Systems Approaches to the City: A Challenge to the University (1970)

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SYSTEMS APPROACHES TO THE CITY:

A Challenge to the University

Summary Proceedings of the Workshop
Sponsored by the
National Academy of Engineering
and the
National Science Foundation

October 23 and 24, 1969

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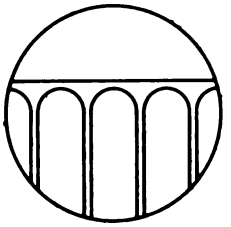

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PREFACE

The following pages constitute the summary proceedings of the workshop on "Systems Approaches to the City -- A Challenge to the University" held on October 23 and 24, 1969 in Washington, D.C., sponsored jointly by the National Science Foundation and the National Academy of Engineering.

The workshop immediately followed the symposium on "The Engineer and the City" sponsored by the National Academy of Engineering on October 22 and 23, 1969.

The workshop was sponsored financially through funds provided by the National Science Foundation's Division of Engineering, Dr. John M. Ide, Director.

The preliminary program was suggested by an ad hoc committee consisting of Walter E. Cushen, National Bureau of Standards; Nicholas DeClaris, University of Maryland; Alvin W. Drake, M.I.T.; William L. Hooper, Office of Science and Technology; John M. Ide, National Science Foundation; Thomas F. Jones, University of South Carolina; William K. Linvill, Stanford University; Louis Santone, National Bureau of Standards; Elias Schutzman, National Science Foundation; and Ronald W. Shephard, University of California at Berkeley.

The purpose of the workshop was to bring together faculty members, students, government officials, industry representatives, and union leaders in an attempt to determine how universities could respond to the need to alleviate urban problems. Although the invitees represented multifarious disciplines and occupations, the emphasis was on the engineering aspects of the problem at hand.

As a rule the proceedings of a conference are a verbatim record of the spoken and written word presented. Although this does assure "Fact," it does not necessarily guarantee "Truth." This is particularly the case in an informal workshop where impromtu utterances are made and issues are debated with vigor and passion in an attempt to arrive at useful truth and illumination. Furthermore,

verbatim discussions are frequently disconnected and the reader has trouble in arriving at the spirit of the discussions. Accordingly, it was decided to ask an experienced editor, Irwin Hersey, to study all of the submitted papers and the verbatim transcript taken down by a court recorder. From this material he collated the essence of the discussions and presentations. The material was then perused by the undersigned and he prepared the Conclusions and Recommendations, for which he takes the responsibility.

In closing, thanks are extended to all those who contributed to the workshop and this must include all attendees because the entire affair was a working meeting. Of course, special thanks are due to Nicholas DeClaris, Alvin Drake, William K. Linvill, Simon Ramo, and Ronald W. Shephard who presented papers; to Gordon S. Brown, Martin Goland, Walter R. Hibbard, Jr., J. Herbert Hollomon, Thomas F. Jones, Alan A. Siegel, and Myron Tribus who served as able panelists; and to Alfred Blumstein, H. Fred Campbell, Andrew F. Euston, Lucius P. Gregg, Bertram M. Gross, Alfred C. Ingersoll, John Ingram, Howard Margolis, Paul E. Massaron, and Walter A. Rosenblith who chaired the workshop sessions and prepared the summaries of their discussions.

Last but not least, thanks are due to the staff of the National Academy of Engineering. Without their enthusiasm and hard work, the workshop and these proceedings would have been impossible.

Ali Bulent Cambel
Workshop Chairman

Detroit, Michigan
January 1970

INTRODUCTION

If one thing has become evident in recent years, it is the fact that the engineer has a major role to play in the all-out struggle being waged to save our cities. Equally evident, however, is the fact that, until now at least, no one has been really quite sure as to exactly what that role should be. And even more uncertain at this point is exactly what kind of education and training should be provided by the university to the budding engineer to enable him to work effectively and, hopefully, to solve pressing urban problems.

Thus it was particularly appropriate that the two-day symposium on "The Engineer and the City"* sponsored by the National Academy of Engineering in Washington, D.C., on October 22 and 23, 1969, should be immediately followed by a workshop on "Systems Approaches to the City -- A Challenge to the University," cosponsored by the Academy and the National Science Foundation, on October 23 and 24.

