NUREG/CP-0018
BNL-NUREG-51419

Workshop on Frameworks for Developing a Safety Goal

Held at Palo Alto, California
April 1-3, 1981

Sponsored by
Office of Policy Evaluation
U. S. Nuclear Regulatory Commission

Proceedings prepared by
Brookhaven National Laboratory

Available from

GPO Sales Program
Division of Technical Information and Document Control
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Printed copy price: $3.75

and

National Technical Information Service
Springfield, VA 22161

NUREG/CP-0018
BNL-NUREG-51419

Workshop on Frameworks for Developing a Safety Goal

Held at Palo Alto, California
April 1-3, 1981

Manuscript Completed: June 1981
Date Published: June 1981

Sponsored by
Office of Policy Evaluation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Proceedings prepared by
Brookhaven National Laboratory
Upton, NY 11973

ABSTRACT

The "Workshop on Frameworks for Developing a Safety Goal" was designed to help in pointing to directions for narrowing safety goal options for further consideration. The topics addressed included both quantitative and qualitative elements and economic, ethical, social and political issues. It was a discussion workshop, involving invited, knowledgeable persons representing a broad range of viewpoints, drawn from technical, social and humane disciplines. The general objective of the Workshop was to develop an information base on specific topics related to the formulation of a safety goal.

"Toward a Safety Goal: Discussion of Preliminary Policy Considerations" (NUREG-0764) was used as a principal basis of discussion at the Workshop, but discussion was not limited to the content or scope of that document. "An Approach to Quantitative Safety Goal" (NUREG-0739), a study prepared by the NRC's Advisory Committee on Reactor Safeguards (ACRS), was used in the discussions as one example of a concrete application of concepts discussed and as a point of reference for comments.

NRC WORKSHOP ON DEVELOPING A SAFETY GOAL

TABLE OF CONTENTS

INTRODUCTION

The "Workshop on Frameworks for Developing a Safety Goal", held at Rickey's Hyatt House in Palo Alto, California on April 1-3, 1981, was sponsored by the U.S. Nuclear Regulatory Commission's Office of Policy Evaluation. Brookhaven National Laboratory was responsible for providing the arrangements for the Workshop, including the establishment of consulting contracts with a group of participants from industry, universities, public interest groups and elsewhere. The discussion guidelines (Appendix A) and agenda for the Workshop were prepared by NRC. Mr. George Sege of the Office of Policy Evaluation served as the Program Chairman. Four other members of the NRC Inter-Office Steering Group on Development of a Safety Goal served as resource persons in the discussions (Appendix B).

The Workshop was designed to help in pointing to directions for narrowing safety goal options for further consideration. The topics addressed included both quantitative and qualitative elements and economic, ethical, social and political issues. It was a discussion workshop, involving invited, knowledgeable persons representing a broad range of viewpoints, drawn from technical, social and humane disciplines. The general objective of the Workshop was to develop an information base on specific topics related to the formulation of a safety goal. The information sought concerned the following broad questions:

1. What are the principal criteria and considerations for selecting a safety goal? What are desirable and undesirable features?

2. What constraints limit efficacy of safety goal approaches? For example, what limitations are there from data base, methodological, institutional and socioeconomic standpoints? What approaches might minimize such constraints?

3. What are the issues of social impact and value judgment? i.e., what degree of safety is mandatory or desirable? What economic and social consequences of a safety goal and associated implementation are acceptable?

"Toward a Safety Goal: Discussion of Preliminary Policy Considerations" (NUREG-0764) was used as a principal basis of discussion at the Workshop, but discussion was not limited to the content or scope of that document. "An Approach to Quantitative Safety Goals" (NUREG-0739), a study prepared by the NRC's Advisory Committee on Reactor Safeguards (ACRS), was used in the discussion as one example of a concrete application of concepts discussed and as a point of reference for comments.

The Workshop participants were divided into three panels which considered the formulation of safety goals from different perspectives. The panels were:

Panel A: Quantitative Goals

Panel B: Qualitative Goals

Panel C: Economic, Ethical and Sociopolitical Considerations

Panel members are listed in Appendix C. Rapporteurs assisting the Panel Chairmen are listed in Appendix D. The panels were charged with the approaches indicated below:

Panel A - Quantitative Safety Goal

This panel discussed the issues involved in developing a quantitative safety goal. The topic encompasses the manner in which and the extent to which a quantitative goal can be made comprehensive, logical, verifiable, practical, and publicly acceptable. The discussion included regulatory decisions to be affected, goal form and structure, parameters to be specified, approaches to dealing with uncertainty in data, institutional issues of implementation, and the extent to which qualitative elements may need to supplement a quantitative safety goal.

Panel B - Qualitative Safety Goal

This panel discussed the issues involved in developing a qualitative safety goal. The topic encompasses the manner in which and the extent to which a qualitative goal can be made comprehensive, logical, verifiable, practical, and publicly acceptable. The discussion included regulatory decisions to be affected, goal form and structure, qualities to be specified, approaches to verification, institutional issues of implementation, and the extent to which quantitative elements may need to supplement a qualitative safety goal. The issues of quantitative and qualitative considerations in relation to each other received particular attention in this panel.

Panel C - Economic, Ethical and Sociopolitical Issues

This panel discussed the circumstances under which economic impacts should be taken into account in making safety decisions; guidelines that should be used when making tradeoffs between safety and economic values; ethical, social and political considerations in establishing an acceptable degree of safety and in distribution of risks and benefits, and institutional problems of implementation.

In addition to the discussions in the separate panels, to which most of the Workshop time was devoted, there were three plenary sessions. Panel Chairmen reported the interim and final results of their panel discussions at the second and third plenary sessions and these reports were the basis for discussion. The agenda was structured in this fashion to help assure adequate attention to details of significant issues as well as general perspective on the safety goal issues in totality. This report contains the final reports of the Panel Chairmen and highlights of discussions at the second and third plenary sessions. (The first plenary session consisted mainly of a brief orientation and the announcement of administrative arrangements.)

Discussion guidelines, including detailed questions, were provided to participants to frame the discussion. However, the participants were encouraged to depart from the specific questions and to adjust the general emphasis of the discussions, to the extent that their judgment led them to view such departure as conducive to fuller accomplishment of the Workshop's overall objectives. Such departures and adjustments did in fact take place, though to different extents in the different panels.

PANEL A REPORT - QUANTITATIVE SAFETY GOAL

H. J. C. Kouts, Chairman

Summary

There should be quantitative safety goals, in order to enhance the protection of the public - not directly, but through making the regulatory process less capricious and more objective. Goals must be clearly stated so as to permit a reasoned political test. Quantitative goals can force quantitative analysis of system and subsystem standards. They can provide a de minimis basis for deciding what measures are important for safety and what measures are not so significant.

The goals should be constructed around a qualitative statement, related to safety of the people. This should be supplemented by quantitative requirements for achieving the qualitative goals. Somewhere, but not necessarily as part of the goals themselves, there must be highly specific instructions on where and how to use these quantitative limits in a reasonably unambiguous way.

Several kinds of safety goals for nuclear power plants have been recently proposed by individuals and groups with different backgrounds and attitudes. These proposals address different qualitative objectives and they include a variety of criteria that are said to have been used to derive the quantitative goals. Yet, the product as quantitative limits is remarkably similar. Though limits are set on different quantities in different proposals, there is an overall consistency. This is at first surprising, because the guiding criteria in each case are largely arbitrary. The basic agreement reflects more concurrence than would be expected of work done in separate isolated monastic cells. Regardless of how this broad community of agreement may have been generated, much of the job of structuring rational safety goals with a broad consensus does seem to have been achieved already.

There is less agreement among the proposals on the way safety goals should be used. This question of the precise method of use may be as important or, perhaps, even more important than the goals themselves.

The goals should include requirements related to "hazard states" or "substates", so that not only a final grade is achieved. (Every professor knows the difficulty attached to giving only a single grade.) A limit on anticipated frequency of partial core damage is not very useful at this time, because no one knows how to calculate this probability as accurately as would be needed. The goals should also include quantitative components related to individuals more highly at risk and to the aggregate risk to society. They should also include a component related to financial impact on society.

The goals should respond to the question of "how safe is safe enough?", and should imply a judgement as to whether this state will be achieved. An ALARA-type (as low as reasonably achievable) of component should not be included. Such a requirement goes beyond a determination that the proposal would lead to an adequate degree of safety, and opens up the process of judgement to

an extent almost inviting caprice. The ALARA-type of requirement is foreign to processes involving goals and determinations as to whether they are met. For instance, no university could endure if, when students had met the objectives demanded for a degree, this degree was withheld on the ground that with a little more time and effort they could do still better.

This panel was not unanimous in rejecting an ALARA-type of criterion, but was almost unanimous on this.

For the present, the licensing process should continue to be deterministic with the deterministic requirements justified through demonstration that they assure meeting the safety goals. Both subsystem and whole plant analyses can contribute to this, but it is recognized that, in the present state of the art, a large element of judgement will still be involved, as well as recourse to operating experience. The one exception to the deterministic rule should be that an applicant for a license should be free to propose a new system or subsystem, and to prove, by analysis, that it is a better way to achieve a goal.

