COMPROMISING THE FUTURE:

THE PROBLEM OF BOUNDING UTILITY MEASURES

FOR TECHNOLOGICAL ENDEAVORS

by

John N. Warfield

Department of Electrical Engineering

University of Virginia

Charlottesville, Virginia

22901

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COMPROMISING THE FUTURE: THE PROBLEM OF BOUNDING UTILITY MEASURES FOR TECHNOLOGICAL ENDEAVORS

John N. Warfield+

It is likely that improperly bounded utility measures for technological endeavors will compromise the future of civilization. The same is true, and with even more emphasis, in relation to political endeavors.

Therefore it is important to give careful consideration to how utility measures for technological endeavors are bounded: that is, to the way in which it is decided what is and what is not to be included in such utility measures.

While this paper is primarily concerned with measures for technological endeavors, it is appropriate to recognize that there are areas of significant overlap and interaction between technological and political endeavors. These may be found in such sectors as energy, defense, transportation, intelligence-gathering, and international relations. It is believed that what is said in the following is relevant also to these areas of overlap.

RELEVANT PERSPECTIVES

In any consideration of utility measures, it is appropriate to sustain an awareness of the historical context of this subject.

+ Department of Electrical Engineering, University of Virginia, Charlottesville, Virginia, 22901

It will be recalled that the English jurist and reformer, Jeremy Bentham (1748-1832), synthesized "utilitarianism", based on ethical hedonism (the doctrine that happiness is coincident with "good", hence the primary ethical goal is to produce the greatest amount of happiness for all humanity). It was inherent to this concept that happiness stems from what an individual values, regardless of its nature or the reasons for valuing it.

Bentham believed that it was possible to construct a calculus of happiness based on such factors as intensity and duration of happiness in relation to various social options.

Among the accomplishments of Bentham and his followers may be listed the institution of health control measures, insurance, poor laws, humanitarian prison reforms, founding of the University of London, and extension of democracy and self-government. Bentham also advocated international law, a league of nations, and the emancipation of colonies.

Bentham was not literarily inclined, but was a doer in the political arena. Bentham's ideas were largely documented and explained by John Stuart Mill (1806-1873), who backed women's suffrage, land reforms, and cooperatives, and wrote profusely.

Certainly a major statement of the general principle that evolved from this historical background is the following:

> Social value should not be attached directly to actions, policies, laws, or institutions, because of their intrinsic character, but rather indirectly because of their consequences in human experience; i.e., in terms of the

general welfare of all persons affected by them.

It must be apparent that, in the absence of the development of the calculus whose possibility was postulated by Bentham, this principle is often extremely difficulty to apply in a quantitative way, though its qualitative or intuitive application may not be so limited.

It is tempting to suppose that present-day analyses are much more solidly based--that operations research, cost-benefit analyses, and similar quantitatively oriented approaches or methods have somehow overcome the difficulties, or at least circumscribed the basis--but there has been no fundamental resolution. Possibly the most fundamental difficulty lies in the absence of any independent, basic set of values upon which to build a component analysis. Even if there were a mutually independent set of basic values that was exhaustive of human values, the application of the principle would still require unparallelled data-gathering and computation. But even if such data could be gathered and such computations could be made, there would be no assurance that the conclusions based on them would continue to be representative through time, or even appropriate by the time the data were fully analyzed. And if all of these objections could be met, there would still be no assurance that the values of those polled would represent adequately the interests of the very young, or of the future generations.

The foregoing argument surely demonstrates that the greatest difficulty in attempting to apply the general principle is the inability to bound it in any sensible way so that it can be put into service.

Accordingly, it is appropriate to consider whether there are other principles, perhaps less encompassing or cutaneously attractive, that might be put to work to help develop utility measures for technological endeavors that would be appropriately bounded. It is inherent in the word "measure" that quantitative expressions be present. And it is also inevitable that narrowness and sharpness be there, for these attributes go along with the quantitative. How narrow a context can be involved?

Let us remember that we are involved in a conceptual hierarchy at this meeting. Figure 1 shows four levels of this hierarchy. At the top is the general theme of this meeting, "science and our expectations", and at the second level is one of the three major topical categories, "uses of science". Under this heading, our session is a part of an array of sessions having to do with "science and technology policy", and within this general framework, we are discussing social utility measures for technological endeavors. Regrettably, from the standpoint of sharp quantification, the context of our discussion is broad. While measures might be set forth that would be quite quantifiable, it is not at all clear that such measures would be harmonious with the broad context within which we are embedded by the designers of this conference.

