THE SYSTEMS APPROACH TO ENVIRONMENTAL POLLUTION CONTROL

by J. Venn Leeds, Jr.

We live in a strange time. For the first time, Man has changed his environment significantly. Most of us live in a city where the natural waters are no longer pure and the air is contaminated with obnoxious and dangerous matter. We live in a time when literature about our city suggests that sightseers visit the top of the Humble Building without mentioning that you probably cannot see the city for the smog.[1] We live in a time when the Chamber of Commerce sponsors a study on air pollution in Houston.[2] We live in a time in which an editorial cartoon shows a visitor trying to find the smog-covered city of Houston, with the visitor stating he must be close since he can smell it.[3] We live in a time when the same newspaper runs a contest for photographs of pollution in Houston and prints them under the headline, "Album of Houston."[4] We live in a time when the mayor, in addition to welcoming industry, pledges "air fouling prosecution."[5] We live in a time when a city councilman states that the Texas Air Pollution Control Board has bowed to industrial pressure and the City must protect itself.[6] We live in a time when the standards adopted by the Texas Air Pollution Control Board are barely below the average level found in Houston today.[3,7] We live in a time when the Air Pollution Board announces standards for suspended particles when it is not clear that one could determine which sources of pollution were causing the tolerance level to be exceeded.[7] We live in a time when a national magazine has a picture cover which is almost devoid of detail except for the words, "*Time,* the Weekly News Magazine, The Polluted Air, Los Angeles 3:30 P.M.,"[8] and contains a picture of a garbage dump burning only five miles away from The White House. We live in a time when an editorial states, "The conclusion is inescapable, that most other large cities in the United States could be regarded as uninhabitable within a decade."[9] We live in a time when a newspaper states, "It's high time to demand clean air."[10]

From the above, an obvious conclusion is that pollution is one of the im-

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portant problems of our time. Based on the evidence to date, old solutions are not satisfactory. Furthermore, the methods used to obtain these solutions are no longer effective for today's problems. The purpose of this paper is to discuss an approach which has a chance of solving today's problems.

The pollution problem is a small part of a larger problem: the problem of the cities. In the next thirty-four years, it is estimated that a major portion of the cities already built will have to be rebuilt, and, at the same time, new cities equal in number and size to the ones that presently exist will have to be built.[11] It is quite obvious that if the problem of the city is not solved in the near future, civilization is going to be in desperate trouble because the city is presently in trouble.

A recent report to the Congress from a panel of experts quite clearly points out that pollution is part of a still larger problem and that a systems approach is necessary.[12] Furthermore, the report even questions the capability of science and engineering to solve the problem. The report to the Committee on Science and Astronautics, House of Representatives, by the Subcommittee on Science, Research, and Development chaired by the Honorable Emilio Q. Daddario, states: " . . . it is the opinion of the panel that environmental pollution must be considered in a larger context even while dealing with specific problems. . . . We see the necessity for long-range planning and allocation of finite environmental resources, both renewable and consumable. . . . System analysis as a research management tool has evolved in the military aerospace industry. Although it must be accompanied by deep understanding of the problem, systems analysis, a guide for research into critical areas, can show the proper priorities for scheduling development, trial, and installation of advanced waste treatment methods. . . . It would be unfortunate if advances were delayed so that future expansion would have nothing better than present technology when basic decisions on sewers have to be made. . . .Furthermore, pollution abatement research and development require an interdisciplinary approach." The panel then asks: "How far can new technology development proceed without comprehensive waste management systems analysis as guides to the allocation of scientific resources? In the limitations and opportunities for systems analysis in environmental management, is there an adequate modeling technique or is the available input data accurate?" Thus, the need for systems approach to the environmental health problem is recognized by the Congress at least, if not by local governments.

The term, systems approach, needs to be defined. It is often used and everybody has some thoughts on a definition. However, most would be hard pressed to be precise. First, we must define a system. Affel defines a system as a set of operations organized to satisfy a definable user requirement, i.e., a functional answer to a human need.[13] He uses the word "operations" in order to include things such as manual procedures and computer programs in addition to the standard hardware that one normally associates with the systems approach or any engineering objective. Thus, one is immediately directed to a meaningful definition of the systems approach. The systems approach takes the user's requirement and then organizes the operations necessary to attain the goal. The order is quite important—goal first, then solution. Contrast this with the other approach. In the case of the cities, the other approach says, "Use today's technology and make it a better city." This won't work for cities. It's been tried year in and year out. The systems approach says, "We shall by 19— have a city capable of supporting twice today's population with clean air, quick and efficient transportation, excellent schools, and sufficient recreational facilities for all." Another example: President Kennedy did not say, "We have surplus ICBMS. What shall we do with them?" He said, "We shall put a man on the moon by 1970."

