excitement in her body, and loved the shining in her eyes. He kissed her soundly, then pulled back a little.

"There's a slight hitch, though."

"Yes?"

"He wants us there next month. Something about a program review."

Now Consuela drew back a little. "That's not much time."

"No, it isn't. But I think we can do it. You're pretty much done, here, and Joe can manage the plant well enough by now. Once this crop is harvested, we'll be in a good position to move on."

"I guess so . . . perhaps you are right." She looked thoughtful for a moment. "Yes, we are ready for a new challenge, aren't we?"

They hugged each other once more, then David turned back down the hill. "See you at home. Let's go out tonight and celebrate. Okay?"

"Okay, amigo. Hasta luego!"

The two waved, then turned to their separate tasks--she
gathering samples of her crop to test for yields, and he
driving back to his office at the plant where, if all went
as planned, it would be processed in a few weeks.

II

The sunset had transformed the desert sky. The deep
blue was edged with gold, and the few high clouds turned
lavendar as the sun sank toward the horizon. But Consuela
Archer was hardly aware of the evening's beauty. Lost in
thought, she prowled through the house, going from room to
room, checking the movingmen's progress. As she did so, a
sleek black cat followed, seeming to imitate his mistress'
movements, certainly reflecting her mood.

The last night. Tomorrow a new home. New people,
perhaps not so tolerant of a "chicana"--no matter that she
was an agronomist married to an engineer. What if they were
racist? What if the new house wasn't right after all? what
if . . .?

"Oh, please don't put that in there--it's very
precious. Perhaps with the dishes?"

"Sorry, ma'am, but they're already in the van. The
best I could do is a separate carton. Maybe a book box."

"That would do, I think. If you don't mind."

"No problem. I'll just get one out of the front room."

The man left, and Connie picked up the object in
question. It was a sculpture--metal--a globe nestled in a

flowering plant.   On the base were the words:

INTERNATIONAL SOCIETY FOR AGRONOMIC RESEARCH

Outstanding Achievement Award

Consuela M. F. Garcia

She studied it for a moment, then put it down. Wearily, she sank into the one remaining chair, leaned back, and closed her eyes, absently stroking the cat who had joined her.

Was it all possible? Could she, Consuela Maria Fernando Garcia, really be here, in this place, with all of this? How could it be? How could it possibly last? They were the questions she continually asked.

She took a deep breath and let it out. With the next breath, she seemed to move back in time. She was in school again, finishing her Master's at the University. Her advisor was a well-established researcher with a flare for picking fundable projects. He had just received a grant from a rubber company when she joined him, and was trying to develop an improved strain of guayule (Parthenium Argentatum gray) for rubber production. He also had an interest in attractive girls, which had made him doubly glad to have her join him in his research. It was uncomfortable sometimes, keeping his hands off, but it had been worth it. His support was invaluable getting her through the program-- not only did it ensure her degree, but he had helped her publish her results. That publication had led to this award, and to everything else that had come her way.

Settling in the chair, Consuela remembered the long hours in the greenhouse, tending the seedlings, nursing them along until they were ready to transplant into the field. Then the scene shifted, and she was no longer a student at the University, but a girl on her uncle's ejido across the border, going out with the rest of the family to gather the wild guayule. They were in the pickup truck, each armed with a machete, heavy leggings, gloves, and a sombrero or scarf to shade them from the desert sun. Each day, during harvest time, they would fill up the truck's bed with the prickly plants--roots and all on some--and haul their harvest to the cooperativa where it would be chopped and baled and sent to the processing plant in Saltillo. Her hands itched with the memory: it was hot work, and hard, gathering the resinous stuff, but it was an important part of her uncle's income, and he, with the other guayuleros, was proud to be able to earn cash by working on the land. More, he was proud of the consistently high yield his crop had, and carefully chose his gathering site to ensure it.

Once more the scene shifted, and Consuela was in her apartment in Tempe. There was a young man sitting across from her on the couch, earnestly explaining the mysteries of butyl rubber. "It's not just that it can be used for everything from aircraft tires to surgical tubing, it's that we've become dependent on it as a nation. Our whole economy would suffer, if we were to lose our supplies." She had heard his words, and was sure he was right, but though his

sandy hair and ruddy cheeks labeled him a gringo, she was realizing, then, that nothing seemed to matter, except that he existed and was there, with her.