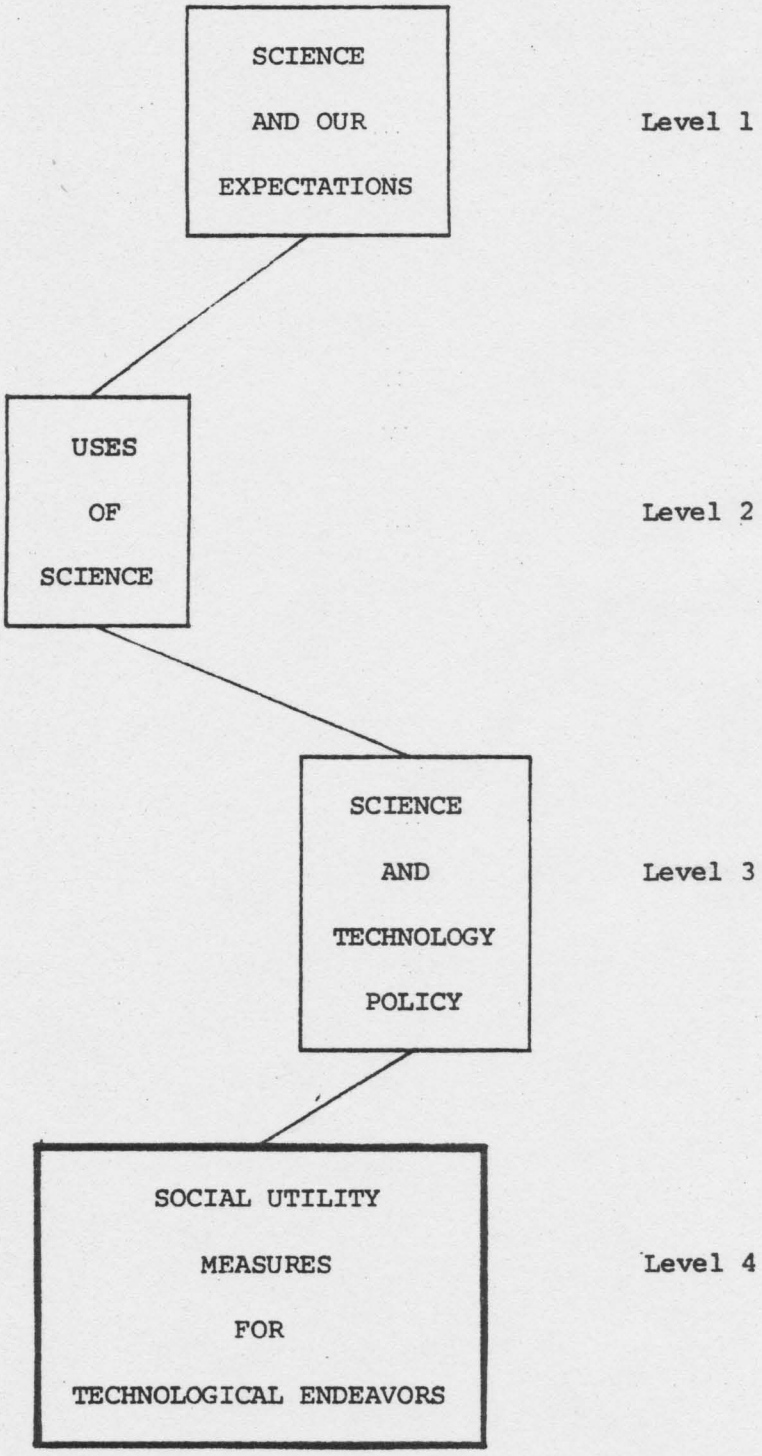

FIGURE 1. The Context of this Paper

In terms of level 3 in Figure 1, it is relevant to note that our measures ought to be connectible to science and technology policy. In fact, their importance would supposedly be directly proportional to their availability for use in formulation of such policy. But this lays the measures open to some heavy bombardment from thoughtful analysts of the difficulties of using quantitative methodology in policy analysis, for example Strauch [1].