The quantitative aspects of the goals will require political consensus, but development of the techniques for calculation requires much more technical work. In particular, there may be some subgoals for which the calculation is now beyond the state of the art.

There is a conflict for resolution here between desirability and complete feasibility. Of course, it would be better if compliance with all safety goals and objectives could be determined with a high degree of assurance as to validity of the conclusion. Of course, the need for an element of judgement is not unique to this human endeavor.

The goals should guarantee, as far as possible, that the public benefit of nuclear power is greater than the risk (which is part of the overall cost). There was some uncertainty as to how this quantitative comparison might be made, but there was substantial agreement that it should be tried. The risk and cost should not be so unevenly distributed that any individual is unreasonably exposed to risk. It is recognized that this trade-off between public benefit and individual cost is inherent in any complex society, and the issues are no different (and no simpler) here.

The goals should be dynamic, to respond to progress in technology, but "grandfathering" plants already approved should be normal policy, in the absence of overriding safety considerations to the contrary. The dynamic character is especially needed because improved quantitative goals will probably find their principal application to plants that will not come into existence and operation for more than a decade. They must be adaptable to conditions that may be important then.

Political consensus, and public acceptance, are essential for the end product, but the responsibility of the NRC is to protect the public and not to satisfy it. These are not always compatible, nor always conflicting. If doctors and other professionals were licensed through a public hearing, we would have more charming quacks than we do now. Satisfying the public is a job for other elements of government whose function is meant to be more political than the NRC should be.

1. Degree of Consensus

There was a broad consensus throughout the Panel on all topics in the summary above except for the rejection of the ALARA concept. One member of the Panel strongly felt that an ALARA-type goal would be appropriate and desirable.

Only one topic generated a clear and widespread difference of opinion among Panel members. This was the reasoning to be used in arriving at quantitative aspects of a safety goal. Several concepts were profferred:

a. Risk by generating (energy/electricity) in nuclear plants should be (less than/not greater than) that attached to competing technologies.

b. The risk from generating (energy/electricity) in nuclear plants should not exceed a certain small fraction of the total risk due to man's initiatives.

c. Nuclear power should satisfy a risk/benefit or a cost/benefit criterion.

d. The risk from nuclear power should be small enough to be acceptable on a consensus basis.

It was suggested that another panel should be convened to consider the specific questions still at issue. This may focus and illuminate the questions better, though it is unlikely to resolve them. Final resolution will probably have to be done by executive decision, subjected to political test.

2. Additional Issues

The question of mode of use of goals is very important, and though it has been addressed above, it deserves additional space here. Some have suggested that each application for a license should be subjected to analysis to confirm meeting the goals as stated. We believe that this is not the proper use of goals; it would simply then be an analytical overlay on the present deterministic frame of requirements, and this would be the opposite of rationalizing the regulatory process. We have stated our view that the goals should be used in testing the adequacy and necessity of deterministic requirements. This process is workable, while direct application of risk analysis may not be fully feasible at this time. Our recommended method would provide an orderly transition from present practice to a possibly more direct use of safety goals in the future, when this may be possible.

The ACRS has proposed four types of limits to be applied to individual risk and two to be applied to societal risk. There may be some redundancy in these choices. It would be useful to explore the question of the number of degrees of freedom of this kind, to determine how much overspecification has been proposed. Some overspecification may still be tolerable, but it is best to be aware of its presence.

PANEL B REPORT - QUALITATIVE SAFETY GOAL

L. B. Lave, Chairman

Summary

The NRC is to be praised for its attempt to set safety goals quantitatively and with increasing specificity as well as to involve the public in an open, systematic process. The previous process was a major source of public dissatisfaction and misunderstanding and led to inconsistent, sometimes unsatisfactory decisions. This criticism does not detract from the exemplary safety record of nuclear power to date.

There are many publics. A mobilized public is apprehensive about the range of high technology industries as well as such areas as food additives and drugs. Nuclear power is not the unique source of public concern and the experience of other regulatory agencies has much to contribute to the resolution of present difficulties.

To satisfy these many publics and arrive at satisfactory decisions, NRC must consider a large number of social attributes. Considering only premature mortality and morbidity is insufficient to arrive at socially desirable decisions. In addition to considering economic and non-economic factors, the NRC must analyze implications for institutional change and the resources devoted to the regulatory process. Finally, the NRC must consider the distribution of each of these attributes across the population. Obviously, this cannot be done quantitatively and explicitly in each case, since this would ensure that no actions would ever be taken. But opportunities must be presented to raise each issue.

It is important to distinguish goals (statements of desires) from regulatory standards, which must be achieved before a license may be issued. Thus, qualitative safety goals are desires for "low risk" or risk as low as reasonable" while quantitative safety goals express a desire to achieve a risk level of 10^{-7}. Performance standards may be stated quantitatively (e.g., a failure rate less than 10^{-9}) while design or process standards can be expressed qualitatively or quantitatively. The AEC and NRC have had numerous quantitative standards but no quantitative goals.

While there are numerous, important advantages of quantifying safety goals, the NRC must recognize that there are important disadvantages. Virtually all of these disadvantages can be overcome by recognizing them and giving them careful attention.

Accident probabilities such as 10^{-7} are statements on the border of what is knowable and probably cannot be measured empirically. Current estimates must be qualified as theoretical with careful detailing of the data, model, and methods of arriving at them; this is especially true for a quantitative standard which must be defined unambiguously. The principal method for reducing confidence intervals about these estimates is a central collection and analysis of data about individual "micro" component failures and other difficulties. An explicit feedback process is necessary taking current experience, analyzing it, improving models, and changing operating instructions and design.

Qualitative and quantitative safety goals are complements not substitutes. Congress inevitably stipulates qualitative goals. The NRC must specify qualitative, quantitative, and process goals. These will serve to enhance safety by providing a coherent framework for regulation.

Arriving at quantitative safety goals involves relevant comparisons of nuclear power with public behavior and regulation of other risky behavior. However, deciding whether a comparison is "relevant" is a difficult issue requiring further research.

Implementation of qualitative safety goals requires coordinating quantitative, qualitative, and process goals at various levels. The goals make no sense without procedures for verification and for ensuring that the system operates as modeled. In particular, the NRC must oversee detailed specification of "good practice" that translates safety goals to the operational level.

For the NRC to establish acceptable safety goals, it must identify and involve all those who have a stake in the outcome. This is difficult and even cumbersome but necessary. The NRC must search for a "felicitous" process for gaining information and arriving at decisions without paralyzing action or absorbing inordinate resources. Information given to these groups must be arranged to facilitate their understanding, but it must be complete, not patronizing, and not sugar-coated.

The ACRS draft proposal is an exemplary beginning but does not satisfy the various attributes sketched above. It should provide a basis for further discussion but cannot be accepted as written.

1. <u>Why is the Public Apprehensive?</u>

It is important to note there are many publics and that measuring public opinion is extremely difficult, exceeded by the difficulty of manipulating public opinion. The mobilized public, those who demonstrate or contribute to support lobbying or litigation, represent a small proportion of the general public and one that is quite different in knowledge and often in attitudes. Without drowning in controversies about who speaks for the public, it is important to consider whether the questions raised are significant and have good answers.

Many people in the nuclear industry are accused of being paranoid about criticism. This is not paranoia since the criticism is real. But it is important to recognize that the criticism is not unique to nuclear energy. Much high technology, along with food additives, toxic wastes, and many other areas, are subject to intense criticism concerning safety.

We may be a nation of "healthy hypochondriacs," but attitudes toward safety are affected by current levels of income and health, as well as general values. In a democracy, public attitudes ultimately determine government actions. Thus, it is important that the media reports be accurate and present the facts and uncertainties.

Nuclear power has a set of attributes that intensify public apprehension. These include unfamiliarity with the technology and ionizing radiation, the possibility of latent effects, effects in the distant future due to genetic changes or future disease caused by long lived radionuclides, and cancer as the disease outcome. These special attributes of nuclear power must be considered in explaining public attitudes, comparing nuclear with other technologies, and setting safety levels. The exemplary safety record of nuclear power to date has not been sufficient to allay public fears.

2. Attributes Relevant to Regulation

Cancer deaths are not the only attribute to bear in mind in regulating nuclear power. To fail to consider the vector of possible attributes would lead to inferior judgements. For example, other health factors include other changes in premature death or changes in life expectancy, as well as changes in morbidity, especially in disability.

A host of other attributes is relevant, beginning with various measures of economic efficiency such as the level of goods and services available to consumers. Noneconomic attributes include aesthetics and values such as feelings about species extinction, damage to natural habitats, and damage to farmland. Finally, institutional changes and the resources devoted to the regulatory process are relevant.

Regulatory decisions must account, at least implicitly, for myriad attributes. When there are changes in technology or in these attributes, changes in goals and regulations may be warranted.

It is important to recognize that not all attributes can be considered explicitly, much less be subject to detailed analysis. Requiring this would paralyze the regulatory process, preventing action. Instead, the attributes that are most salient must be singled out in each case.