A rustling sound brought Consuela back to the present, and she opened her eyes with a sigh. The mover was coming back into the room with a box full of crumpled paper. She go up from the chair, dumping the cat, as he looked at her questioningly.

"Think this'll do the trick?"

Consuela nodded. "It looks fine. Thanks for taking the trouble."

The man shrugged, smiling, and Consuela--with the cat behind her--resumed her prowl. The kitchen was empty except for a box of cleaning supplies. The dining room was full of boxes, empty and full. She gave the packer some additional instructions then went on to check the garage, her mind still awhirl with memories.

It was strange how those three memories were linked together. They were what had defined her life, had brought her here to this place and time. The annual guayule harvests, the need for a research project to complete her degree, and the earnest young expert on rubber--the three had come together in her development of a new strain of guayule. And that strain--using less water and yielding more rubber under "wild" conditions--had won the award which had led to her job, and it was developing it that had led to her marriage.

A car door slammed outside, and, as it had years before, Consuela's heart began to beat a little faster. She turned to the doorway, her face lighting up at the sight of her husband silhouetted in the rectangle of light.

"Oh, David, it's good you are here. There are so many things left to pack and I haven't even thought about dinner, and your mother called and wants to meet us, and the . . . "

"Hey! Slow down! Mas poco, por favor!" He kissed her soundly and led her out to the back porch. There, the last rays of sunlight could be seen touching the mountains to the east, turning them red then deep purple, as the night's shadow moved across the desert.

"Now tell me, what's the problem here?"

"Well, mostly, the movers are nowhere near done, and they promised to be out hours ago. I'm afraid we're going to miss our flight if they don't finish tonight."

"That's typical. They never seem to believe us when we tell them how much stuff we have. How many rooms are left to pack?"

"Only the study, but it has all the books and papers, and the paintings. . ."

"Hm-m-m. That shouldn't take more than two hours for them to finish--I'll see if I can't persuade them to stay and finish tonight. When they're gone, we can go grab a bite to eat on our way over to your brother's house. That way we'll get there too late to talk politics. How's that sound?"

"Good enough, as long as you call your mother in the meantime. I don't think she should drive all the way to the airport to meet us, but she'll only listen to you."

"Okay, it's a deal. Anything else?"

Consuela shook her head "No . . . yes . . . .No, I guess not. You go call her and keep an eye on the packers for a while. It's so nice here, I think I'll take a break and enjoy the evening's coolness."

Sure, Boss, you do that. I'll bring us a drink on my way back out."

"Thanks, amore!"

"You bet, chica!"

Consuela laughed and turned back to the view. She tried to memorize every detail: the valley filled with sparkling lights, the band of darkness twisting through them where the river ran, the sillhouette of the cactus against the darkening sky. It was hard to believe they were leaving all of this. It seemed such a part of her after all the years. First school, then later, the work with the agricultural extension agency, trying to get the farmers to plant her strain and save the seed. That had been a difficult time, a Mexican woman working with the gringo farmers. Thank heaven she'd had David's support; his recommendation that she come work for his company had given her a new level of respect from the farmers--and herself. How glad she was he had convinced her to marry him.

Her mind focused for a moment on their wedding day. Poor David, inundated by her family, as brothers and sisters, cousins, aunts and uncles all swarmed in to celebrate the youngest granddaughter's marriage. Never mind her husband was a gringo, he got the same treatment they all did--including the endless discussions of politics and sports. Fortunately, he spoke a fair amount of Spanish. And when he got tired, he could always pretend not to understand. It was a transparent trick, but tolerated because he was, above all, courteous, and more, he was now Consuelo's esposo: a member of the family.

