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ON THE CHOICE OF OBJECTIVES IN SYSTEMS STUDIES

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ON THE CHOICE OF OBJECTIVES IN SYSTEMS STUDIES

Charles J. Hitch

One of the more tiresome bromides to which operations researchers or systems analysts are subjected is the injunction to first choose the right objectives.

Now I would be the last to urge you to choose the wrong objectives. Nothing is more important in systems studies than to define the right ones. Working out solutions, however elegantly, with the wrong objectives is equivalent to answering the wrong question, seldom a useful exercise.

It might appear then that it would make sense to begin with some broad "given" or accepted objectives; to derive from them appropriate local or sub-objectives for the systems problem in hand; and then to design the analysis to maximize, in some sense, the proximate objectives. In the special case of national security problems, with which I am most familiar and from which I will therefore select most of my examples, this means beginning with given national objectives and deriving from them the appropriate proximate military sub-objectives. In industrial operations research it usually means starting with company objectives, and deriving appropriate departmental or lower sub-objectives.

Not only is this a plausible approach; it is in some special cases an acceptable one; it is usually (not always) better than making no systems study at all; and it is frequently, given limitations on available time or manpower, the only feasible approach. I think I was the first to use the term "sub-optimization" to describe this style of operations research (in 1952), and I am no implacable or dogmatic foe of its use. Some of the most

rewarding systems studies have in fact been low level sub-optimizations.

But in general sub-optimizing is not good enough; moreover, it foregoes some of the greatest potential gains from the application of our craft. I am concerned that sub-optimizing has such great appeal to many physical scientists and mathematicians engaged in operations research and systems studies. Their interest is concentrated on technical aspects of their problems and on the design of appropriate models. "Objectives" appear to come from a different sort of world, and hopefully someone else's world. They are tainted with "value judgments" -- anathema to any true scientist. They involve economics and other social sciences. Many -- by no means all, but many -- physical scientists are happy to accept authority for inputs so uncongenial to their accustomed modes of thinking. And they don't much care whether the authority is a general, the president of a company, or a social scientist. A definition -- the clearer and less ambiguous the better -- will permit them to get on with the fascinating, if sometimes relatively unimportant, task of designing models.

Unfortunately, escape is not so easy. The principal theme of this paper is that in many of the most important problems objectives cannot be taken as given; that ends and means interact in complex ways that the systems analyst must master; and that he can, indeed, and should as one of his major objectives, help clarify and define the objectives that he strives to maximize.

Why doesn't the plausible and superficially attractive device of getting the best qualified person to "give" you the objectives work? There are lots of reasons, some important in some cases, others in others. I am going to try to sort them out systematically, taking my examples mainly from the

field of national security.

First, it is impossible to define appropriate objectives without knowing a great deal about the feasibility and cost of achieving them. And this knowledge must be derived from the analysis.

Is deterrence of attack by the threat of nuclear retaliation a feasible military objective, assuming current technology and a more or less rational enemy? We are highly confident that the answer is yes, given the geography and GNP of the United States. Pretty obviously the answer is no, given the geography and GNP of Liechtenstein. But what of the interesting intermediate cases like Great Britain, France, Japan, India? The answer is not obvious to me. The important role for military systems analysts in these countries is to help them decide what their strategic objectives should be, what kinds of objectives are feasible in terms of resource costs. If we shift our attention from retaliatory forces to active air defense during the next decade, the answer to the feasibility question is unclear even for the U.S. -- or so it seems to me.

In fact, cost is always relevant in defining insurance objectives. Air defense, like many other national activities, has only a contingent value. Its value may be nil or very great depending upon what happens in the future. Providing it is equivalent to buying insurance at the national level. Now insurance is a nice thing to have, at either the national or the personal level, but one doesn't necessarily buy it for that reason. Whether one buys it depends upon how disastrous the contingency would be; how likely one thinks it is to happen; and the cost of the insurance; as well as upon the basic objectives or character of the person making the choice. Some people, in their personal lives as in making decisions for the nation, play for

safety, while others take risks and live dangerously. I am inclined to be cautious in such matters. I carry a great deal of insurance of various kinds. But you can't deduce from that that I buy any and all insurance against all unfavorable contingencies irrespective of cost. Even I draw the line.