Also important is the distribution of each attribute change. Some groups benefit while others bear the cost or risk. Often, compensation should be paid to those bearing the cost or risk if they do not receive the benefits. Finally, benefits or costs may be distributed unequally across individuals. The effects on old or young groups, rich or poor groups, individuals of different race, gender or region, may prove important and influence the outcome.

3. Consequences of Quantifying Safety Goals

Attempting to quantify safety goals has major advantages and disadvantages. It is important to understand each in order to enhance the regulatory process.

The most important advantage is that quantification allows comparisons with other technologies and human experience generally. Without quantification, one is left with rather vague statements about "reasonable risk" or "generally safe." A secondary consequence is the ability to specify de minimis actions and effects. This notion can be defined rigorously and consistently only with quantification. Indeed, the consistency of decisions generally depends on quantification, at least when consistency is defined in benefit-risk or benefit-cost terms.

One additional implication is the ability to define what is an acceptable level of detection. For many toxic substances, and especially for radiation, detection is possible down to trivial amounts. It is important to define acceptable detection levels, lest minute quantities trigger massive over-response due to qualitative criteria.

Quantification provides the ability to keep an accurate historical record that can be used to measure performance, thus permitting a judgement about the quality of past performances. Similarly, it permits learning and evaluation of improvement. Experience and problems permit careful notice to people both inside and outside the agency of goals and performance, thus providing a necessary educational function.

Finally, it seems likely that an agency rule concerning a quantitative safety goal would resolve many issues. Thus, individual decisions need only be commensurate with the goals -- there would be no need to raise the goals anew with each decision. It seems likely the agency could proceed with its business more expeditiously after establishing precise goals and that legal challenges would be reduced.

A large number of disadvantages are associated with any attempt to establish a framework for consistent decisions. Indeed, there are methods for solving, or at least lessening, each difficulty.

The first disadvantage is a tendency to give too little attention to aspects that cannot be quantified. Numbers command attention, even when everyone agrees that unquantified aspects are of greater importance. Another aspect of this difficulty is the tendency to focus on numerical goals and neglect non-numerical goals.

Quantification and elaborate modeling can easily hide value judgements. Thus, not even the analyst may be aware that one formulation or parameter choice implies a crucial value judgement. Elaborate modeling can easily obscure goals and process so that no one is quite sure what is going on.

Quantification tends to pinpoint shortcomings, since it isolates failings. The immediate implication is acute embarrassment but there is the salutary effect of promoting a search for a solution. Indeed, of greatest importance is establishing a process that leads to better data collection, analysis, and decisions over time. Given the nature of scientific discovery and of our political justifications, it is naive to assume that current decisions will solve all problems and not be revised.

Finally, it is impossible to quantify such qualitative changes as war, revolution, or social ferment. If quantification engenders a false sense of security or confidence, the solutions may be badly adapted to the inevitable qualitative changes that occur.

Each of these disadvantages has been recognized previously and vast effort devoted to overcoming them. By listing the disadvantages and giving them attention, they can be overcome.

4. Is It Possible to Determine All Relevant Data?

Many nuclear events, but especially accident probabilities, cannot be known with certainty. For example, stating that an event has a probability of 10^{-7} per reactor year defies empirical verification and possibly even meaning. What certainty can be attached to such statements? What is the confidence interval about such a statement?

Such statements are built on an array of data and models. The data can presumably be verified, but the models depend on assumptions about which there may be disagreement and no easy possibility of resolving differences. Were there no way of resolving disputes over modeling and assumptions, quantitative safety goals would be undefined.

However, a macro event, such as a large accident, is composed of a series of micro events. The latter occur frequently and individual micro events, as well as a short series of these, can be observed and checked. Thus, additional data and aspects of the modeling are subject to verification, with greater verification possible as experience accumulates. Indeed, the modeling can be extended to calculate the probability that unobserved events will occur in the future.

This process is built on a feedback system that accumulates data, confronts and revises the model, design, and operations as needed, and continually attempts to learn from experience. The experience of individual reactors must be brought together and analyzed to get the greatest insights into rare events.

Sabotage depends on human behavior which cannot be estimated for the regulatory process or even modeled with confidence. However, bounds can be placed on damage and effects, even though probabilities of these events are undefined.

Sabotage is one type of event outside previous experience and thus represents an inherent uncertainty. As experience accumulates, one can have confidence that there will be fewer of these surprises, but they can never be eliminated. For some events, it is difficult even to bound the consequences.

The important aspect of modeling safety is the feedback process of collecting data, improving models, improving design and operating procedures, and collecting more data. Not only does this process lead to better estimates of accident probabilities, establishing this process as a quantitative goal leads to safer, more reliable operations.

5. Qualitative vs. Quantitative Goals

A qualitative goal is a statement of concern that directs action, but gives only the vaguest guidance as to how far to go. Statements such as "unreasonable risk" or "as low as reasonably achievable" mean different things to different people, especially in the sense that they would arrive at different regulations given the same data.

In contrast, a quantitative goal is quite specific, leaving no doubt about what is intended. Judgement is still involved in translating this goal into operational rules or standards, but expert judgement should converge as to whether a set of operating rules attains a set of quantitative safety goals.

Qualitative goals are general expressions of concerns that need little change over time. For example, "no unreasonable risk" could stand as the goal through varied circumstances. In contrast, a quantitative goal is attempting, at least implicitly, to balance benefits and costs and so depends on available technology, values, income levels, etc. As these change, the standards must evolve.

Congressional statutes nearly always contain qualitative goals. Unless Congress were prepared to add a vast amount of technical expertise and to devote inordinate amounts of time to investigations and revisions of these goals, they could not establish quantitative safety goals. Congress must delegate this function to the agencies, giving as specific direction as possible regarding how to settle value conflicts, what processes to use, and what is generally intended. Congress must also exercise its oversight function to ensure that the quantitative goals established by the agency fulfill Congressional intent.

For each agency, there is a complementarity among qualitative, quantitative, and process goals. The agency must take rather vague qualitative goals and translate them into specific quantitative ones and then into standards. That is not a value-free process to delegate to experts. Instead, the process needs public input (see Section 7).

Having established quantitative safety goals and standards, the agency must provide for advances in technology so that small changes in goals can be made easily and frequently. This can be done via ALARA with a dollar value of saving a man-rem. Finally, the agency must ensure that the system is operating as intended; if not, actual safety level will be lower than predicted in the analysis. Both the ALARA and checks on operations are qualitative (or mixed quantitative-qualitative) goals to complement the quantitative safety goals.

6. Implementation

A quantitative goal is meaningless without the means of verifying that it is being met as well as detailed procedures for implementation. Indeed, it is the set of standards and practices that define a safety level and determine if a quantitative goal is being met. The Congressional qualitative goal is linked to the agency qualitative goal as well as agency process and quantitative goals and standards to form a coherent regulatory framework. If any piece is missing, the framework is no longer coherent. In particular, either in regulation or "good practice," detailed decision rules or standards must be specified. Presumably, regulation should merely require that vendors, constructors, and operators use good practice, leaving the definition of good practice to a less cumbersome process. Preserving flexibility and being able to react quickly and easily to new circumstances is important.

Clearly, a proposed reactor must meet the qualitative and quantitative safety goals and their associated standards and practices before it is licensed. However, scientific progress and changes in goals mean that reactors in construction or operation will sometimes be found not to meet the quantitative safety goals. When this occurs, the seriousness of the violation must be estimated to decide which of a range of possible actions, from no action to delayed modification to immediate shutdown should be taken. The costs and inconvenience of each action must be recognized and weighed against the level of risk.

Performance standards are preferred to design standards where possible. The agency should specify its goals in terms of outcomes and hold those regulated responsible for achieving these outcomes. Specifying how this is to be done has two major disadvantages. First, it impedes innovation in finding cheaper, better ways of achieving the outcome. Second, it forces those regulated to defer to the agency even when they know that local circumstances mandate changes in procedure. The result is passivity in those being regulated; they do what they are told rather than take an active role in improving safety. The regulatory agency cannot possibly have the expertise or manpower to perform such a role for every local plant and so the system is inherently unsatisfactory.

To be sure, there are many times when it is currently impossible to specify adequate performance standards. For example, in licensing reactor operators, if there were a sufficiently good simulator, one would require only that operators pass a simulator test. However, if the best simulator available cannot test the range of knowledge and ancillary factors required, standards such as course requirements may be necessary.

Perhaps the most difficult aspect of implementation is focused on the reactor operator who normally performs only tasks calling for little training and no theoretical knowledge. However, a small part of the time, the operator must perform at a high level. The issues are how to recruit highly qualified people and then keep them at a peak of readiness for the few occasions when they will be tested.

The situation is akin to aircraft pilots or radar operators. Much can be learned from the studies and histories of these similar groups.

7. Finding a Felicitous Process for Involving Stakeholders

A vast number of groups, from Congress to the general public and industry have a stake in the regulatory decisions. A process is needed to get the proper input from each group, from statements of goals, to technical expertise, to information about whom is being discomforted. The process must be felicitous in the sense of raising the most important issues first and in a manner that elicits constructive responses and facilitates resolution.