Connie chuckled at the recollection, shifting her seat on the porch steps. Many of them had already met him, sometime earlier, when she had been visiting her uncle between terms. David had been part of a group touring northern Mexico. When the group had arrived in her uncle's village, Connie had been brought out to act as interpreter. David had insisted on seeing guayule "in the rough" and was willing to pay for samples. So they'd all piled into her uncle's truck to take the crazy tourista and introduce him into the profession. Since it wasn't time for harvesting, they only took along sacks for seeds to sell to the seed companies in the U.S., and a machete to show him how it was done.

David had been fascinated. She could still hear the wonder in his voice. "This is latex! It's the real stuff, in a cactus!" Of course, he had known all along that it

was, but she supposed it was one thing to know about something and quite another to experience it.

Whatever, he was very excited and insisted on keeping samples--both of the bush and of the seed. He'd also asked for Connie's address in the States and promised to pay a visit.

And a good thing, too, Connie thought. For it had been those very seeds that had made her strain the wonder that it was, using so much less water and fertilizer, hardier in a wider range of temperatures, and yielding as much and more than other varieties. That had been a very opportune visit, even not counting the fact that they'd fallen in love.

The sun was fully set now, and the breeze was turning chill. Connie went back inside, where David was just finishing his drink preparations.

"Sorry, no salt for the rims."

"Oh, well. I guess we'll have to rough it."

They smiled and touched glasses, toasting each other with the margaritas in a little ritual that had marked every important occasion since their first date some five years before.

"Did you work things out with your mother?"

"I think so, she's planning to meet us at the new house, with a picnic supper and some 'moving in' things, rather than at the airport. That way we'll get a chance to get oriented a bit, and she can feel like she's helping. Okay?"

"Fine, of course." She took a long, slow swallow from her drink.

One of the movers came in and announced that they were through packing. "We'll just load the rest of this in the van and get out of here," he said.

David looked up at him. "Sounds good. Thanks."

"Sure." He picked up a box marked 'files' and proceeded out the door.

"Must be time for us to get out of his way," said David. He escorted Connie into the empty kitchen, where they perched on one of the counters. "Let me tell you what happened at the office today."

He took a sip of his drink while Connie waited expectantly.

"Frank called from Akron, wanting to know when we were arriving. I told him late tomorrow, and he sounded terribly relieved." David paused to look at his drink, then went on. "It seems that the program review for guayule has been moved up for a special Board meeting on Monday. And, if it goes well, he wants to call for a reorganization, to set up a new Division, separating guayule out from the International Division.

"Why David, that's wonderful! That means they've realized guayule has the potential to meet the shortfall and they're going to go for it!"

David held out a hand, as if to steady her. "Well, almost. So far only Frank has. He still has to convince

the Board that there's even going to be a shortfall in
rubber, then that guayule can meet it and finally that the
company should increase it's investment and open the second
plant." He slid off the counter and began to pace. "And
that's where we come in. He needs our input for the
presentation on Monday."

"That means we'll need to work on it there, this
weekend."

"Yep. I told him we'd come in Saturday afternoon.
That'll give us the morning to get ourselves together, and
leaves Sunday to work out the details."

"Sounds good." The two looked at each other for a
moment, and smiled. Without knowing, they were sharing the
same thought--"Where would I be without you?" Then, at the
same time they both began,

"But, you know. . ."

"Still, I think. . ."

They laughed, and David pointed to his wife to go first.

"I was just thinking that it made so much sense to push
guayule to fullscale development, especially with the work
we've done overcoming the environmental problems. With my
strain and your process, they really can't lose!"

David nodded. "My thought precisely, but we still have
to convince the Board."

"I suppose you're right . . . I just hope they have the
sense to see how important it is." She looked thoughtful
for a moment, took another sip, then downed the last of her

drink. "Well, we've a busy weekend ahead of us. Let's see how those movers are doing."

Connie strolled out of the room, while David watched her admiringly. Then he gulped down his drink and followed her.

III

"Well, so much for that hope," Connie thought as she watched her brother come out to meet them--from the look of him they were in for a good talking session tonight, after-all. But she put the thought a side, and by the time he had the car door open for her, she had a smile for him. Not only was it expected of her, but she was genuinely fond of this older brother who, like her, had made his way across the border to learn the skills he could take back and work with. They both were chicanos here--successful, but still Mexican. And they had come to depend on each other for support over the years.