On the other hand, a certain amount of focusing is also obtained. If it is clear that measures are expected to be useful in policy setting, then to some extent criteria that measures ought to satisfy can be adduced from the functions of policy [2]. The purpose of policy is to influence human behavior, and policy does this through enabling, regulating, or inhibiting behavior. Then such measures as may be developed should be either directly or (if indirectly) closely related to specific forms of behavior that are to be affected by policy. If, for example, the behavior of concern relates to doubling or tripling the amount of coal mined in a year in the United States, then the measure ought to have some rather apparent relevance to this type of behavior. Since this particular behavior represents an expansion, it is the enabling function of policy that may be of most direct concern, and measures might relate to enabling such an increase.

But as policy is involved, and especially public policy, our discussion tends to move more into the area of overlap between technological endeavors and political endeavors. Is expanding coal production a "technological endeavor"? The answer clearly is

"yes" and "no".

Whenever science and technology are closely allied with the political, science and technology take on a certain hazard or risk. Specific examples could be mentioned from the late 1960's and early 1970's. But our concern is largely with the future. In this respect, it is desirable to be aware of some current concerns for the future of politics.

Studies of the attitudes of children in grade school toward the president and the government of the United States were carried out in 1962, 1973, and 1975. Arterton [3] presents the data and renders the following interpretation:

> There is a suspicion "that we are headed for a profound legitimacy crisis in our political future. This guess need not be based so much on the causes of children's rejection of political authority as on its existence. . .the longer these sentiments and beliefs are maintained, the more thoroughly they will become embedded in the individual's cognitive structuring, and thus the more resistant to change they will become... ."

The data show a shift in attitudes from highly positive in 1962 to highly negative in 1973, with only modest diminution in 1975.

Regrettably, if this highly negative attitude toward government is sustained in the adult years, it may well be that in the next ten to twenty years everything that government touches will suffer from the association. Hopefully such a situation can be avoided by government, but it seems that some conscious effort will be required, ~~to achieve it~~. It is even more appropriate that science

and technology go to considerable lengths to help the government improve its image by legitimate means. But even if government does not achieve such a result, science and technology should not be carried down by association. Science and technology has to protect its own image. In our context, this means that it will not be enough simply to invent a few measures to go by. The credibility of social measures will be of increasingly greater importance in the years ahead. It is for this reason that science and technology is going to have to be more responsible than in the past in setting high standards of performance in all those matters that involve a connection of science to public policy. This may mean, for example, that a kind of "Bureau of Standards" for social measures will have to be institutionalized, at least in a semi-formal way, within the scientific and technological community, simply to have a formal way of recognizing which social measures come up to the kinds of standards deemed desirable.

The "kepone" scandal in Hopewell, Va., is a depressing example of the kind of difficulty that we could do without.

THE "NET ENERGY" CONCEPT

The "net energy" concept, as described by Gilliland [4], was taken as an example of a potential measure for purposes of this session. The basic idea behind a social measure of "net energy" is that it would be helpful, in using public funds to develop energy sources for the future, to concentrate attention in those areas where the amount of energy to be gained from some technological endeavor would exceed the amount of energy expended in gaining it. If, for example, it was necessary to expend two units of energy from petroleum to get one unit of solar energy, then solar energy would be relatively unattractive, whereas if it were possible

to get two or three or more units of solar energy for every unit of energy from petroleum, the development of solar energy could be quite attractive. In view of the apparent reasonableness of this kind of measure, it would be supposed that it would immediately become a part of federal energy policy. Nevertheless, very little emphasis on net energy analysis was observed by the Office of Technology Assessment in reviewing the Energy Research and Development Administration's national energy plan submitted to Congress on June 30, 1975. In its critical analysis of the energy plan, the Office of Technology Assessment pointed out [5]:

> "...net energy may not comprise the most significant criterion in setting energy policies and pursuing national objectives; for example, reduction of oil imports may be more important than the net energy ratio of a coal liquefaction facility...Clearly, a great deal of research must be performed before net energy analysis can be a consistent and widely accepted methodology. The ERDA Plan and Program virtually ignores the subject, despite the consideration of net energy as one of the five basic principles in the law establishing the agency."