It is not necessary to explicitly include Congress in the process; Congress clearly has an interest in the process of setting agency goals and will take a hand in the process when it feels it necessary. It will decide process and presumably follow the historical one of giving qualitative goals, deciding authorizations, and exercising oversight.

The goal from public input is to clarify public values, learn which individuals or groups are being harmed, learn if the current process is considered adequate, and gather evidence about whether goals are being met. The goal from industry and other technical experts is to learn if the technical issues have been handled correctly and to discover if goals are being met. Designing a felicitous process that accomplishes these goals is difficult, but of the highest priority.

Finally, a word is necessary about communicating with these groups. The agency must be forthright and candid in giving information. It should be explicit and avoid patronizing these groups or sugar-coating bad news. It is particularly important to present information in a helpful format to avoid confusion and misunderstanding.

PANEL C REPORT - ECONOMIC, ETHICAL AND SOCIOPOLITICAL CONSIDERATIONS

P. Slovic, Chairman

Summary

Panel C addressed its discussion to the following general questions: (a) What are the main economic, ethical, and sociopolitical issues in the formulation of safety goals for nuclear power? and, (b) How does the ACRS proposal deal with these issues?

In addressing these questions, Panel C focused on seven major issues, as follows:

1. Distributional questions
2. Treatment of genetic risks
3. Problems of scale
4. Level of risk
5. Risk aversion
6. Incentives
7. Process and verification

Although we feel that each of these issues is important, some are somewhat more important, and complex, than others, in their relevance for the formulation of quantitative safety goals. The resolution of some issues, such as risk aversion and process, could have enormous effects on the nature and acceptability of the resulting goals. Others, such as distributional effects, pose extremely complex ethical and methodological problems, some of which are unlikely to be resolved in the near future. The treatment of genetic risks is a complex, but potentially resolvable, technical problem. Each of these issues is discussed below.

1. Distributional Questions

Those who bear the risks from a technology may not share proportionately in its benefits. Many feel that it is ethically necessary to compensate those on whom risks are imposed inequitably. Two kinds of inequities were distinguished, spatial and temporal. Spatial inequity is illustrated by the example of siting a reactor in an unpopulated region in order to reduce the risk to a more populous region, which receives the electricity. Several of the panel members felt that this sort of circumstances warranted compensaion of those near the site, as it is done in France.

Temporal inequities are exemplified by the foreseeable transfer of risks to future generations. The principle of compensation seems much harder to apply in such cases. How does one determine the type and amount of benefits that would offset an increased cancer rate in some future generation? A few general principles were suggested (e.g., "leave the future a menu of opportunities at least as great as that of the present" or "don't increase the total risk burden to the biosphere"). However, it was generally felt that these were not complete or adequate. For example, the second of these principles would severely restrict many technologies in use today. Some cautioned that, in our zeal to protect future generations, we should not slight the needs of the present generation. It was pointed out that intergenerational problems are not unique to nuclear power, e.g., toxic chemical dumps raise similar (some would say even more serious) problems. Similar ethical principles should be applied to all such hazards.

Discussions of temporal issues led to a debate over the proper discount rate for losses. Most felt that a zero discount rate was appropriate (meaning that future losses would be weighted equally to present losses). Others felt that some discounting was appropriate but it could not be represented by any simple, constant discount rate.

The ACRS proposal didn't treat spatial and temporal inequities or discount rates. Defenders of the proposal asserted that it attempted to make the individual risk levels low enough that spatial and temporal inequities would not be a serious problem. Others felt that the issue could not and should not be sidestepped this way.

In summary, the panel expressed significant concern about the treatment of inequities in any safety goal program. There was some optimism regarding the development of compensation schemes to redress spatial inequities in the present but it was felt that intergenerational issues were much more complex.

2. Treatment of Genetic Risks

The ACRS proposal treats early and delayed deaths as surrogates for genetic effects. Most of the panel felt that this was inappropriate (a few felt it was justified because it was valid and because it led to appropriate simplification of a document that was already too complex). The majority felt that explicit treatment of genetic effects should be included in a safety goal, especially since the linear hypothesis is generally believed to hold for genetic, if not somatic, effects. The group was divided as to whether the explicit treatment of genetic risks should be quantitative or qualitative.

3. Problem of Scale

Another important consideration in setting safety goals is scale. Most of the panel agreed that it could make a difference whether goals were being designed for a world of 70 reactors or a world of 500. We discussed three general classes of problems in implementing safety goals due to scale. Institutional problems include possible slippage in the designing, licensing, and monitoring of plants and in the emergency response systems. In addition, large-scale nuclear systems may experience a shortage of trained personnel and produce severe demands on the regulatory system. The second problem is vulnerability arising from an unbalanced mix of energy technologies. A society heavily dependent on nuclear power may face severe hardship in the event of an industry-wide disruption. The third class of problems are contextual. How, for example, would communities near reactors or society in general react to the more frequent serious accidents that would arise from a large-scale system?

The ACRS proposal does not treat problems of scale. Many of the panel members felt that there should be a concentrated research effort aimed at determining the effects on operations and institutions due to scale. In the absence of definitive evidence, there was sharp disagreement within the panel about the direction and importance of such effects. There were also several panelists who questioned whether issues of scale were really within the scope of the NRC's goal-setting program.

Assuming that large-scale systems were likely to strain management capabilities, some felt that the following steps should be built into the planning process:

(a) Design plants to minimize the need for extraordinary organizational behavior to achieve nearly error-free performance and to minimize the cost of accidents.
(b) Minimize the regulatory burden on the state and federal agencies.
(c) Minimize the needs and costs to the community for maintaining emergency response readiness.
(d) Establish institutional means to accrue in the present the necessary resources to pay for rectifying accidents occurring in the future.

4. Level of Risk

One panelist came to the meeting with the anticipation that we might all sit around the table holding up cards, at appropriate times, with 10^{-x} numbers on them, somewhat like judges at the Olympics. Actually, we did not argue the merits of various levels of x. Instead, our discussion of level of risk focused on the issue of whether standards for nuclear power should be stricter than standards for other hazardous technologies.

Several of the panelists felt that standards for nuclear power should be stricter, because of greater uncertaintly surrounding the level of risk from accidents* and related issues of public perception and acceptance. One individual stated that while public concerns should be factored into safety goals, concerns fed by misinformation or exaggerated claims should not be considered (how does one separate this from "legitimate" concerns?).

Some of the panelists took a different position, arguing that nuclear power is already safer than alternative energy-producing systems, but that standards should be the same for all hazardous technologies. It was noted that, although some uncertainties may be larger for nuclear power, others (e.g., uncertainties about dose-response effects) were smaller for nuclear power. Further, stricter standards for nuclear power might lead to allocating large resources to reduce small risks in a way that would ultimately allow more death and damage from other sources. Some felt that other technologies, such as dams, posed similar risks as nuclear power (e.g., flooding resulting from a dam failure could cause the dispersal of chemical toxins having carcinogenic

*At least one panelist expressed serious concerns about the validity of the probabilistic risk analyses that underly the establishment and verification of safety goals. According to this view, events predicted to occur rarely are actually occurring with much greater frequency than anticipated. To take this into account, the probabilities summarized in the ACRS proposal would have to be revised downward.

and mutagenic effects). Another argument for the "equal standards" view asserted that we don't know enough about all the relevant issues to differentiate appropriately among hazards when setting target levels of safety.

In sum, although some panelists felt that stricter standards were warranted for nuclear power, there was sharp disagreement on this issue.

5. Risk Aversion

The ACRS proposal asserts that "because of the societal trauma and other secondary aspects that affect societal resilience in the event of a catastrophe, the societal cost of a single large accident may be greater than that of a large number of smaller accidents which, in the aggregate, kill the same number of people or cause the same amount of property or environmental damage" (p. 64). This "risk aversion" is modeled in the ACRS proposal by raising the consequences of an accident to some power α, where α is greater than 1.0.

This panel spent considerable time discussing the merits of risk aversion and the α model. Most agreed that some form of risk aversion was justified, not only because of the societal resilience argument, but (a) to offset the inequities of imposing risks on others, (b) to induce conservatism that would keep options open and facilitate information flow, (c) to offset lack of trust, and (d) to provide incentives for prevention and mitigation of accidents (e.g., remote siting).

A minority of the panel argued that risk aversion was not justified ethically or politically. On the ethical side, it can be shown that risk aversion leads to greater loss of life expectancy than does a policy in which $\alpha = 1.0$. On the political side, doubt was expressed that varying the exponent α would solve the problems caused by distrust.

The α model was also attacked as being simplistic and invalid. The social impact of a loss of N lives cannot be modeled by the function N . Accidents are perceived as signals containing information about the probability of their recurrence in similar or more destructive forms. As a result, a small accident in an unfamiliar or poorly understood system may have immense consequences if it portends further, and possibly catastrophic results. As Three Mile Island has shown, even "contained" accidents may prove to have immense costs (one estimate put the total cost in lost generating capacity due to TMI at $500 billion through the end of this century). These higher-order costs (labeled the "ripple effect") can swamp the more direct costs due to immediate and latent loss of life, property damage, cleanup, etc.