"Ola, Miguel! Como esta?--How're things going?"

"Bien! and you, little sister?"

"Well, your 'little sister' is feeling pretty ancient right now: it's been a long day. But generally, things are going pretty smoothly--aren't they, David?" She turned to her husband as he emerged from the other side of the car.

David reached across the roof of the car to take Miguel's hand. "Yeh, things are in pretty good shape--at least at this end. It looks as if we'll make tomorrow's

flight after all." He grinned at his brother-in-law.

Miguel's return grin was genuine as they clasped hands. They too were good friends. He offered to help with the luggage. "You'll get the room on the patio tonight. Tio Juan went home for a few weeks to meet with the ejido--he's worried about the guayuleros--but he left explicit intructions that you were to have that room."

Connie was delighted. "How thoughtful of him! Our uncle knows how I love the sound of the fountain at night."

Miguel smiled gently at his sister. "Yes, he is a thoughtful man. And right now a worried one. He left a letter for you. Maybe after you're settled we can talk about it."

"This doesn't look good at all." It was David who broke the silence after they'd all read the letter.

They were sitting on the low benches around the fountain in the patio, drinking Miguel's specialty--strong hot coffee with tequila and a sugar cube. Miguel was leaning back, his eyes closed, all traces of smile gone from his face. Across from him, David was still going over the pieces of a paper in his hand, as if reading the words one more time would change their meaning. Consuela sat between them, her chin in her cupped hand, staring into the flowing water of the fountain.

"That's an understatement," she said, and took another sip from her cup. "If I were Tio Juan, I'd be worried

sick--the ejido can't afford to miss the guayule harvest.
Not this year, or any year for that matter."

Miguel sat forward. "The question is, what can we do
about it? Or, more rightly, what can you two do about it?
You're the experts."

"I don't see that we can do anything about it," David
said. "It's oil money that's drawing workers off the ejido,
not guayule."

"I think I understand what Miguel's getting at, amore."
Connie's voice was tense with fatigue. "He's saying that
oil money elsewhere wouldn't be half so attractive if there
were steady guayule money at home."

"Yes, that's it exactly," Miguel put in excitedly.
"Only if the land can produce a living will the ejidos
survive." He was warming to his subject. "And the ejidos
must survive if the Revolution is to have any meaning. Only
if they succeed will the government continue the land
reforms our fathers won for us."

"You mean that if they leave the land they lose it?"
David sounded incredulous.

"Well, it's not that direct. But that's what it
amounts to." Miguel stood up and began pacing the area in
front of the fountain. "You see, the ejidos developed out
of the Land Reforms that were the promise of the Revolution
back in the thirties. Land for the people, not just the
rulers. The process still isn't complete--only about half
the land has been redistributed, and most of that is

marginal desert. But the promise is still there, and it's still a big issue throughout Mexico."

Miguel stopped for a moment and looked at his companions. "You know, I've never looked at it that way before, but in a way, the banks and the big corporations, they're just like the old patrons--controlling most of the land and money and paying paysans to do the work." He looked thoughtful and resumed his pacing.

"In any case," he went on, "the redistributed land must be worked and occupied, or the politicians and big companies say, 'Look, it doesn't work! These people don't really want to own their own land!' And stop the program altogether."

"So, in the long run, the land reverts back to the state or gets sold to the corporations, is that it?" asked David.

"Close enough, anyway," Miguel sighed.

"And in the meantime," Consuela put in, "Tia Carmela and old Carlos and all the others who have lived their lives for the land are left without it." She turned to her husband, "Oh, David, we must go to help!"

But David was looking at the letter again. "No, I don't think that's what your Uncle Juan had in mind." He stood up too, and with Miguel, looked down at his wife. "I think what he wants us to do is create a market for guayule that's big enough to keep the guayuleros at home. He wants that second processing plant nearby--it would have to be on

the border--and he wants good prices for the harvest, to
boot."