At a banquet on the evening of October 23, which brought together both symposium and workshop attendees, Dr. Simon Ramo, Vice Chairman of the Board of TRW Inc., neatly summed up one of the main problems facing the universities as they begin to work on urban programs on a broad scale as follows:

"What is required now is to recognize that engineering, being the application of science to society, requires as a minimum qualification that the practitioner be trained in the society as well as the science he plans to apply to that society. We would not consider that we were properly training a physician who prescribes drugs for the human body if we trained him solely in drugs and gave him some courses about the human body only as a cultural embellishment. How can one seriously proclaim that he is a 'professional' in applying one thing, science, to another, society, if he is not trained professionally in both? This is not to say that every member of the profession has

*The Engineer and the City, proceedings of the symposium, is available from the Academy, 2101 Constitution Avenue, Washington, D.C.

to be equally expert in the society and in the physical science that underlies his technology. We must continue, of course, to have our specialists...(but) what we must understand is that the whole team -- the profession, the fraternity -- must embrace every aspect of the interface of science and technology with the social side of our world."

That Dr. Ramo had hit the nail on the head was evident from many of the comments made in the course of the summaries of three representative university programs given at the workshop; in the panel discussion that followed the presentation of these papers; in the small-group workshop sessions reviewing opportunities for the universities in meeting the needs of the urban society; and particularly in the comments of a group of students who attended both the symposium and the workshop.

In his address on "The New Inadequacy of Engineering," Dr. Ramo pointed out that twice in this century -- once in the early 1930's, about a third of the way along, and now again at the two-thirds point -- there has been a mismatch between engineering and the requirements of society, in which the preparation of the engineer has proved less than adequate and the practice of the profession has not fully met the challenges that existed.

On the first occasion, it was the separation of science and engineering that was the problem, and it proved possible to remedy the deficiencies in the profession, and in the preparation for it, in a relatively short time with relatively straightforward steps. "When engineering was found to be inadequate a third of a century ago," he noted, "the shortage was made up by a kind of merging with other professional groups -- the physicists, the pure scientists, the mathematicians. The conversion of engineering to meet the requirements could thus take place over a decade or so."

This time, however, it may be more difficult. For one thing, there is really no specific group to turn to now. It is not the sociologist, the behavioral scientist, the lawyer, the businessman, or the politician who can fill this engineering gap, he stated. Moreover, to try to turn such people into seasoned technologists would be unrealistic.

"It is one thing to take nuclear physics researchers accustomed to dealing with apparatus and measurements, and make radar system

developers out of them," he pointed out. "It is another to make a problem solver -- an engineer -- out of someone of academic bent or someone who is interested in the formulation of a principle, rather than the application of it to a specific 'now' problem, even though that problem needs urgent attention."

It is this kind of "doing" -- solving a problem, getting the data, setting down the alternatives and the criteria for judging them, extracting the available wisdom from the scientist, the academician, and the experience of the whole society, and bringing it all to bear on a specific problem to obtain a sound solution -- that is the work of the engineer.

However, Dr. Ramo observed that there is a profession that is missing in the world today -- the profession of applying science to society. "Can the engineers do less than recognize this inadequacy?" he asked. "We have the manpower, we have the analytical training, and we have the theoretical mission by the definition of our professional pursuit. We understand a very important part of the application of science to society, the science part. We are accustomed to doing things on schedule within economic constraints. We will get an adequate amount of heckling, but also solid aid and guidance, from the sociologists and social scientists, from the practical as well as academic individuals who make it their life work to seek to understand some aspects of society."

Thus, Dr. Ramo. However, there was little agreement among the 160 educators, government officials, and students who attended the workshop on how best to accomplish this task. In fact, on only one point was there unanimous agreement: that the government wasn't spending enough money to help the universities come to grips with urban problems.