Such higher-order costs are not adequately represented by the α model. Were they to be incorporated into analyses of safety goals, they might warrant extremely strict standards aimed at preventing even small (but costly) accidents. The panel engaged in a vigorous discussion regarding whether such higher-order costs fell within the mandate of NRC to protect the public health and safety. Some favored a narrower view that would exclude such costs. Others felt they must be considered in establishing safety standards. It was noted that, in principle, some of these higher-order economic effects could be built into the ALARA portion of the ACRS standards, although others felt this was awkward and unsatisfactory.

6. Incentives and Accountability

There need to be better ways to evaluate risk assessors and their assessments, much like the credibility of weather forecasters' predictions has been evaluated. There was concern that probabilistic risk assessments were difficult to evaluate. In addition, some panelists felt that safety goals should contain a sophisticated system of rewards and punishments providing incentives for better performance, maintenance, and operation of nuclear plants.

7. Process

O. last discussion was our most intense. On one side of the debate were those who felt that it was critical to weave process considerations into the fabric of the goals. Such processes would insure that the goals are properly implemented and met. The ACRS document, in fact, briefly proposes that the NRC "arrange for a third party review of the probabilistic risk assessment" (p. 74).

How should this third party be appointed? Extensive discussion occurred over the merits of having reviewers appointed by the National Academy of Sciences, Presidential committees, or intervenors. Some felt that industry should take the lead in insuring that experts whom the public trusts are brought into an oversight role. Many of the panel felt that inclusion of processes to insure that safety standards are implemented and met is the crucial issue with respect to the value of safety goals and their credibility in the eyes of the public. Without a trustworthy process, some felt that goals could be used simply to speed up licensing, rather than to insure public health and safety.

As in most of our discussions, there was some dissent. A minority felt that safety goals should be treated in a narrower way--that they should not be expected to address all significant problems--hence, this issue was beyond the scope of the present forum.

SUMMARY - SECOND PLENARY SESSION

The second plenary session was convened on the morning of April 2 for the purpose of hearing interim reports by the panel chairmen. It also provided for the generation of ideas and suggestions by the participants with regard to directions being taken by each of the panels. The essence of those reports is contained in the final reports of the panel chairmen in this document.

Several points made in the interim report by Chairman Paul Slovic of Panel C are cast in different form in the final report. Briefly, these are:

1. There was concern that quantitative goals might capture or dominate the decision process, driving out valuable qualitative standards or procedures.

2. There was concern that the great uncertainties in quantifying certain factors and accompanying verification problems might lead to a number game and handwaving designed to give the illusion of satisfying the criteria at the expense of emphasis on some sound tried and true principles such as defense in depth.

3. There was concern about public acceptance and the effect of establishing quantitative safety goals on it. Some felt public acceptance of nuclear power might in fact be diminished. The public may prefer defense in depth relative to perceived obscure goals. There was a view that in a certain sense, these goals should proceed independent of specific concerns about public acceptance and the public should be consulted only where issues of relevance had a significant impact on their lives such as catastrophic loss of life.

Following the chairmen's reports, Dr. Lave presented some highlights of his interim report "A Survey of Safety Levels in Federal Regulation," a study to be published separately. He described eight decision frameworks for dealing with risk: market regulation, no-risk, risk-risk comparison, technology-based standards, risk-benefit analysis, cost-effectiveness analysis, regulatory budget, and benefit-cost analysis. He included some brief descriptions of their application in other Federal agencies with health and safety regulatory responsibilities.

Although the bulk of this plenary session was devoted to the interim reports, sufficient time was provided for discussion which is summarized below.

The plenary discussion of issues pertaining to Panel A centered on the need for a goal that is realistic enough both to be verifiable and to make regulation predictable and orderly. Several proposals were made concerning the possible relationship of a safety goal to present regulation. The question of how safe nuclear power should be in comparison with other sources of energy was also discussed briefly.

The plenary discussion of issues pertaining to Panel B centered on the difficulty of quantifying some factors and the need to consider them qualitatively in making a decision.

The plenary discussion of Panel C concerned mainly the relative difficulty of quantifying goals dealing with routine operation and goals dealing with accidents and how to consult the public about values relevant to establishing a safety goal.

SUMMARY - FINAL PLENARY SESSION

The final plenary session (April 3) began with summaries of Panels A, B, and C activities by their respective chairmen. The summaries encompassed the discussions that transpired during the panel sessions on the previous days.

Following the presentations by the panel chairmen, there was an open discussion of each panel's activities. The highlights of these discussions centered around the following topics as given below:

A. ALARA (as low as reasonably achievable) Concept
B. Process Issues
   Probabilistic Risk Assessment (PRA)
   Role of Public
C. Panel B issues
D. Risk Aversion

A. ALARA Concept

Those who opposed an ALARA concept believe that once a level of safety is achieved which satisfies the safety goal, then one should not go beyond this. It was felt that going beyond the level set by the goal would undermine the purpose of the safety goal and would introduce an irrational aspect to the regulatory process. While the majority of Panel A concluded that an ALARA provision should not be included in a safety goal, other participants were divided and the Panel A conclusion did not receive general endorsement.

There were also concerns with how the cost-benefit aspect of the ALARA concept relates to the safety goal. The following opinions were given:

- Setting an absolute standard may lead to actions which were not cost-effective, contrary to the ALARA aproach. Specifically, there was concern that the goals might be set too conservatively in the absence of an ALARA provision.

- The safety goal itself should be subject to a cost-benefit analysis if the regulators wanted to change the goal.

- An ALARA approach would be reasonable if the goals were set within a framework of a cost benefit comparison with alternative means of generating electricity.

- On the other hand, it was pointed out that a difficulty with a cost-benefit approach is the problem of dealing with the inequities in the distribution of the benefits and the costs.

- An opinion was expressed that society would want to reduce risks below a safety goal level if it could be done in a cost-effective way.

- Finally, an opinion was given that, the ALARA concept has been frequently carried below the de minimis dose level.

B. Process Issues

There was much discussion of the process of methods for establishing that a given goal, once set, was actually met. There was general agreement that the question of application of the goals is very important, perhaps at least as important as the goals themselves. These discussions centered on two areas: (1) the role of probabilistic risk assessment, and (2) the role of the public.

Probabilistic Risk Assessment

The prevailing opinion was that the verification of a safety goal should be done on a deterministic basis. In addition, there were several views on how probabilistic risk assessment could be used to supplement this process. One opinion was that if deterministic requirements were imposed, probabilistic analyses would, nevertheless, be needed in order to establish that the specified goals were met. Another opinion was that NRC should justify the present deterministic standards through probabilistic risk assessment and then permit licensees to deviate from the deterministic standards by providing probabilistic justification for doing so. There was a strong recommendation that the details of the verification process be considered more explicitly at future meetings (how would the results of probabilistic analyses be authenticated, and by whom, etc.?).

Role of Public

Discussion concerning the role of the public centered around the statement made in the Panel A summary that "the responsibility of the NRC is to protect the public and not to satisfy it". The delay in the venting of the TMI-2 containment was given as an example of a situation where, in the view of some participants, the NRC "catered to uninformed public views", rather than carrying out its responsibility and doing what was best for the public. It was noted that in addition to protecting the public, a responsibility of the NRC should be to satisfy the public that it is being protected.

The difficulties associated with this issue were underscored by an example of the experience of the Food and Drug Administration (FDA). This agency considers three questions in setting its priorities. The first is what are the largest sources of risk in the American food and drug supply. These are analyzed and ranked. The second is what is the largest source of concern expressed by the American public. There is, according to the participant who described the FDA process, almost no congruity between the answers to these two questions. The third question is where the agency can be most effective in terms of reducing risk. The agency puts these three questions together in setting its priorities without using any special formula for the decision.

There was a general consensus that technical issues should be addressed by the technical experts; however, the process of reaching decisions as well as the decisions themselves should be understandable to the public (the process should include critics as well as "well-intentioned experts"). This would add credibility.

C. Panel B Issues

A number of opinions were expressed in the course of the discussions related to Panel B (Qualitative Safety Goals).

- Quantitative safety goals should be flexible so that if changes occur in economic conditions, or health, or values, the numbers associated with the goal can be updated (e.g., a proposed goal of $1000/man-rem could change due to inflation, etc.). Qualitative goals, on the other hand, can stay fixed for all time, but will mean different things at different times.

- The earlier example of the experience of the FDA showed some of the difficulties inherent in taking somewhat vague qualitative goals, and then deriving meaningful quantitative goals from them. A quantitative safety goal is not derived from a qualitative goal by some theorems or lemmas--the reverse is perhaps more accurate.

- A qualitative goal provides a support structure as part of the meaningfulness of a quantitative goal. In addition, a qualitative safety goal, stated in qualitative terms is a felicitous summary of the quantitative safety goal and its effects.

- An explicit safety goal can provide a way to specify the intensity, nature, and speed of a required regulatory response as a function of the size of the difference from a perceived safe state. This would be extremely constructive in achieving a more rational process.