In addition, the following statement is particularly illustrative of the general dilemma of constructing good utility measures:

> "Energy analysis has yet to advance beyond the stage of establishing a coherent framework of definitions and accounting procedures. The

> assumptions underlying energy analysis are still subject to widely varying interpretations, thereby yielding widely varying results. The most important difficulty involves determining the boundaries of the analysis." (Underlining added.)

It is believed that the statement just quoted applies to most social measures that would be broad enough to have policy relevance, if the word "energy" is replaced with whatever topic is addressed by the measure.

SOME THOUGHTS ON BOUNDING

The problem of bounding a utility measure is not too different from that of bounding a technology assessment, or establishing the scope of an organization or agency. In its most elementary and concrete form, bounding a utility measure can be interpreted as deciding the following questions:

A. What numerical factors will be represented in the formula that yields the measure? (And, by implication, what numerical factors will not be included therein?)

B. In what way will the factors enter in the formula (e.g., linearly, additively, multiplicatively)?

C. What will be the scale and range of the measure?

In this form, while the essential properties are made visible, the root difficulties alluded to earlier are still buried.

The latter have been explored, in relation to bounding, in a recent workshop [6]. From the ideas generated in this workshop, it is possible to articulate three principles believed to be very relevant to bounding. These are called the "triple-A" principles.

The first of these, the "accordion" principle, states that it is very important in bounding to follow the practice of deliberately expanding the scope as well as narrowing it. This practice is suggested by Figure 2, illustrating an iterative expansion and contraction of scope, generally diminishing in sweep and duration, until a satisfactory bound is attained.

The second, the "association" principle, states that a measure should always be associated with at least one model (and that a model should always be associated, in turn, with a set of relevant assumptions upon which it is based). This principle can also be applied to help establish a basis for setting measures. Figures 3, 4, and 5 show three different dominance scales for three different worlds. If the dominance scale of Figure 3 is assumed, it might be postulated that since values establish political philosophy, and political philosophy dominates policy, and policy dominates decisions, the way to establish measures is to extract them from existing policy considerations, so that decisions could thereby be guided. A very different concept would follow if the dominance scale of Figure 4 is assumed, wherein policy does not even appear, and values and technological options are brought together as a basis for decision making. With this concept, measures could be sought by direct analysis of values in relation to technnological options, in order to facilitate decisions.

