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Henry S. Rowen

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SOME FUTURES OF OPERATIONS RESEARCH

Henry S. Rowen*

The Rand Corporation, Santa Monica, California

I am pleased by your invitation to take part in this Twenty-Second Symposium of the Military Operations Research Society. But more than pleased, I am impressed. I am impressed because this invitation bears witness to the fact that even in this scientific, rationalist age there can still be a triumph of faith over reason -- in this case, your faith that my remarks here tonight will be worth listening to and will fit into this pleasant pattern of food and good company. I hope that your faith turns out not to be misplaced.

I have taken as my title, "Some Futures of Operations Research." Let me say a few words about the last part of that title -- "Operations Research." The field that you and I cultivate has been variously referred to as operations research, operations analysis, economic analysis, systems analysis, and others. Without concern for the differences that have sometimes been alleged to exist between the activities that carry these

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several labels, and without trying to define any or all of them, I will probably use most often the term "systematic analysis." But feel free to translate this into your own favorite term.

In the first half of my title I have spoken of "Some Futures." Not "the future" but "some futures." Dennis Gabor has said that any attempt to predict the future tells one more about the predictor than it does about the future. But, fortunately, this cautionary advice does not stop Gabor from peering into the future and reporting what he sees there, however dimly.

Now I am not so brash as to try to lay out before you the future of operations research. But I do invite you to consider with me for a few minutes tonight some of the currents that are moving in the murky depths of our discipline, currents that may grow in force in the years ahead.

Let me turn now from these explanatory notes on my title to an explanatory note on the substance of my talk. I shall sometimes speak of the analysis of military problems, sometimes of non-military problems, and often I shall not distinguish into which of these two pigeonholes, if either, my remarks are intended to fit. Because you and I are here tonight as part of the Military Operations Research Society, I owe you a note of explanation about what may sometimes appear to be a cavalier treatment of the boundary between military and non-military problems.

This boundary between military and non-military is a fuzzy one and the fuzziness is going to increase in the future as we recognize more and

more the interrelations between these two areas. In fact, this is the first of the "futures," the first of the trends that I want to mention tonight.

The most obvious connection between work on security and on general social issues is in the transferability of analysts and analysis, of men and of skills. Mathematical models designed to deal with inventory problems in military logistics systems may be usable for civilian supply systems. We have found at Rand that a computer model built for military logistics use can be valuable in the dispatch of New York City's fire fighting equipment. The study that Ted Harris did years ago of the analysis of military interdiction of a railroad network has led to a large and valuable body of work by Ray Fulkerson and others on network flow theory and its applications.

Here is another example of this intertwining of military and civilian factors. Some time ago at Rand we were studying the interception of ballistic missiles. As you know, a crucial problem here is discrimination, that is to say, the shell game -- which shell is the pea under? Of the objects we might see coming at us, which is the missile warhead, which are the decoys or booster fragments? From missile tests it turns out that there may be a very useful device here -- very old-fashioned, non-automated, non-computer -- just a man. A man looking at objects reentering the atmosphere is unexpected successful at discriminating among nose cones and other incoming objects. We developed the concept that if man's vision could be extended into the infrared and radar regions, then man might surpass any mechanical device in his ability to discriminate. This

means that we must translate infrared and radar signals into visual colors. We were led to study the characteristics of the human visual system, the physiology and psychology of vision, and the eye and mind as an information processor.

Out of this missile defense activity there grew presently a byproduct -- a study of the eye and of vision for reasons that have nothing to do with missile defense, a study carried out by engineers and physicists and physiologists and others who together bring to the subject a variety of skills and experience.

Why study the eye? Because the eye provides a large area of unsolved problems in information processing, fluid flow, stress analysis, and energy transfer. It is a very sophisticated sensor and processor of information, one that should reward the researcher with a hoard of data on information-processing systems. To the medical researcher, the eye is a window to brain and body; in diagnosis, the blood vessels and other tissues in the back of the eye reveal early evidence of such ills as diabetes, hypertension, brain tumor, and senility. The eye is one of the few places in the body where the blood flow can be observed without disturbing tissue, thus constituting, literally, a window to the microcirculation system.

I mentioned that in the ballistic missile defense problem we had to translate invisible signals, radar and infrared, into visual colors. This idea turns out to be useful in other situations. In a black-and-white photograph the human visual system is able to discriminate only about

fifteen shades of gray and much of the information actually present in the photograph is not available to the eye and mind. But we discriminate several thousand colors. By translating shades of gray into colors, we can extract far more information from the photography. We have applied this idea, for example, to satellite photographs of Mars from Mariner 4, whose television signals carried 64 separate shades of gray.