- Recommendations were made concerning the structure and content of the draft policy statement that should result from meetings of this kind in order for it to be "useful". Specifically, the policy statement should contain: a) a declaration of intent (including what aspects of the issue will, and will not, be considered); b) the process by which regulatory standards will be developed, and c) the class of regulatory decisions that is going to be affected (or at least addressed) by the policy statement. A plea was also made that "bureaucratese" and jargon be avoided in documents on which the public is asked to comment. (There must be a common language if one wants to bridge the gap between engineers and the public.)

- The issue of performance vs. design goals (or standards) was considered, particularly in the context of the problem of verification. Although there was generally a preference for performance criteria, it was recognized that the problem of verification was more difficult in this case than with design goals.

- One of the most useful uses of safety goals is to evaluate existing regulatory practice (or proposed rulemaking, e.g. Anticipated Transient Without Scram) to help assure that the results are rational.

D. Risk Aversion

There was a general (though not universal) feeling that large consequence accidents should be penalized in some fashion, i.e., given greater weight than the same total consequences distributed over a larger number of smaller accidents. However, how this should be done in the context of a safety goal was not clear. Although the ACRS approach, as described in NUREG-0739, (involving an exponent α on the consequence factor in the probability-consequence product as a measure of risk, where $\alpha > 1$) was criticized, no concrete alternative was offered. (Panel B recommended that NRC try to tackle this issue through a set of "relevant comparisons"; however, since these were hard to arrive at, they suggested some sort of public consensus). It was recognized that inclusion of some kind of "risk aversion" (the term was objected to by one participant who felt that it was misleading) can act as a surrogate for certain kinds of safety philosophies that the agency might want to encourage (e.g., remote siting). However, there was also a concern that assigning a large value for α (in the ACRS scheme) might lead to misallocations of resources away from areas which might be more effective in reducing the risk to various segments of society.

APPENDIX

DISCUSSION GUIDELINES

WORKSHOP ON FRAMEWORKS FOR DEVELOPING A SAFETY GOAL

Location: Palo Alto, California

Date: April 1-3, 1981

Arrangements contractor: Brookhaven National Laboratory

Date of these guidelines: March 9, 1981

Office of Policy Evaluation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

CONTENTS

INTRODUCTION

In October 1980 the Nuclear Regulatory Commission instituted a plan to develop a safety goal, to define more clearly the level of protection of the public health and safety that it believes is adequate. The Commission issued in March 1981 a Statement of Preliminary Policy Considerations, along with a supporting discussion paper. The statement and supporting discussion are included in NUREG-0764, "Toward a Safety Goal: Discussion of Preliminary Policy Considerations." NUREG-0764 is being issued for public comment. Its purpose is to elicit comments by indicating the kinds of considerations which may enter into an articulation of the Agency's safety goal.

NUREG-0764 has been prepared with a view to characterizing the domain of potentially useful approaches and perspectives with a comprehensive sweep. The intent was to create a wide enough starting base for later narrowing down to a few structured alternatives -- and perhaps one recommended approach.

The Advisory Committee on Reactor Safeguards has prepared "An Approach to Quantitative Safety Goals for Nuclear Power Plants" (NUREG-0739). The ACRS has characterized its proposal as intended to "serve as one focus for discussion." It is the only specific proposal that has so far been formally submitted to the Commission, and is detailed and accompanied by background information. The Commission has at this time not formed any views as to the merits of the approach described by the ACRS or any other single policy.

The April 1-3 Workshop is designed to help in the later narrowing of options, by illuminating the important issues of safety-goal formulation, including both quantitative and qualitative elements and economic, ethical, social, and political issues as well as technical considerations. This will be a discussion workshop, with assigned topics (and sub-topics assigned to sub-groups), involving invited knowledgeable persons representing a broad range of viewpoints, drawn from technical, social, and humane disciplines, from industry, public interest groups, universities, and elsewhere.

NUREG-0764 will be used as a principal basis of discussion at the Workshop. However, as will be evident from these guidelines, it is not intended that the discussions hew closely to that document or be constrained to its scope. The ACRS proposal (NUREG-0739) is intended for use in the discussions as one example of a concrete application of concepts discussed and as a point of reference for those of the discussants' comments for which that concrete example is convenient.

The Workshop agenda is structured along lines intended to help assure adequate attention to details of significant issues as well as general perspective on the safety-goal issues in totality. Much of the discussion will take place in three separate panels, each comprising about one-third of the Workshop participants. The panels are:

- Panel A: Quantitative Safety Goal
- Panel B: Qualitative Safety Goal
- Panel C: Economic, Ethical, and Sociopolitical Conisderations

The charters for the panels (presented in these discussion guidelines) include some overlap of subject matter in areas where it was judged that that could be useful in focusing on diverse aspects of an issue. Plenary sessions at mid-course and at the end of the Workshop will consider the chief results of the discussions in the panels.

A second workshop, to be held early this summer, will discuss merits and problems of a reference safety-goal statement and its chief alternatives.

The results of both workshops will be available to the Commission. They will also be used by the Office of Policy Evaluation as a part of the basis for preparation of a policy paper, scheduled to be submitted for the Commission's consideration in late summer 1981.

GENERAL GUIDELINES

Workshop Objectives

The general objective of the workshop is to develop an information base on specific topics related to the formulation of a safety-goal. The information sought will bear on the following broad questions:

1. What are the principal criteria and considerations for selecting a safety goal? What are desirable and undesirable features?
2. What constraints limit efficacy of safety-goal approaches? For example, what limitations are there from data-base, methodological, institutional, and socioeconomic standpoints? What approaches might minimize such constraints?
3. What are the issues of social impact and value judgment? I.e., what degree of safety is mandatory or desirable? What economic and social consequences of a safety-goal and associated implementation are acceptable?

General Description of Work Requested

1. Develop answers to the guideline questions or contribute information, analyses, and reasoned opinions that would be helpful in working towards such answers.
2. Identify the more significant issues within the issue area assigned to each panel; i.e., within the general area suggested by the questions, as well as the specific questions themselves.

IMPORTANT NOTE: The questions are stated in considerable detail, generally with explanatory subquestions, in order to describe as fully as possible the nature, range, and aspects of issues of interest. The panels are not expected to respond to a strict interpretation of these questions. Rather, the panels' judgments are sought on the issues and circumstances underlying the questions. What is considered important should be addressed. What is considered trivial should be brushed aside. Where a panel feels that the questions do not pose an issue cogently, the question should be addressed as it should have been phrased. In other words, the panels' judgment in interpreting the issues described by the questions is itself an integral part of the results sought.

3. Identify resolution options with respects to those issues where possible major constraints or areas of significant social evaluations are identified.

4. Describe expected impact of each option and comment on significance, merits and drawbacks.

5. Identify issues believed to be important but not sufficiently understood and, if possible, recommend means for addressing those issues.

Content of Panel Reports

The reports of each discussion panel should respond to the following questions:

1. What are the highlights of conclusions and views developed?

2. What conclusions and views command wide consensus?

3. What issues are strongly in debate and elicit widely divergent opinions and attitudes?

4. What means are recommended to resolve issues in dispute?

5. Of the suggested issues and questions which ones, if any, are considered of little or no significance?

6. What additional issues and questions are particularly important to address?

SPECIFIC GUIDELINES FOR PANEL A

SUBJECT: QUANTITATIVE SAFETY GOAL

SCOPE

This panel should discuss the issues involved in developing a quantitative safety goal. The topic encompasses the manner in which and the extent to which a quantitative goal can be made comprehensive, logical, verifiable, practical, and publicly acceptable. The discussion should include regulatory decisions to be affected, goal form and structure, parameters to be specified, approaches to dealing with uncertainty in data, institutional issues of implementation, and the extent to which qualitative elements may need to supplement a quantitative safety goal.

QUESTIONS

A. ACRS Proposal

1. What are the key characteristics of the approach to quantitative safety goals proposed by the ACRS? For each such characteristics:

   a. How strongly is it featured?

   b. How central is it to the overall approach reflected in the proposal?

   c. What would be the effects of possible modifications?

2. (a) To what extent does the ACRS proposal take into account:

   (i) Exposure of the most exposed individual?

   (ii) Exposure of an average individual?

   (iii) Worker exposure?

   (iv) Total exposure of populations?

   (v) Distinctions among effects of different kinds?

   (vi) Distinctions among effects of different severities?

   (b) What would be the effect of changes in the choice of means by which hazard is measured as specified by the ACRS approach in its decision rules (hazard states within the reactor, risk to the individual, societal risk)?

3. (a) What methods does the ACRS approach embody for ascertaining compliance?

   (b) What would be the effect of alternative methods?

   (c) Does the ACRS approach take uncertainties into account?

   (d) What would be the effects of alternative approaches to uncertainties?

4. What other comments concerning aspects of the ACRS proposal does the Panel wish to offer?

B. Other Proposals

5. What comments does the Panel wish to offer in response to Questions 1 to 4 as applied to other quantitative safety-goal proposals?

C. Structure of a Quantitative Safety Goal

6. In structuring a safety goal:

   (a) What process should be followed?

   (b) What elements should be included?

7. To what extent should the goal reflect protection of individuals regardless of numbers of persons affected, and to what extent should it reflect total, integrated population or societal effects?