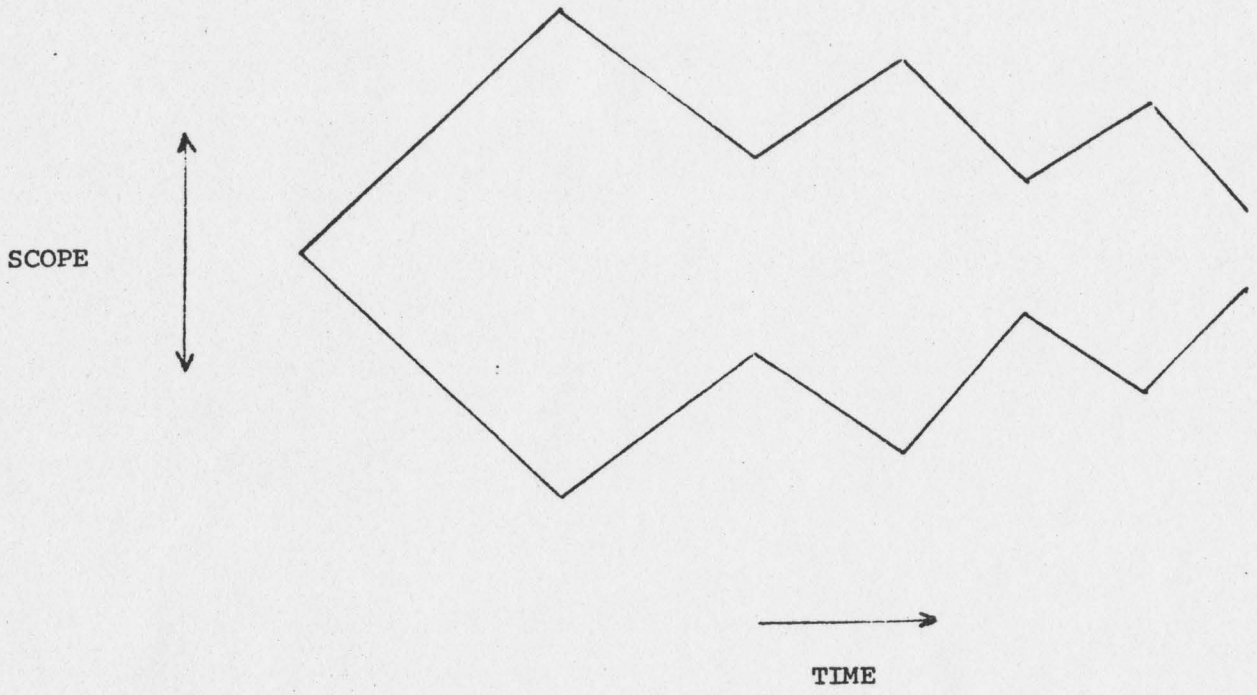

FIGURE 2. Illustrating the "Accordion" Principle of Bounding

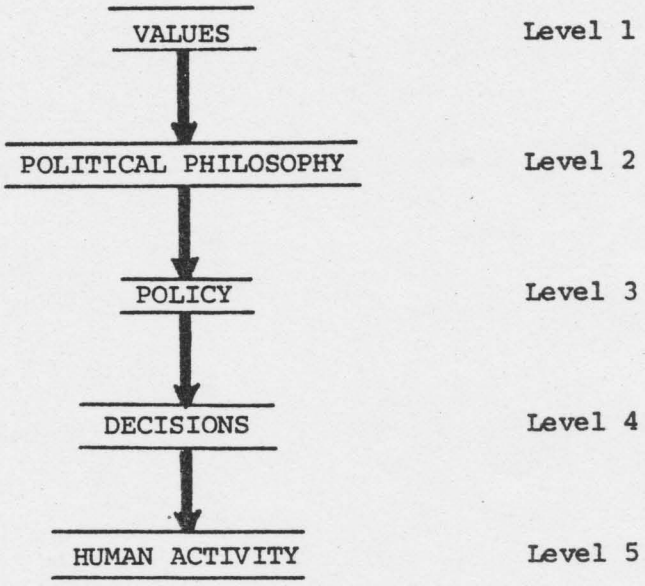

FIGURE 3. DOMINANCE SCALE FOR WORLD "A"

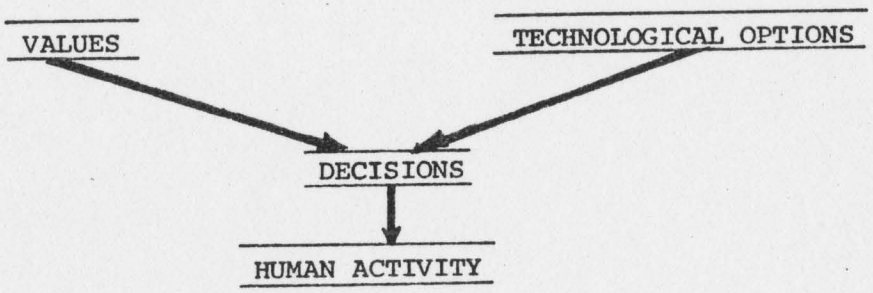

FIGURE 4. DOMINANCE SCALE FOR WORLD "B"