Arguments about how to go about it centered for the most part on the degree of formal training required. One group felt that education in depth in a number of different areas was essential; another, that a normal engineering education was more that adequate for the task at hand and what was needed was practical field operations. Some argued that universities were inclined to be too "theoretical" in their approach whereas the problems lend themselves better to activism. In contrast, some suggested that it is impractical to make attempts at problem-solving before developing the theory needed to do the job right. There were statements that there was more than enough theory to do the job, and arguments that the universities had

not as yet even begun to develop the methodology required to tackle urban problems. There was even some disagreement as to exactly what the problem was, one speaker commenting that the real problem might not be understanding the problem. Others felt the problem was a lack of government leadership in the area; an improper ordering of national priorities; an inability or failure to face reality, accept responsibility or make decisions; an antiquated political system, etc., etc.

It became evident in the course of the meeting that many of those in attendance, anxious to get moving on urban problems, were unsure and/or confused about where to begin and how to start. Others, who had already made a start, weren't certain that they were heading in the right direction -- or, for that matter, whether there even was a right direction at this time. As one speaker commented: "If you don't know where you are going, any route will get you there."

If they came to the workshop in an effort to ascertain where to go, they received a plethora of advice. The trouble was that all too often it was conflicting advice, and at this stage in the universities' involvement in urban technology and social problems, it is all but impossible to tell the good advice from the bad. In great measure this is due to three reasons: (1) urban problems are numerous; (2) local conditions are different; and (3) different universities have different institutional constraints. Therefore, one cannot generalize readily. What is good for Wayne State University in Detroit does not readily apply to Columbia University in New York City.

It was obvious when the workshop had ended that the universities have to date only been feeling their way in this area. No one is sure about anything yet, and despite an impressive list of university projects and an obvious desire on the part of the universities to become involved in urban problems, little in the way of specific proposals for future actions was generated.

THREE CURRENT UNIVERSITY PROGRAMS

The workshop got underway with three papers describing ongoing urban technology programs at three universities: Stanford, M.I.T., and the University of California at Berkeley. Although the programs could scarcely be described as comprehensive, representative, or typical, they did provide a detailed look at three different approaches to urban problems, and also provided the background for the panel discussion that followed.

The Stanford University Program

In the paper entitled "Engineering-Economic Systems," William K. Linvill of Stanford University discussed what he described as "a coherent area investigation linking applied matematics, engineering, and economics with experience on practical problems in the field of systems analysis and decision-making."

In his introduction, Linvill foresaw the need for a new professional discipline embodying the systems approach that could apply technological advances to the problems of our society. "This profession," he said, "will involve more management than engineering has contained and more technology than managers have customarily used, and it will have a stronger basis in applied mathematics, economics and the humanities than either present management or engineering disciplines contain." Interestingly enough, he failed to stress the main point raised by Dr. Ramo in his keynote address -- the need for training engineers "in the society as well as the science he plans to apply to that society."

Because of the dynamic nature of the technology our society is confronting, Linvill said professionals trained to do systems planning must have both unusual flexibility and the ability to focus on specific problems. Flexibility can be developed through education in the fundamental disciplines at any modern university and

the ability to focus on specific problems comes from field experience in practical situations. The Stanford program attempts to combine the two.

The University's Engineering-Economic Systems program has two components: an analytical component to couple the concepts developed in the field with those formulated from "foundation" courses, and a set of problem-solving concepts. The logical and mathematical language embodying the analytical concepts is clean and precise, and it represents an idealized structure for many system problems. The color and shading required for effective representation of human and social concepts is carried in the second component of the program, problem-solving, which includes an inductive component, called exploratory studies, with a deductive component, called decision analysis.

Problem-solving concepts are developed by generalizing on field work on specific problems. This obviously requires a wide variety of field projects, and about a third of the total effort of the faculty and about a quarter of the time of graduate students is taken up with field work. "We hold that it is absolutely essential in the early phases of the development of this professional discipline," Linvill said, "to focus our thoughts by selecting a specific problem emphasis for each of our interdisciplinary teams in the field."

Since it would be impossible for a small staff of eight professors to develop practical programs by themselves in all the relevant areas, those areas covered are limited to a subset of all the possible areas, in the hope that the subset covers the main principles under development. Furthermore, although the university assumes responsibility for the projects in the practical world, it does not assume sole responsibility for overall field programs, and thus finds itself working with may different agencies and companies in the field. Students usually serve as graduate interns, while professors serve as consultants in the field or occasionally take program responsibilities while on leave from regular academic duties.