Connie sat there, looking at the two men. All of a
sudden it was too much. She was too tired. On top of
everything, now she was to create a processing plant. The
idea was staggering. Looking at the two men, she started to
laugh, a long low chuckle that soon turned into giggles and
then guffaws. She leaned back and held her sides, shrugging
her shoulders in apology. "And (titter, titter) I suppose
(gasp) he wants (giggle) it next (whoop) week!" With that
she collapsed in a gigglingly helpless heap.

Watching her, David couldn't help but smile, himself.
"No, but I imagine next month," and he chuckled, "might be
soon enough." Then he, too, started to laugh.

Miguel, watching these two, shrugged his shoulders,
muttering something about "loco gringo" and started to leave.
Then, turning back, he gave them both a hug, said goodnight
and left them to their hysterics, knowing that once they had
considered it, these two, they would find a solution. If
there was one to be found.

IV

The Board room was quietly luxurious. The deep plush
carpet, the upholstered chairs, and the intricate pattern of
inlay in the table top all spoke of a long tradition of
affluence. As Connie looked around the room, she was once
more impressed that she should be here, now, in such a place

--and frightened now lest it be taken from her all too quickly. She studied the men around her, looking for signs that they might be open to the reasonable and logical arguments she and the others had worked so hard to put together this weekend.

There was the Chairman, a grandson of the original founder who thought of the company as part of his family. There were two lawyers, an accountant, and three other members who had worked with the company for years. Two of these, she knew, had been part of the International Division--responsible for natural rubber from Libya and Southeast Asia, and now responsible for guayule. They were used to being at the top and would be disinclined to see any limitations placed on their division, its role within the corporation. These were the ones to worry about. Then the Chairman started to speak, and she turned her attention to him.

"Since this is a special meeting," he began, "we will dispense with minutes and move right along to the matter at hand." He cleared his throat. "We are here to listen to Mr. Frank Wyman, director of the Guayule Project, and to review its progress to date. Mr. Wyman, you have the floor."

Frank stood up and paused, waiting for everyone's full attention. "Thank you, Mr. Chairman, Gentlemen of the Board. It's a pleasure to be here this morning." Then he began the presentation.

He ran quickly over the main points of the argument for maintaining a strong supply of natural rubber, including the rising costs of oil. He discussed the currently unstable international situation, and particularly the social, political, and economic changes being experineced in the rubber-producing countries. He then described the advantages of a domenstic supply, briefly reviewing the successes and difficulties the company had in developing such a supply.

He reminded them of the development of a new high-yield strain, making guayule commercially viable, even a potential major profit-maker. Then he introduced Consuela.

"And today, gentlemen," he announced, "we are fortunate to have with us the developer of that strain. Ms. Garcia has recently accepted our offer and will be heading the guayule stock-development program in our Research Department." He paused to let the approving response die down.

Then Frank introduced David. "We also are fortunate to have Dr. David Archer with us today. He has been directing our operations in Arizona, and has developed a processing system which not only ensures maximum recovery of latex from the plant, but does so with a minimum effect on the natural environment, and with a net gain in energy used. Dr. Archer has agreed to manage our production operations."

Once again, Frank paused while sound of approval filled the room.

Then he let them have it. Using the charts, he demonstrated how the new strain and new production techniques had moved guayule from a small experimental operation to an increasingly significant source of natural latex. He moved quickly through the graphs and tables, showing with each a steady increase in production for guayule and a highly unstable and defintely decreasing supply of the hevea latex from other countries.

Finally, he turned back to the Boardmembers. "Gentlemen," he said, "we have come to the point of decision. Either we accept that guayule is and must be our major source of natural rubber in the future, committing ourselves to its full development as a resource, or we continue to rely on an increasingly unstable and decreasingly productive supply of hevea. We believe that the best interest of the company lies in the sure, steady, local supply.

"Moreover," he went on purposefully, "we believe that the only effective way to develop it is to create a separate Continental Rubber Division within the company, which would be headed by a Vice President and would parallel the other Divisions in terms of organizational structure."

New sound--coughing, throat clearing, chair scraping, and voices talking--suddenly filled the room. Consuela stifled a groan as she thought of her uncle, the ejido, and all of the work leading up to this point. The Chairman had to pound for order.