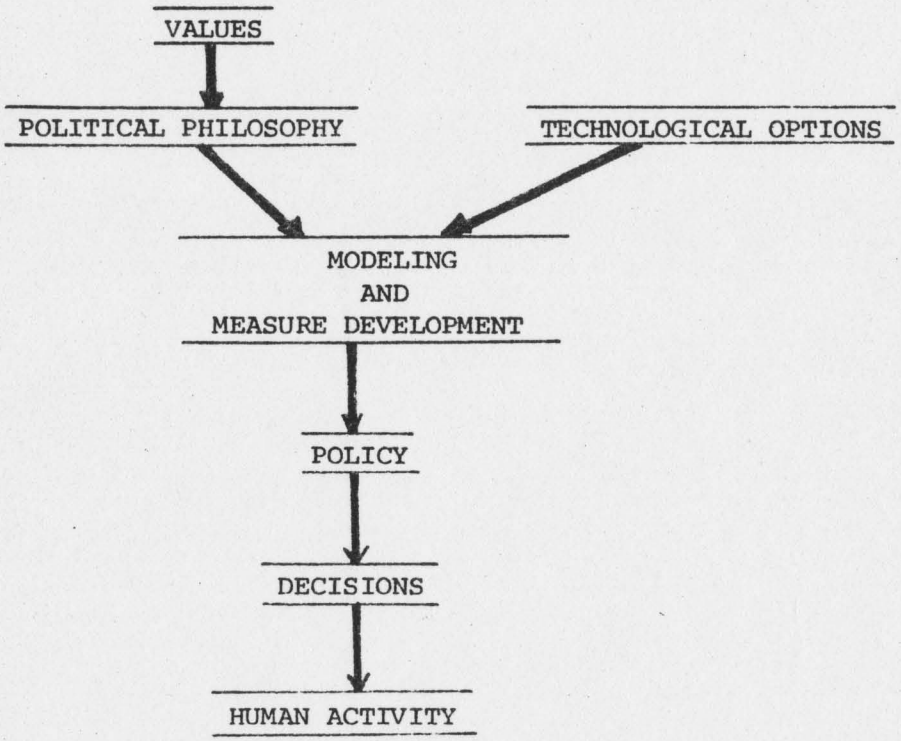

FIGURE 5. DOMINANCE SCALE FOR WORLD "C"

A still different concept accrues from Figure 5, wherein it is suggested that values dominate political philosophy, and that modeling and measure development can be dominated by a mixture of political philosophy and technological options, and can, in turn, dominate policy, with policy then providing the basis for decisions leading to human activity.

The third principle, the"amalgamation"principle, asserts that the conceptual aspects of measure development and the management aspects should be melded. With this principle assiduously applied, it would be hoped that situations could be avoided wherein one or the other type of consideration was emphasized unduly. For example, in educational institutions, it is sometimes found that there are guidelines as to how many technicans can be hired per faculty member, how many secretaries per faculty member can be hired, how many telephones per faculty member are permissible, etc., which heavily restrict managerial discretion to narrow categories. Conceivably, it would be possible to construct an overarching guideline, such that individual managerial discretion would be permitted to allow the separate guidelines to be violated, as long as the overarching guideline were observed. This might permit more secretaries and fewer technicians, more telephones and fewer secretaries, or other combinations. Recalling that the functions of policy are to enable, to regulate, and to inhibit, and that though one only is intended, others may be incidentally achieved, it is hoped that the use of the amalgamation principle in designing measures will help achieve a better balance among these functions.

In applying the triple-A principles enroute to the bounding of utility measures, it is helpful to have available a set of stimulus ideas that can be used to help establish bounds. Some of these ideas seem to help in the inclusionary or divergent aspects of the accordion principle, while others are primarily of help in the exclusionary or convergent aspects, and others may intervene either way depending on the situation.

Among the divergent factors can be included, for example, studies of impacts upon pre-established lists of societal problems, social values, or social sectors, as well as considerations of political aspects and managerial aspects.

Among the convergent factors are often found resource limitations, cognitive limitations, contemporary assumptions, habitual thought patterns, technological parameters, institutional rigidity or inertia, selection rules, and geographical restrictions.

The identification of the constituency, i.e., the people who will use the measure, may often serve either to cause a divergence or a convergence, depending on whether the constituency is very narrow or very broad.

Other factors that may be useful in considering measures are the number of people affected, the likelihood of chain reactions in which primary impact gives rise to secondary and tertiary impacts, the magnitude and significance of impact, the power relationships involved, criticality to escalation or deescalation, and the probability of occurrence.

No doubt the association principle will be readily accepted by that sector of the technical community which specializes in the construction of dynamic models. It is appropriate to introduce the recent work of Gaines [7] who has demonstrated that "the assumption of causality when modeling acausal systems can lead to indefinitely complex models of comparatively simple systems." It is appropriate also, in view of Gaines' conclusion, to recommend increased use of interpretive structural models [8] as an aid in applying the triple-A principles.

Finally, it is also desirable to append one more principle adapted from [6]. The "saliency" principle states that it is not as important that a measure be the right one as that it be exposed to very careful examination, and that an inexact answer on the right issue is preferable to a very exact answer on a peripheral issue.

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