Several years ago we lived on the beach in Malibu and I of course insured my house against fire (even though that was very expensive), wind damage, earthquake, and falling airplanes (because that was very cheap and I can't resist a bargain). I seriously thought about insuring it against tidal wave, the effects of which would have been catastrophic (but probably for me and my family as well as for the property, which reduced my incentive; note the analogy to air defense). I did a little research on the risk and the cost (I won't dignify it by the name systems analysis, but it was that sort of thing) and learned that there hadn't been a tidal wave on our coast in nearly 200 years of recorded history, while the only insurance company interested in assuming the risk demanded premiums of ten per cent per annum. I had little trouble deciding to take my chances. Rigorous, systematic analysis of the risks and costs in analogous national security problems can be equally helpful -- even if we can't insert at the beginning of the analysis some neat formula defining the nation's propensity to avoid risks. (I couldn't do that explicitly in solving my personal problems.)

Which leads into my second difficulty with this approach: there frequently is no national or other high level objective that can be taken as "given." For all sorts of good reasons that are not about to change, official statements of national objectives (or company objectives) tend to be non-existent or so vague and literary as to be non-operational. It is easy, but

not helpful to the systems analyst, to say that the objective of the military establishment is to prevent war if possible and to win one if it occurs.

So how and from whom does the analyst obtain his high level objective? To whom does he appeal? Can the President (of the U.S. or of the company) give a sufficiently definitive and precise answer? And even if he can in some theoretical sense, what if he is inaccessible or inarticulate?

Actually, ours is a democratic and plural society, with a government distinguished by division rather than concentration of power. There is no single authority, neither the Joint Chiefs nor the N.S.C. nor the President, that can say "These are our national objectives." There are many important influences on national decisions -- high officials, assorted low officials, Congress as a body and many individual Congressmen, the judiciary, public opinion and the opinions of many influential private persons.

And the views of these bodies and these persons differ. Some are risk takers, others risk avoiders. Some are conservative, others liberal. Some emphasize and others de-emphasize military solutions. When objectives conflict, they will assign different weights to the alternatives, and sometimes different signs to their values.

"This wouldn't matter of course if we could construct from all these individual objectives functions some appropriately weighted national objectives function. But this is a practical absurdity, and even theoretically it has been demonstrated that there is no unique or even plausibly satisfying way to derive social preference functions from individual preference functions.

In more authoritarian countries or organizations these difficulties would be less than in the U.S. government. But I am acquainted with no country or company so authoritarian and monolithic that they are less than formidable.

There is an added difficulty if the systems study relates to a future time period (as it usually does). The relevant objectives when the system is operational are future objectives, the relevant circumstances are future and uncertainly predictable circumstances, and the relevant officials and influential personages unknown. The only thing you may know is that the incumbents won't still be around.

Even in the best of circumstances ignorance and uncertainty about high level objectives make reliance on official definitions a precarious procedure. We know little enough about our own personal objectives. There are doubts about the therapeutic value of psychoanalysis, but no doubt at all that it has revealed to surprised patient after patient that his real motives for action bear little relation to what he believed were his motives. National objectives can only be some combination or distillation of the objectives of people who comprise (or rule) the nation; and we should learn to be as skeptical and critical of the verbalizations and rationalizations that pass for national objectives as we have learned to be of apparent or claimed personal objectives. No lower order of caution and sophistication gives promise of success.

Of course, there is another and lazier way for the analyst, perplexed by such problems, to get on with his sub-optimizing, namely, by accepting a proximate objective from his local commander or department head. This is sometimes worth doing, lacking anything better, and sometimes obligatory.

But we should not deceive ourselves that there is any scientific justification for this procedure. Officials in a bureaucratic hierarchy have no special competence in deriving appropriate low level objectives consistent with higher level objectives. In fact, there are built-in biases in any bureaucratic organization which make it likely that proximate objectives defined by an official at one level will give inappropriate weight to important interactions with objectives for which other officials are responsible.