By its very nature, the systems approach is interdisciplinary. It puts together many different types of people working toward a clearly defined goal. Since it does not start with a given technology, the systems approach can easily bring in people from such diverse backgrounds as the social sciences, the engineering sciences, and government. Perhaps those from government are far more important in pollution abatement than any of the former. Solutions must be politically achievable.

Let us examine in somewhat more detail some of the features of the systems approach. The systems engineer (the word "engineer" is here used in a broad context) faces great disorder. The users' wants are poorly described and there is a complex set of capabilities in existence which might fit part of the problem. Furthermore, none of the technologies presently available will satisfy all of the needs. In addition, the systems engineer must predict the consequences of building the system. Once you have built the system, if it is a nontrial system, things are not the same anymore.

What characterizes a systems engineer? First of all, the systems engineer knows about many things—technical things. He is oriented toward analysis. He can strip away details to get a basis of what something does. He is a functional man. This does not mean that he can do everything. It means that he is able to work with other people. He knows something about a lot of things. He knows enough to know what is possible and what can reasonably be achieved. He is not necessarily able to carry out detailed designs, but he can evaluate detailed designs. He puts the problem together. Especially, he is able to put the problem in perspective.

One of the basic tools of the systems engineer is a mathematical model. No one can make predictions without adequate mathematical models. The systems approach many times conjures the vision of a giant computer with somebody sitting at the console punching buttons. Then, the computer gives the correct answer quite mysteriously. Without an adequate mathematical model, the computer can tell you nothing. Without verification of the model, any calculations on a computer are nothing more than academic exercises in computer programming.

A mathematical model is nothing more than a set of assumptions about the real world. The set of equations which normally is presented as a mathematical model is developed from these assumptions. The assumptions are selected so that a set of resulting equations might describe what goes on in the real world. In other words, a mathematical model is really an approximation to (or an abstraction of) the real world.

As stated, the mathematical model is nothing but a set of assumptions. When assumptions are given to a skilled engineer or scientist, the development of the equations is nothing more than the deductive process. Once one has obtained the equations, one can then obtain solutions. If the model is successful, these solutions are correct predictions of future events. The most important aspect of a mathematical model is the ability to make a correct prediction of future events.

Once one has made a set of assumptions, written the equations, and done the necessary analysis, then one must determine whether or not the assumptions are correct. In other words, the model must be verified. This is the most important part of the development of the mathematical model—the verification step.

The systems approach to a particular problem may be illustrated by the following example. There is a small town in South Texas adjacent to a river. Depending upon whom you talk to, the river is either a scenic arroyo or an open sewer. Regardless, the city wishes to develop the area adjacent to the river and the river itself into a facility which will cause the town to grow. Much to its credit, the city asked that a study be made of what could be done to turn the area into an asset rather than a liability. How would you develop each of the areas around the river? Should you not change the environment by damming the river and creating a lake? If so, what then happens to the pollution? The basic problem is not a problem of pollution, although it is a major portion of the problem. The problem is how to create a new look in the city. In this case, the system engineer was an architect. He took the basic problem; he examined it, defined it, and produced a workable plan for the city. He recognized that pollution would be a problem and sought assistance.

Another more specific problem is development of a mathematical model of estuaries. The basic mathematical model being used to characterize bays and estuaries is subject to some question. Furthermore, no one has developed a satisfactory model of a two-dimensional bay (one which includes, in addition to the time variations, variations in space—both length and breadth). Most previous work has been done with estuaries in which only one spacial dimension needed to be considered. Research presently under way at Rice will develop a simple model of a two-dimensional bay. This model has to be verified.

Near Galveston Bay, there exists a small body of water called Clear Lake, which is connected to the bay. Clear Lake would form an ideal experimental station for such a model verification. Plans are presently being considered to establish an experimental test facility for environmental pollution and ecology studies. This facility would provide controlled experimental conditions to evaluate the effects of pollution on ecology and the usefulness of the systems approach to environmental problems.

What is the role of a private university in this area? Professor Busch has already explained the educational program at Rice University, and, by necessity, the research program that goes with it.[14] After all things are evaluated, the most important product of a university is students who can think. After students, what other role does the university have? The private university is free from political control and normally free from industrial control. Therefore, it is ideally suited to provide unbiased advice in the areas of urban development to those people who need it. There is a need for research in the area of pollution abatement. In particular, there is a need for evaluation of the systems approach to environmental problems. The private university, again, is well suited to do this. There is no great pressure on the private university to obtain an instant solution to the problem. No one will come to it and state, "Regulations now—no more research."[10]

In summary, the systems approach holds the only real hope for attacking one of the major problems of today, the city. As a subproblem, environmental pollution has to be studied by the systems approach. The role of the private university is one of providing consulting services to the various levels of government and industry and carrying out advanced scientific research on the problems of the city and its environment.

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