8. To what extent should the goal relate to accidents and to what extent to normal operation?

9. What should be specified?

   (a) Probability of some event? E.g.:

      (i) Catastrophic accident including serious release outside containment?

      (ii) Core melt?

      (iii) Severe core damage?

      (iv) Failure of major systems (feedwater, scram, etc.)?

(b) Radiation exposure?

(i) In what terms?

(c) Some probabilistic measure of impact?

(i) In what terms?

10. What is the role of safety-cost tradeoffs?

(a) Should there be a mandatory degree of safety that would not be permitted to be compromised regardless of cost?

(b) Under what circumstances, in what manner, and to what extent should costs enter safety decisions?

(c) To what extent should benefits of nuclear power -- absolute and relative to alternatives -- enter safety-requirement decisions?

(d) To what extent is it appropriate for requirements for new and previously approved plants to differ?

11. In view of inherent uncertainties, how should probability estimates and consequence predictions be verified?

(a) By what technical approach?

(b) By what institutional arrangement?

12. What policies are appropriate in the face of gaps in knowledge as to what the risks are and the need for clarity of licensing requirements?

(a) Should there be an overall top-level safety-goal policy that would control lower-order specific decision classes, with toleration of uncertainties in interpretation of overall policy in terms of specific regulations? Or should goals be defined in operationally useful form for narrower areas, thereby achieving better predictability of requirements, though at the cost of losing some overall philosophical consistency and conceptual completeness?

(b) What is the proper balance between stability of requirements and flexibility for modification as knowledge develops and insights change?

13. Are there areas in which a quantitative safety goal needs to be supplemented by non-quantitative elements?

    (a) Where?

    (b) How?

    (c) What partial applications of a quantitative goal are advantageous?

D. Application of the Safety Goal

14. Should the safety goal be applied directly to cases, in order to attain a similar degree of safety from case to case (even though that may result in specific design and operational requirements differing according to circumstances)? Or should goals be applied generically and have requirements, rather than estimated degree-of-safety results, be uniform?

15. Under imprecision of goals or doubts as to their interpretation, how should judgments be made in:

    (a) Establishing generic requirements?

    (b) Cases?

E. Public Involvement

16. What are the institutional issues of public involvement in quantitative goal setting and in understanding verification?

    (a) What mechanisms are available?

    (b) How can the gap between the needs for highly technical analysis and the needs for formation and recognition of informed views of affected lay publics be bridged?

F. General Evaluation

17. What can a quantitative safety goal accomplish?

    (a) What can it not accomplish?

    (b) What are th key problems?

        (i) To what extent do these lend themselves to resolution with time and effort?

        (ii) What problems are irreducible?

SPECIFIC GUIDELINES FOR PANEL B

SUBJECT: QUALITATIVE SAFETY GOAL

SCOPE

This panel should discuss the issues involved in developing a qualitative safety goal. The topic encompasses the manner in which and the extent to which a qualitative goal can be made comprehensive, logical, verifiable, practical, and publicly acceptable. The discussion should include regulatory decisions to be affected, goal form and structure, qualities to be specified, approaches to verification, institutional issues of implementation, and the extent to which quantitative elements may need to supplement a qualitative safety goal.

QUESTIONS

A. ACRS Proposal

1. What qualitative elements does the ACRS approach contain?

   (a) What would be the effect of possible modifications or additions?

2. What other comments concerning aspects of the ACRS proposal does the Panel wish to offer?

B. Other Proposals

3. What comments does the Panel wish to offer in response to Questions 1 and 2 as applied to other proposals?

C. Structure of a Non-Quantitative Goal

4. What can be specified? E.g.:

   (a) Defense in depth (i.e., multiple, independent barriers, which may be physical barriers, redundant instruments and equipment, operational safeguards, location, etc.)?

   (b) Specific requirements (placed on design, location, operation, quality assurance, etc.)?

   (c) Qualifications of people (designers, operators, operations managers, etc.)?

(d) Organizational excellence and esprit?

(e) A technology-based parameter (e.g., best available technology)?

(f) A reasonable-efforts criterion (e.g., a requirement to keep risks as low as reasonably achievable (ALARA)).

(g) A non-quantified comparative criterion (e.g., no greater risk than from coal or other non-nuclear electric energy sources)?

(h) Combinations?

5. To what extent should a safety goal relate to accidents? To normal operation?

6. What mechanisms are available for translating a non-quantitative goal into specific criteria for deciding license applications?

   (a) How should uncertainties as to concrete meaning of a non-quantitative goal be dealt with?

   (b) How may compliance be verified?

   (c) Alternatively, on what basis may verification be foregone?

7. What is the proper balance between stability of requirements and flexibility for modification as knowledge and technology develop and insights change?

8. To what extent is it appropriate for requirements for new and previously approved plants to differ?

9. To what extent should safety goals vary according to populations protected? E.g., workers vs. general population, people who benefit from the plant vs. those who do not; adults, children, future generations?

10. What problems arise with non-quantitative approaches?

    (a) How can these be dealt with?

D. Hybrid Qualitative-Quantitative Approaches

11. To what extent is there a need for use of quantitative specifications in conjunction with a non-quantitative goal?

12. How and to what extent can non-quantitative guidelines fill gaps left by lack or imprecision of data in quantitative safety-goal approaches? E.g.:

    (a) In conjunction with risks subject to wide uncertainty but neither clearly excessive nor clearly trivial in relation to an established quantitative goal.

    (b) To override calculated results where fidelity of the calculational model is poor or suspect.

13. How and with what effect can a non-quantitative goal be used as a fixed general goal, with guidelines to interpretation, but with translation into quantitative terms allowed to vary as facts and perceptions change? E.g.:

    (a) "At least as safe as coal," with quantitative interpretation changing as technologies and understanding of risks change.

    (b) "As low as reasonably achievable," with translation into specific equipment, operational, etc. requirements handled by rulemaking?

14. What are advantageous combinations of quantitative and non-quantitative elements in a safety goal?

E. Application of the Safety Goal

15. In view of inevitable difficulties in interpretation of safety goals, how should judgments be made in:

    (a) Establishing generic requirements?

    (b) Cases?

F. Public Involvement

16. What are the institutional issues of public involvement in qualitative goal setting?

(a) What mechanisms can achieve effective public involvement, in view of the technical complexities presented by translation of non-quantitative goals into specific technical requirements and accomplishments?

G. General Evaluation

17. What can a non-quantitative goal accomplish?

    (a) What can it not accomplish?

    (b) What can it accomplish in conjunction with quantitative elements?

    (c) What are the key problems?

        (i) To what extent and how can these problems be solved?

SPECIFIC GUIDELINES FOR PANEL C

SUBJECT: ECONOMIC, ETHICAL, AND SOCIOPOLITICAL ISSUES

SCOPE

This panel should discuss the circumstances under which economic impacts should be taken into account in making safety decisions; guidelines that should be used when making tradeoffs between safety and economic values; ethical, social, and political considerations in establishing an acceptable degree of safety and in distribution of risks and benefits; and institutional problems of implementation.

QUESTIONS

A. ACRS Proposal

1. What are the key issues posed by the ACRS approach to safety goals from institutional, social, and ethical standpoints?

   (a) Does the ACRS proposal deal with those issues? How?

   (b) What would be the effects of alternative ways of dealing with those issues?

2. What issues are posed by the ACRS suggestion of a Risk Certification Panel with statutory authority to make findings on risk values under uncertainty?

   (a) Does the ACRS proposal deal with those issues?

   (b) What would be the effects of possible modifications or alternatives?

3. What other comments concerning aspects of the ACRS proposal does the Panel wish to offer?

B. Other Proposals

4. What comments does the Panel wish to offer concerning other safety-goal proposals?

C. Main Issues

5. What are the main economic, ethical, and sociopolitical issues in nuclear power-plant safety-goal formulation?

D. Equities and Tradeoffs

6. What is the role of safety-cost tradeoffs?

   (a) Is there some mandatory degree of safety that must be assured regardless of cost?

   (b) What ethical and sociopolitical principles should underly safety-cost tradeoffs?

   (c) Under what circumstances, to what extent, and how should costs be taken into account in safety decisions?

7. To what extent should benefits of nuclear power -- absolute and relative to alternatives -- enter safety-requirement decisions?

8. To what extent is it appropriate for requirements for new and previously approved plants to differ?

9. To what extent should goals reflect protection of individuals regardless of numbers of persons affected, and to what extent should they reflect total, integrated population or societal effects?

10. To what extent should equities of distribution of benefits and adverse impacts influence safety requirements?

11. In what circumstances and to what extent should differing risks and interests of various population groups be taken into account? Notably:

   (a) Workers.

   (b) Licensees.

   (c) General population.

   (d) Adults, children, and future generations.

   (e) Those who benefit from the plant and those who do not.

E. Implementation

12. What are the key institutional and sociopolitical issues of implementing (a) formulation and (b) application of a safety goal?

13. What issues are posed by the technical nature and complexity of the safety issues on the one hand and the need for public understanding and involvement on the other?

    (a) How can those issues be dealt with?