"Mr. Wyman," he said, "you are suggesting a major reorganization of this company—more, a major change in corporate policy. While it is true that your figures are very persuasive, and the presence of these two eminent scientists deserves consideration, do they really provide a sufficient basis for such a shift?"

"Mr. Chairman, I believe they do." Frank brought out a new set of charts. "And I think you will, too."

"Up to now," he went on, "we've been looking at historical developments. Here are some projections for the future."

With the Board looking on warily, Frank proceeded to outline three alternative production levels, based on three levels of support within the corporation. Then, against these, he compared two potential futures for the country. In the first, the cost of petroleum continued to rise at its current rate, the national trade deficit continued to increase, oil-dependent countries became more and more unstable, and shipping costs finally exceeded production costs for hevea. In the second, oil prices rose, then leveled off as new energy sources came on line, leveling the trade deficit as well, but increasing instability in the rubber-producing countries, as new energy sources disrupted traditional economic and political structures. Exports of hevea, along with other goods, were severely disrupted.

"As you can see," he said, "the chances of maintaining an adequate supply of hevea look very slim. At the same time, the price of synthetic rubber, based on the price of petroleum, is likely to increase, making the natural rubber more desirable for many uses." He pulled out another chart.

"If this corporation chooses to develop guayule according to its present policies, you can see that, in either scenario, we will have a significant shortfall in our supply. If you choose to expand development but within the current structure, we will be in a good position to make up a significant portion of the natural rubber deficit. If, however, the corporation makes a full commitment to the development of this resource, we can expect to meet both the shortfall of natural rubber and any deficit in synthetics resulting from the unavaiability or high cost of petroleum.

Frank discussed it. He dwelt on the benefits resulting from being prepared. He described in glowing terms the position the company would occupy in a world short of rubber but dependent upon it for everything from tires to surgical tubing. He played on each Board member's personal concerns. For the lawyers, he dwelt on the increased stability of the corporation. For the accountant, he set out high profit margins and relatively low production costs. For the old-timers, he played up the excitement of a new venture, likening it to exploring a new country. And for the Chairman, he mentioned the prestige the company would be accorded for having met and averted a potential crisis.

Patiently and steadily he worked to convince them, answering their questions straightforwardly, point up time and time again how they all would benefit from the change.

Gradually Consuela could see each one buy into the idea. Guayule was becoming important to them. A major source of income. A steady source of supply. One by one they accepted it. Out of that acceptance, Consuela was beginning to believe, would come the development funds needed to establish this crop to which she had devoted so much of her life. And out of it would come to processing plants so necessary to her family's way of life.

She looked across the table at her husband. He caught her glance and smiled. Together, they had come to this point. Working in their own areas, agronomy and engineering, with others and individually, they had made it possible for desert farmers to raise a crop with low water needs and high yields, for the company to have a steady source of profits, and for the country to have a sure supply of the rubber on which it depended so much. As one by one the doubts were laid aside, and the mood of the board reversed, success was in sight. There would be much work to do, planning and building the plants, improving the strain, educting farmers and laboraers. But looking across this table, they knew: the work and the effort were worth it; the project was established, and they had done it--would continue to do it--together.

SUMMARY

Guayule is a desert shrub which grows naturally in the
arid regions of northern Mexico and the southwestern United
States. It produces a latex very similar to that produced
by rubber trees (hevea) grown in Southeast Asia and Africa.
This latex is a necessary ingredient in aircraft tires,
radial tires, and surgical equipment. Therefore, threats to
supplies can be critical to the economy. Such a threat
existed during World War II when hevea was unavailable, and
the Emergency Rubber Project was instituted to provide
guayule rubber. The project was disbanded, however, when
the war was over, oil was discovered in the Middle East, and
the land was needed for food crops.