In another variation of this idea, we can translate medical x-ray photographs into "false-color" photographs and may be able to provide the physician with a valuable diagnostic tool. The medical applications of this idea are just beginning.

The transfer of ideas and skills and analytical tools from military to civilian problems is not simple, is not automatic, is not guaranteed to be effective. On the contrary, this transfer will require much effort and thoughtfulness and a greater regard for problems than for techniques.

I have been talking about the relation between military and civilian problems through the transfer of ideas and skills and analytical tools. But there are other connections between military and non-military concerns.

The problems of national security and of national welfare are not neatly separable from either a research or a policy standpoint; they form part of a continuum.

For example, threats to democratic government that stem from social inequities and the phenomenon of increasing political violence along with suppressive measures are not unique to America. Some of the instabilities

our foreign policy must take account of abroad are not unlike some of our instabilities at home. And our choices and effectiveness abroad are very much affected by our cohesion at home. Vietnam provides an important case in point.

I mention another example of the interactions between problems of national security and those of our domestic scene.

Each year half a million enlisted men leave the Armed Forces and enter the nation's civilian labor force, many of them with skills they have acquired in the training programs of the military services. If we think about this, we are led to consider a number of questions. For example, how can the military best train those for whom the civilian system has failed. To what extent are skills learned in the military transferable to the civilian economy? What are the interactions between integration and discrimination in the military and in our civilian society? Are there innovations in educational techniques that can be transferred from military to civilian teaching, or vice versa? What would be the effects of doing away with the draft in favor of a volunteer army? And so on.

Secretary Clifford recently said:

The question I raise tonight is: What are the basic elements of our total national security? The answer, I think, is clear. First, the power of the weapons of our armed forces. Second, the quality of the training and leadership of those forces. Third, the unity of the American people. The most modern

of weapons will be inadequate to insure our survival in today's world unless our society is keyed to the steady improvement of our political institutions and concerned that all our people participate and share in the benefits of that society.

I think that in the future you and I will see an increasing realization and concern for the web of relationships that knit together the problems of national security and of national welfare.

Let me turn now to a second "future" of systematic analysis. We will see more and more attempts to expand the boundaries of analysis beyond the present limits of concern with quantitative and technical factors. We must learn to take into account political elements, bureaucratic realities, organizational characteristics, and all those aspects of the real world that are usually omitted from the analyst's considerations. As my colleague, James Schlesinger, has said:

We are becoming increasingly aware in an engagement, like the one in Vietnam, in which the opponent's forces are amorphous and difficult to discover, suppress, or destroy, that to devise military systems studies which ignore the organization and psychology of the foe and of the population that he desires to control, is likely to be the basis of continuing self-deception.

There are several things this does not mean. It does not mean that the analysis of every problem should be expanded to consider the full range of social and political elements. It does not mean that the analyst must now learn how to force the soft factors from the social sciences into the Procrustean bed of numerical models or computer simulations where the basis for quantification simply is inadequate. And it does not mean that the analyst should get delusions of grandeur that he will play a significantly larger role in the process of decision.

But it does mean that the analyst must often abandon the implicit assumption that the use of a simple set of mechanical indicators as criteria of performance must be looked upon with suspicion. Consider, for example, our obsession with casualty ratios in Vietnam, a measure that, for all we know, may be of much less interest to our opponents. (In citing the use of casualty ratios, I don't mean to be critical of the analytic community which has been conscious of the inadequacy of that particular measure.) It does mean that we must learn to develop analytical tools and models and processes of analysis that reflect adequately the elements which, so far, have not been quantified. It does mean that we must be more creative in the invention of new alternatives and not limit ourselves to the analysis of given alternatives. It means, as my colleague, Yehzekel Dror, has said:

The approach would be looser and less rigid, but nevertheless systematic, one which would recognize the complexity of

means-ends interdependence, the multiplicity of relevant criteria of decision, and the partial and tentative nature of every analysis (instead of striving for a clear-cut criterion and dominant solutions). In policy analysis, sequential decision-making and constant learning is dominant, and clarification of issues, invention of new alternatives, more consideration of the future, and reduction of primary disagreements to secondary disagreements are main goals.

My third "future" of systematic analysis is, I hope, a short-run future, one that will change before too long. It is a future that spans the spectrum from skepticism about analytical studies to a distrust about rational approaches in general. Let us look at some of the recent criticisms of analysis.

In the debate of the DOD Appropriations Bill for Fiscal Year 1969, Representative Lipscomb said:

There is also a need [within the Department of Defense] for a more balanced view of the use of studies and their contribution to the program objectives. Studies may reduce risk in research but they also consume valuable time and money while delaying and often obsoleting results.