Graduate students have worked in the executive branch of the government in Washington on the University's Federal Internship Program and have also worked with a number of private companies such as Westinghouse, General Electric, and Bell Telephone. There are also joint projects where professors have taken partial responsibility for establishing programs at Stanford Research Institute.

There is a wide range of problem types. There have been long-term efforts concentrating on exploring the future, particularly in education and medical care; some efforts have been devoted to long-term planning; and some have been concerned with the operational aspects of present systems. Many of the projects emphasize human aspects and in most projects, technical, economic, and social aspects are integrated in a single study system.

Field problems undertaken to date fall into three categories: human resources, which would include education and medical care; natural resources, including water resources, mineral development, problems in the use of space, and pollution; and technological, industrial, and political development. The research projects handled are also of three types: initial exploratory projects, where new areas are laid out and the concepts explored; follow-on research after field work, in which more careful analyses are made than can be done in the field; and finally, projects that develop a theoretical basis for the field. A typical progression would thus be a project on optimal water storage management in multireservoir hydroelectric power systems, followed by development of a generalized reliability model with applications to electric power systems; followed by optimization studies with applications to planning in the electric power industry and optimal control theory.

To date, about fifty students have participated in internship programs, and follow-on research has resulted in a considerable number of doctoral and engineer's theses, either already completed or in progress.

The M.I.T. Program

The paper by M.I.T.'s Alvin W. Drake, entitled "Operational Methodology for Public Systems," reviewed the activities of the Institute's Operations Research Center, which came into being largely as a result of the author's education and interest in electrical engineering and operations research, and a belief that the university could play a role in developing policy-oriented models of large systems.

An initial decision to focus on problems that would be approximate counterparts of industrial situations that have been improved by systems engineering led to work on bloodbanking services (financed by the Public Health Service), the Boston Police Department, emergency

ambulance services, and the determination of federal policy with regard to vehicle insurance systems (all financed by the National Science Foundation).

The bloodbanking service was tried first, not only because technical problems associated with the control and distribution of a perishable supply of blood, subject to random supply and demand, appeared to lend themselves to treatment by modern information systems, but also because the service has to date been virtually untouched by modern management and systems techniques. For example, there has been no very useful definition of system goals or ways of evaluating policy decisions, and, even more than in industrial operations, everyone was either too busy or too specialized to be concerned with these issues.

Two students at the master's level took an interest in the bloodbank problem, with one continuing at the doctoral level and actually becoming a national leader in the nonmedical aspects of bloodbank systems. He started by publishing a widely circulated report on the bloodbanking service as practiced throughout the country, which defined potentially promising research areas. Then, for his master's thesis, he developed a simple model that allowed bloodbank administrators to explore the consequences of routine policy decisions.

The student is now using the individual models to quantify the potential costs and benefits of alternative regional bloodbank systems, working closely with the Massachusetts Central Blood Bank and individual hospitals. His models also provide a framework for the system evaluation of such new technology as the use of frozen blood.

One of the first problems selected in the justice system was the modeling and improvement of the system whereby a citizen obtains police assistance. (By initially doing some small things of value to the Boston Police Department, like drawing up more reasonable forms for simple assignment algorithms, Drake and his students had been able to establish some trust in their ability to define and work on more fundamental matters.) The student who developed this area as a master's thesis was able to model the large number of sequential activities that occur before police help arrives, and he showed that minor and inexpensive changes in the dispatch system could reduce response time. Again, the model provided a framework for evaluating new technology, such

as computer routing and automatic car locator systems. The student's doctoral dissertation, done in cooperation with the Project RAND effort in New York City, deals with a model for the allocation of patrol effort and response to incidents, which allows the evaluation of proposed policies and new technology.

Drake noted that the Center's work in these areas has had many offshoots, not the least of which was that one of the students had been offered and accepted a very responsible career appointment with the Boston Police Department. Also, the Center has helped the Department and the state police in getting professional help on a contract basis for problems the Center comes across but finds inappropriate for thesis work. And, last but not least, the Center contributed in several ways to the establishment and staffing of an information system and criminal intelligence cooperative project for the state police departments of six New England states.