This brings me to the third and greatest difficulty in starting with given objectives -- the fact that objectives are multiple and conflicting, and that alternative means of satisfying any one are likely to produce substantial and differential "spillover" effects on others. Ends and means don't fit into neat compartments side by side.

The illusion that there is broad agreement on national objectives stems from the practice of listing, with no exchange rates indicated, nice things for the nation to have. We are all (or almost all) in favor of God, motherhood, peace (and therefore deterrence), winning a war if deterrence fails, protection against nuclear blast and fallout, the containment and rollback of our enemies, better education, more super-highways, a higher standard of living, a balanced budget, lower taxes, more rapid economic growth, etc., etc., etc. But lists of this kind are almost useless for the analyst. In addition to being imprecise, they ignore the all-important questions of choice among nice things when having more of one means having less of another.

Take a hard look at the protection of the population against nuclear blast and fallout. This would be nice to have, and at first glance some combination of air defense and civil defense would seem to be the means of

achieving it. But two sorts of conflicts will plague us as we proceed:

(a) how much shall we spend on air defense and civil defense? Saying that protection is nice to have doesn't help us here a bit. We know that other things are nice to have too, and the more protection we buy the less we have to spend on offensive forces, on schools and highways, and on personal satisfaction out of incomes before tax. As we have already seen, we can't decide whether to spend anything until the analyst has given us some notion of feasibility and cost. And (b), there will be complex interactions and conflicts with other objectives -- direct conflicts, not merely indirect ones through competition for budget and resources.

It is possible, for example, that some of the extreme forms of civil defense would change, for the worse, our whole mode of life; that concentration on air and civil defense would weaken our alliances by appearing to commit us to a fortress America concept; and that air defense and civil defense, by making it more credible that we would, in some circumstances, strike first, might actually weaken deterrence of an enemy first strike on us. Some forms of active defense might even be perilous to our own offensive weapon systems.

Of course, the sign of the effect on other objectives is not necessarily negative. Civil defense shelters might help solve the urban parking problem, or in homes do double duty as wine cellars. Some forms of active defense, especially their warning components, can protect our offensive force as well as our cities, and thereby contribute to deterrence.

Nor is this the whole story. The objective of protecting cities can be profoundly influenced, for good or ill, by means usually associated with the achievement of other objectives -- like a strong, well protected,

offensive force that deters any attack; or an offensive force deployed well away from centers of population that draws fire away from cities; or an offensive force capable of killing the enemy's offensive force; or, to take a negative example, an accident-prone offensive force that triggers a thermonuclear war desired by no one.

Enough of this example, which is illustrative, but fairly typical both of military and industrial problems. All these interactions, positive and negative, have one thing in common: they make it impossible to deal adequately and honestly with the problem of protecting the population against nuclear attack by taking that as the given objective and optimizing the means usually associated with it.

Let me spend just a minute on a slightly different and more subtle form of conflict. We have spoken of deterrence of the enemy as an objective -- perhaps the primary objective -- of our military forces. But you learn, after only a little study, that there are many different forms of deterrence -- many different sorts of action by an enemy that it would be nice to deter. There is the usual question: how far down the deterrence road is it desirable to go. We know we want the military capability to deter him from striking us directly, and that, at the other extreme, it's probably silly to try to deter him by military means from frowning at us. But where in between do we draw the line?

So far, this sounds familiar. But as we dig deeper we discover conflicts within the general objective of deterrence -- cases where strengthening one kind of deterrence weakens (or may weaken, if we choose certain means) another kind of deterrence.