In recent years, prices and availability of hevea have
fluctuated radically while consumption has increased. With
nearly 4 million tons of natural rubber used in this country
this year, shortfalls are increasingly likely, expected by
the year 2000 to range between 1/2 and 5 million metric
tons. They may be met by several alternatives:

    a) reduced demand for natural rubber

    b) new processing methods, including
         -recycling, reclamation
         -development of a cast tire

    c) new supplies, including
         -increased hevea stands in Brazil, Liberia, Ghana

-increased synthetic rubber production (from oil
    wood, or coal)
-production of guayule

Each of these alternatives is under investigation by the
federal government and the rubber companies.

Guayule Production

A desert plant, guayule needs 18-24" of water per
year--less than alfalfa, cotton, corn, or sorghum--and
therefore could be effectively in southwest Texas, New
Mexico, Arizona, or California. Current yields range from
1500lbs per acre of rubber in 3 years at Arizona test sites
to 2880 lbs per acre (in 5 years) at Bakersfield, with an
expected doubling through breeding programs to 20% by weight
by 1990. Potential planted acreage by 2000 is 1.5 to 2
million acres, suggesting a possible yield of 1 to 3million
metric tons of guayule over a 3-5 year period around the
year 2000.

There are a number of potential constraints to
development at the level, including:

- capital formation--a depressed tire industry and a
    lack of investment capital reduce the likelihood
    of new developments by rubber companies;

- potential air pollution--turpines from plant resins
    may create a haze over the fields;

- production costs--processing and cultivation costs
    currently exceed those of hevea;

- availability of government "seed" money--front end
    funds for research and development are needed.

The major interest in guayule's development is on the part of the researchers, who lack economic and political clout.   Rubber companies and government agencies are maintaining a defensive "wait and see" position, while they-- especially the government--are in a position to convince the private sector there is a market for the rubber produced. Such mechanisms as the development of a strategic stockpile could encourage state and other agencies to facilitate experimentation and processing facilities.   As yet, however, there is only talk about such plans, and the available funds are inadequate for a full-scale push for commercialization.

Impacts of Development

Table One summarizes the technical and institutional impacts of the commercialization of guayule. They are listed according to two alternative strategies: Scenario A, in which the rubber companies and the growers operate under a laissez-faire policy; and Scenario B, in which the government plays a major role in developing the resource, following a major cutback in imports of hevea.   They represent four levels of interest, the local, the regional, the national and the international.   Over all, it may be said that the impact of guayule's development is limited across most sectors, except when seen as the only source of natural rubber, when it has significant effect on those industries which are dependent on natural rubber for their products or services.

Guayule can bring back into use those lands abandoned due to lack of water or to poor soil quality. This could increase agricultural employment as much as 26% in Pecos County, Texas, and somewhat less in other areas of the depressed Southwest. In addition, by replacing cotton and other water-consuming crops, it could ease water availability--especially in California and Texas.

Air quality may be affected by the volatile resins, both in the ground and during processing. These and the acetone used in processing may engender respiratory or dermatological problems for workers. In addition, fire hazards are increased, compared to other crops and products in the region.

Another area of impacts is U.S.- Mexico relations. With Mexico a traditional supplier of guayule and currently developing its own controlled productioncapability, there are many opportunities for both cooperation and competition between the two countries.

Policy Issues

A number of policy issues surround the development of guayule. These may be roughly divided into those concerning how it should be developed, what the results of its development might be, and strategic concerns for the nation with regard to the importation of rubber. Issues relating to the stimulation of guayule's development include conflicts over

federal or private investment, and federal or private risk-
taking. The extent of this issue's importance depends on
the relative strategic importance placed on a domestic sup-
ply of natural rubber by the U.S. government.

A second major issue are with regard to guayule
is its regulation. Whether federal, state or local agencies
will regulate cultivation and processing of guayule is, to
a large extent determined by the nature of its impacts, and
again, its strategic importance. To the extent that the
federal government perceives guayule's development as es-
sential to national security, it will maintain regulatory
control. To the extent that it is a smallscale private
venture, the local governments will be responsible for reg-
ulating the industry's development in their areas.

Mitigation of any adverse impacts resulting from guayule's
development will also depend largely on the perceived need
for the product. If, for example, it is found that signi-
ficant reductions in air quality result from large plantings
of guayule, and guayule is not seen as strategically important,
then stringent measures—including possible limitations on
crop size—may be put in place to mitigate that impact. At
the same time, even if the federal government places great
importance on guayule's development, the Environmental Review
process may slow development considerably—particularly if
someone chooses litigation as a means to set policy.