    (b) By what processes and under what influences is a public will with respect to a safety goal formed and how and by whom expressed and asserted?

    (c) How and by whom can those processes be ministered to in the public interest?

14. What issues are posed by limitations of human and social capability in the face of complex systems and processes, such as those of nuclear power plants?

    (a) What are the implications of those issues for formulation and application of a safety goal?

    (b) How may those issues be dealt with?

15. What institutional mechanisms are available for dealing with uncertainties as to risk, stemming from lack and imprecision of data and limitations on ability to apply data?

16. What is the proper balance between stability of requirements and flexibility for modification as knowledge develops and insights change?

F. Degree of Safety

17. (a) What factors should determine the degree of safety to be sought?

    (b) On what basis should one determine:

    (i) What known risk levels are acceptable?

    (ii) What uncertainties are acceptable?

    (iii) To what extent there is increased aversion to risk of high consequences even at low probability?

18. How should stringency of safety goals compare with:

    (a) Risks accepted from other (non-nuclear) electrical energy sources and with risks arising in various other contexts?

    (b) Current nuclear-plant practice?

G. General Evaluation

19. From the economic, ethical, and sociopolitical standpoints, what are the main potentialities and pitfalls of a safety goal?

    (a) What key measures can help realize the potentialities and avoid the pitfalls?

APPENDIX B

NUCLEAR REGULATORY COMMISSION PARTICIPANTS

Mr. Robert M. Bernero
Division of Systems & Reliability Research
Technical Resource - Panel A

Mr. Malcolm L. Ernst
Division of Safety Technology
Technical Resource - Panel C

Mr. Morton W. Libarkin
Advisory Committee on Reactor Safeguards
Technical Resource - Panel B

Mr. Martin G. Malsch
Office of General Counsel
Legal Resource - All Panels

Mr. George Sege
Office of Policy Evaluation
Program Chairman

Appendix C

PARTICIPANTS IN THE NRC WORKSHOP ON DEVELOPING A SAFETY GOAL

PANEL A - QUANTITATIVE SAFETY GOAL

Dr. Herbert J. C. Kouts, Panel Chairman
Brookhaven National Laboratory
Chairman, Dept. of Nuclear Energy
Ph.D. - Princeton University (Physics)

Dr. Jan Beyea
National Audubon Society
Senior Energy Scientist
Ph.D. - Columbia University (Nuclear Physics)

Mr. Sol Burstein
Wisconsin Electric Power Company
Executive Vice President

Dr. Vojin Joksimovic
General Atomic Company
Manager, Safety Reliability and Systems Department
Ph.D. - Imperial College (Nuclear Engineering)

Mr. Saul Levine
NUS Corporation
Vice President and General Manager of Consulting Division
M.S. - Massachusetts Institute of Technology (Nuclear Engineering)

Prof. Harold Lewis
Department of Physics
University of California at Santa Barbara
Member, Advisory Committee on Reactor Safeguards
Ph.D. - University of California at Berkeley (Physics)

Prof. William Lowrance
Life Sciences & Public Policy Program (Risk Assessment)
Rockefeller University
Ph.D. - Rockefeller University (Organic Chemistry)

Prof. Allan C. Mazur
Department of Sociology
Syracuse University
Ph.D. - Johns Hopkins University (Sociology)

Mr. David Salisbury
Christian Science Monitor
Denver Correspondent
B.S. - University of Washington (Physics)

Niel Wald, M.D.
Professor, Department of Radiation Health
University of Pittsburgh
M.D. - New York University College of Medicine

PANEL B - QUALITATIVE SAFETY GOAL

Dr. Lester Lave, Panel Chairman
The Brookings Institution, Senior Fellow
Carnegie-Mellon University, Prof.
Ph.D. - Harvard University (Economics)

Prof. Norman Bradburn
Department of Behavioral Sciences
University of Chicago
Director, National Opinion Research Center
Ph.D. - Harvard University (Social Psychology)

Mr. Dale Bridenbaugh
M.H.B. Technical Associates
President
B.S. - South Dakota School of Mines (Mechanical Engineering)

Mr. Stephen L. Derby
Independent Consultant
Ph.D. Candidate - Stanford University (Engineering Economic Systems)

Prof. Merril Eisenbud
Institute for Environmental Medicine (Radiation Physics)
New York University Medical Center
B.S. - New York University (Electrical Engineering)

Peter Hutt, Esq.
Attorney-at-Law
Covington & Burling
LL.M. - New York University

Dr. Margaret N. Maxey
South Carolina Energy Research Institute
Assistant Director
Ph.D. - Union Theological Seminary (Christian Ethics)

Karin Sheldon, Esq.
Attorney-at-Law
Sierra Club Legal Defense Fund
Staff Attorney
J.D. - University of Washington

Mr. Mark I. Temme
General Electric Company
Manager, Reactor Safety
Chairman, IEEE Working Group SC-5.4 (Risk Criteria)
M.S. - Stanford University (Computer Science)

Dr. Edwin Zebroski
Electric Power Research Institute
Director, Nuclear Safety Analysis Center
Ph.D. - University of California (Physical Chemistry)

PANEL C - ECONOMIC, ETHICAL AND SOCIOPOLITICAL CONSIDERATIONS

Dr. Paul Slovic, Panel Chairman
Decision Research
Ph.D. - University of Michigan (Psychology)

Gerald Charnoff, Esq.
Attorney-at-Law
Shaw, Pittman, Potts & Trobridge
LL.B. - New York University

Dr. Thomas Cochran
Natural Resources Defense Council
Senior Staff Scientist
Ph.D. - Vanderbilt University (Physics)

Prof. Todd LaPorte
Institute for Governmental Studies
University of California at Berkeley
Associate Director
Ph.D. - Stanford University (Organization Theory)

Prof. Douglas E. MacLean
Center for Philosophy & Public Policy
University of Maryland
Research Associate
Ph.D. - Yale University (Philosophy)

Mr. Edward O'Donnell
Envirosphere Company
Vice President
Chairman, AIF Subcommittee on Probabilistic Risk Assessment
M.S. - Columbia University (Nuclear Engineering)

Prof. David Okrent
School of Engineering & Applied Science
University of California
Member, Advisory Committee on Reactor Safeguards
Ph.D. - Harvard University (Physics)

Prof. Talbot Page
Environmental Quality Laboratory
California Institute of Technology
Ph.D. - Cornell University (Economics)

Prof. Charles B. Perrow
Department of Sociology
State University of N.Y. at Stony Brook
Ph.D. - University of California (Sociology)

Dr. Chauncey Starr
Electric Power Research Institute
Vice Chairman
Ph.D. - Rensselaer Polytechnic Institute

APPENDIX D

BROOKHAVEN NATIONAL LABORATORY PARTICIPANTS

1. Workshop Organization and Coordination:

   Walter Y. Kato
   Anthony J. Romano

2. Rapporteurs:

   Michael Todosow, Panel A
   Ralph J. Cerbone, Panel B
   Robert A. Bari, Panel C

3. Secretaries:

   Barbara M. Barrett
   Dorothy K. Thompson

NRC FORM 335 (7-77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER (Assigned by DDC) NUREG/CP-0018 BNL-NUREG-51419	
4. TITLE AND SUBTITLE (Add Volume No., if appropriate) Workshop on Frameworks for Developing a Safety Goal	2. (Leave blank)
	3. RECIPIENT'S ACCESSION NO.
7. AUTHOR(S)	5. DATE REPORT COMPLETED MONTH June YEAR 1981
9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) Brookhaven National Laboratory Upton, NY 11973	DATE REPORT ISSUED MONTH June YEAR 1981
	6. (Leave blank)
	8. (Leave blank)
12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) Office of Policy Evaluation U.S. Nuclear Regulatory Commission Washington, DC 20555	10. PROJECT/TASK/WORK UNIT NO.
	11. CONTRACT NO. FIN A3222
13. TYPE OF REPORT Formal Report	PERIOD COVERED (Inclusive dates)
15. SUPPLEMENTARY NOTES	14. (Leave blank)

16. ABSTRACT (200 words or less)

The "Workshop on Frameworks for Developing a Safety Goal" was designed to help in pointing to directions for narrowing safety goal options for further consideration. The topics addressed included both quantitative and qualitative elements and economic, ethical, social and political issues. It was a discussion workshop, involving invited, knowledgeable persons representing a broad range of viewpoints, drawn from technical, social and humane disciplines. The general objective of the Workshop was to develop an information base on specific topics related to the formulation of a safety goal.

"Toward a Safety Goal: Discussion of Preliminary Policy Considerations" (NUREG-0764) was used as a principal basis of discussion at the Workshop, but discussion was not limited to the content or scope of that document. "An Approach to Quantitative Safety Goal" (NUREG-0739), a study prepared by the NRC's Advisory Committee on Reactor Safeguards (ACRS), was used in the discussions as one example of a concrete application of concepts discussed and as a point of reference for comments.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT Unlimited	19. SECURITY CLASS (This report) Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS (This page) Unclassified	22. PRICE $

NRC FORM 335 (7-77)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. NUCLEAR REGULATORY
COMMISSION

U.S. MAIL

NUREG/CP-0018