One of my colleagues, a sophisticated systems analyst, once tried to

solve a personal problem by a rigorous maximization of an objective function supplied by his doctor. He needed to lose weight, so he determined by consulting the experts his minimum requirements for proteins, carbohydrates, fats, vitamins, minerals, etc. He also obtained the quantities of each of these food elements in the 500 or 600 foods on the BLS list. Then, on the plausible theory that mass is filling and that most dieting attempts fail because the subject feels hungry, he maximized, subject to various constraints, the weight (not counting water content) of the diet that would give him his minimum caloric requirements. The answer, ignoring minor quantities of various foods, was that he should drink 80 gallons of vinegar per day (vinegar is a weak acid, and its weight per calorie is remarkably high). Since his own taste buds and digestive tract were to be the victims of this experiment, he knew intuitively that the answer was crazy, and informed his machine that it should re-calculate, ignoring vinegar. The second answer, incidentally, proved to be as unacceptable as the first, so he introduced still other conditions.

Now my colleague was proceeding very sensibly with his problem, starting with an oversimplified formulation and adding complications as their necessity became apparent. But it is slightly worrisome that the method he used is very similar to the one so many of us use: to take some plausible objective as given, and calculate like mad to maximize it. But we are using it in areas where our intuition doesn't reach very powerfully, and it therefore isn't so easy to recognize vinegary answers for what they are. That doesn't keep them from being just that.

So what does the analyst do? If he can't find anyone to give him acceptable objectives, where does he obtain them? The only answer I have

is that learning about objectives is one of the chief objects of this kind of analysis. We must learn to look at objectives as critically and as professionally as we look at our models and our other inputs. We may, of course, begin with tentative objectives, but we must expect to modify or replace them as we learn about the systems we are studying -- and related systems. The feedback on objectives may in some cases be the most important result of our study. We have never undertaken a major system study at RAND in which we were able to define satisfactory objectives at the beginning of the study.

In spite of some provocative remarks near the beginning of this talk, I'm not really afraid that American analysts will neglect the study of objectives. It is a national trait to be fascinated by higher level problems. A friend of mine, an economist, recently returned from a visit to Russia, where he interviewed a large number of industrial officials in the hinterland. He was reporting to a group of us on his impressions from these interviews. He found that the officials, almost without exception, talked interestedly and intelligently about their own problems and the problems of officials below them in the hierarchy. They received (from on high) a plan or target, and exercised all their ingenuity in carrying it out. But my friend was completely unsuccessful when he probed for information about decisions at higher levels. The officials did not know how such decisions were made. It was none of their business. They weren't interested. They wouldn't even speculate. They had nothing intelligent to say.

A voice spoke up from the audience: "In the United States it's precisely the opposite."

If the Russian is an incorrigible sub-optimizer, presumably for reasons

of health, the American is unwilling to be just that. I think we all understand that we can't hope to sub-optimize appropriately without knowing a good deal about the problems of at least the next higher level, and that we may have to go higher than that, as well as to collateral levels. The question isn't really whether we should be concerned with higher level objectives, but how we should concern ourselves with them.

One snare, I have tried to say, is to assume that someone else can supply the answer. Another is to look for something too pat and neat -- some function to be passively maximized. The higher level world is seldom like that.

Nothing but rigorous, quantitative analysis can tell us whether some objective makes sense or not -- whether it is feasible, how much it will cost. Nothing but rigorous analysis can reveal the conflicts between objectives. Nothing but inventive and ingenious analysis can uncover means or systems that contribute to several objectives, or that function in a wide variety of relevant circumstances, or that satisfy influential people or organizations with quite different views about higher objectives.

This is a lot messier than maximizing given objective functions. But it can also be a lot more fruitful. We know this intuitively in our personal and family life, and act accordingly. If I love vacations in the mountains and hate the seashore, and my wife is just the opposite, we don't devote all our effort to analyzing which of the two is preferable; we spend some of it seeking a third alternative that we both like. National life and company life aren't too different from family life in this respect.

To conclude: we must broaden our horizons and ambitions. In the hierarchy of ends and means there is no essential difference among levels,

or between means and ends. The systems analyst may be able to make contributions at high levels as well as low; and may frequently be unable to contribute at low unless he also contributes at high. This is a challenge and opportunity. If there is to be any clarification of objectives for systems studies, any gain in their concreteness, detail, and operational usefulness, we are going to have to do the clarifying. No one else can help much. And we have tools to use if we can rid ourselves of dogma and false hopes for tidy, authoritarian or external solutions.

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