Another potential problem resulting from the fullscale

development of guayule is the promotion of corporate farms in an area which has been traditionally family-farmed. The high front-end costs of guayule planting and the long (3 to 5 years) wait for returns through harvesting the shrubs, makes it difficult for the small family farm to finance it. Larger farms with acreage to spare, or corporations with greater risk-taking capabilities will have greater incentives to cultivate the crop.

Finally, there is the whole set of issues surrounding the relative importance of strategic policy compared to existing water, land, and agricultural policies throughout the region, and national antitrust policies as they affect the rubber companies' control of the resource. These may be resolvable only as the question of leadership is resolved: insofar as the federal government takes the lead in the development of guayule, it can override or preclude conflicts with other policies. This leadership, however, is somewhat in conflict with the current administration's efforts to maximize private sector development of resources.

Table II summarizes these policy issues with their potential problems and resolution.

TABLE ONE

SECTORS AND PARTIES AFFECTED BY
GUAYULE COMMERCIALIZATION

ECONOMIC SECTORS Parties-at-Interest	IMPACTS OR CONSEQUENCE Scenario A	Scenario B
Local Focus		
Unemployed workers -agricultural -semiskilled	Localized benefits from new jobs Very limited benefits from newly created processing jobs	Same Same
Environmental, health, safety	Limited effects	Potential adverse effects in the short term
General business community	Benefit from increased farming and processing revenues and tax base, multiple effects	Potential construction of tire or other rubber fabrication plant in Southwest, multiple effects
Regional Focus		
American Indian and other minorities	Limited positive effects	Probable economic gains for Indians thru land, water leases
Nondocumented farm workers	Limited effects	Probable increased migration
Marginal farm operations and economically displaced farmers	Benefit by shifting to less water-demanding crop	Benefit from SBA assistance and risk absorption
Banking and financial instutions	Uncertainty related to financing a four-year crop	Moderate impacts in risk absorption, loans, futures market
Communities at large	Increased needs for social goods, including housing, health, roads, police, fire protection	Same
Environment at large	Minimal impacts over near and middle term	Possible new patterns of insect infestation, other pests, moderate pollution potential at processing facilities, moderate fire hazard
National Focus		
Balance of trade for U.S. rubber imports, rubber	Minimal effects over near and middle term	Moderate effects over middle, long term
Mexican-U.S. relations	Probable strains if black market appears	Improvement thru cooperation in trade, research
Mexican Government	Benefits limited to land base development and employment in rural, depressed communities	Benefits by shared technology and R & D advance
International Focus		
hevea growers	No loss of U.S. markets	Loss of U.S. markets, gain in other world markets
Relationship between U.S. Rubber Co.s and Mexican Government	Mexican land ownership laws prohibit large-scale plantation ownership	Same

SOURCE: Foster, K. et al., "A Technology Assessment of Guayule Commercialization", University of Arizona, 1980.

ANALYTICAL DISCUSSIONS

In this section would be included the discussion of
scenarios and impacts from the University of Arizona study
and the discussions of organizational structures and pro-
cesses from the Portland State University study. Some
additional discussion--describing the forecasts implicit
in the other reports--would be included as well.

METHODOLOGY

This section would include the models and their results
as used by the University of Arizona team and the "analysis"
and introduction from the Portland State University report.

TECHNICAL PAPERS

This section would be made up of the working papers,
data base descriptions, and in-progress resports which sup-
port and substantiate the earlier sections. It would be
organized in a structure that parallels those sections and
is indexed along with them. For example, the material sup-
porting the sections on guayule's development would precede
that on the scenarios.

DATA BASE

In this last section would be any tables, charts, graphs,
or listings which provided the basic data for the models
and the discussions presented earlier. In many cases they

would be simply referenced. In many others, however, a single page will be adequate to provide the specific numbers or relationships used as the basis for analysis and synthesis in the assessment.