Senator Stennis, floor manager of the DOD authorization bill, said this Spring that studies and analyses were "soft," about "the softest spot in all the research and development program."

Senator Strom Thurmond, in a bitter attack on the management of research and development programs and particularly studies and analyses, described conditions of a large number of defense programs as "paralysis by analysis."

A story in Aerospace Daily last August begins, "Systems analysis is expected to soon follow the TFX and FDL into the limbo now being accorded many pet projects of former Defense Secretary Robert S. McNamara."

This climate of skepticism about the utility of analysis is part of a larger atmosphere of questioning of science and rational processes in general. Listen to Representative Daddario in a recent speech:

Technology is the Janus of our age.

It is at once the source of many of our greatest blessings and -- as we are beginning to realize -- the root of many of our greatest evils.

Without technology we would not have the great production of food, clothing, and shelter which we now take for granted...

Neither would we have the bursting populations... nor the obsoleted worker... displaced by automation; nor the superdense urban areas, the residents of which live in constant smog...

The list of pros and cons could go on and on. Lately, however, it seems to me that the cons are becoming overpowering.

From Philip Abelson, director of Carnegie's Geophysical Laboratory
and editor of Science:

But since all good things must come to an end, I think you may agree that the cozy relationship between the physical sciences and the Federal Treasury is on the rocks. And the situation is liable to get worse before it improves. ... The public, who had heard a good deal about the miraculous benefits that science had created, was suddenly bombarded by massive evidence that science and technology could produce side effects.

Robert Wood, Under Secretary of the Department of Housing and Urban Development, said:

... we are seeing a noticeable change in the temper of the public regarding the ability of science to resolve national problems. This change is evident in the relative parsimony of that sensitive barometer, the United States Congress. It is evident in the anti-intellectual asides of the third-party candidate; it is evident in the sharp questions of the young and the poor...

If you talk to the articulate students on our campuses today, you find a loss of faith in rational approaches to our urban dilemmas. They are "turned off" by talk of relative gains or incremental improvements. They are interested in absolutes, in values, in total change.

It is easy when faced with this "new mysticism" to retreat behind the generational gap. There is a fair amount of youthful provincialism in the New Left's visceral indictments... But if we refuse to listen to the student skeptics and the black community, we do so at our peril.

I am not going to try to tell you what to do about this third future of growing skepticism concerning analysis. I could claim that lack of time prevents me from going into this. But the truth is that I do not know the answers. I think we can see some of them, however. My first two futures are relevant here -- the extension of systematic analysis from military problems in the narrow sense to problems of national security in the broadest sense, and the extension of analysis beyond the boundaries of purely quantitative analysis that seeks merely a limited economic efficiency. As Bob Wood has said, "the value of systematic scientific research on urban problems cannot be assumed to be self-evident. It must be demonstrated by our progress not only on limited, obviously technological questions, but on the more intractable ones."

While we are stretching the boundaries of our art we must also attend to improving the quality and skill with which we cultivate that art.

For example, we still do a better job of talking about interdisciplinary work than of practicing it. It is a cliché to remark that the problems with which we are concerned arise from the interactions of military, economic, political, and technological forces and that we must create environments in

which economists and engineers and physicists and political scientists and many others will work together effectively. But doing this calls for a never-ending effort. Thinking is still essentially a solitary process, and our formal attempts to distill wisdom from the efforts of two or more thinkers are often awkward and painful. We must work on this.

While we are studying how to improve the interdisciplinary character of our work, we might also give some thought to improving our ability to communicate. With rare exceptions, analysts do an abominable job of communicating with anyone except other analysts. Much of our writing is sloppy and ridden with jargon. When we do occasionally write with precision we too often forget to ask how the reader will interpret what we have written. The message we intend to transmit may not be the same as the message received. And how we phrase our message may be as important as the formal content it contains. If you doubt this, let me suggest a simple experiment. When all of you return home and greet your wives, do so with essentially the same greeting. But those of you sitting on the right side of this room express it in the words, "My dear, when I look into your face, time stands still." Those of you who are sitting on the left side of this room express it in the words, "My dear, your face would stop a clock." Let me know what happens.

There are many other lessons we will have to learn before we solve the problems of the third future. One of these lessons is the value of

modesty. As Peter Szanton says, even to use the term "city planner" is to be guilty of the sin of pride, for no one yet knows how to plan a system of health care, much less a city. In conclusion, I would like to quote Herman Kahn on the subject of modesty:

Today systems analysts are getting to be both more modest about their claims and better at their work. If the trend continues, we may well come out with a match between claims and product.

Thank you.