Several points were raised by Drake relative to his own experiences in university reaction with the city. "We must be willing to adjust our interests and our educational programs in order to learn how to deal with problems as they exist," he stated. "Urban problems are different in character and less suited to abstraction and removal to classroom and laboratory than are our more traditional technological work areas."

He also felt that the development of a strong and continuing coupling of professionals and educators is essential at this early stage, since research and educational programs developed almost wholly within the university are likely to overemphasize the use of *a priori* skills and approach either the wrong problems or non-problems.

In the area of education, Drake said he thought it might be advisable to emphasize subjects valuable for initial problem definition and for modeling large systems. In particular, he suggested introductory work at the undergraduate level in economics, mathematical programming, probabilistic models, and inference, with more subjective aspects best handled by means of seminar discussions and case studies. He also suspected that, for a variety of reasons, "public systems engineering" might be more plausible as an undergraduate, rather than graduate, experience.

In every case, Drake recalled, he and his students had been received warmly and cooperatively, but skeptically, at first encounters with public officials. He surmised that this was because most of the officials had already had disappointing experiences with "students, techniques, and products of technology offering wondrous solutions to the problems of the city, as conjectured at a distance." He also stressed the importance of providing study results in a form wholly useful to the public agency.

Like other speakers, he noted that financial support for university urban programs is difficult to obtain on the local level and that very few, if any, of the clients for the services the universities think they can offer are both able and prepared to pay for them. He also thought that student interest in the public sector was surprisingly high and that generating such interest did not seem to constitute a problem. The problem, he felt, was to stir up public interest to the point where people would be willing to put a premium on effective management of the public sector, and be willing to pay the price for it.

The University of California (Berkeley) Program

The paper by Ronald W. Shephard described the research program on system design and optimization of the Operations Research Center of the College of Engineering of the University of California at Berkeley. The program, which got underway about two years ago, is supported by the National Science Foundation and focuses on research efforts in four main areas -- probabilistic models for system reliability, stochastic models of computer service systems, optimal design and operation of systems for responding to freeway accidents, and optimal control and utilization of natural resources. The programs are under the guidance of seven faculty investigators. In addition, one faculty investigator participated in a research project on solid waste disposal undertaken jointly with the Sanitary Engineering Laboratory of the University and sponsored by the Public Health Service.

Shephard noted that the educational aims for undertaking research have been well met, since the work has led to five MS and twelve PhD degrees. Students who worked on the programs

are now employed in industrial research laboratories, consulting firms doing research, the government, and American and foreign universities.

Research in the area of system reliability models has led to results that extend the theoretical basis for analysis and optimization of reliability in the design of complex systems, while research on stochastic models of computer systems has led to the establishment of models for analyzing optimal priority disciplines in time sharing.

Research on the design and operation of freeway accident systems is not yet complete, but results to date demonstrate progress in understanding the structure of the problem. A system evaluation model for systems made up of conventional elements has been developed and will be subject to additional field experiments, and a study of patrolling strategies is contemplated. The model has already been tested extensively using traffic flow and accident rate data for the San Francisco-Oakland Bay Bridge. The success of this project, Shephard said, depends strongly on a joint effort with a faculty investigator of the Institute of Transportation and Traffic Engineering of the University and on the use of its data-gathering facilities.

The research effort on solid waste disposal is similar. Here, both conventional and unconventional systems are under study, with the Operations Research Center providing models for optimal operation and evaluation of waste disposal activities, and the Sanitary Engineering Laboratory handling data-gathering, experimentation, and definition of technologies.

The research undertaken in the area of natural resources has been the smallest effort of the Center because of the limited availability of investigators and funds. Three pilot studies have been made, one dealing with the adaptation of linear programming models for determining optimal water quality management and multicomponent effluent control; and a third with the determination of long-range optimal pumping schedules for the California Aqueduct.

Shephard also had some points to make about the Center's experince with these programs. First, he felt, a substantial direct involvement of the Center with primary responsibility for attaining objectives in the public sector would present certain conflicts of purpose even though it seemed clear that staff talents could usefully

be brought to bear on societal problems. "Our main purpose of supporting the education of advanced-degree students in the scientific knowledge of the field of operations research," he noted, "would be hampered by such an undertaking because the diversion of effort required by this responsibility would imply neglect of the basic education of our students."

However, elsewhere in the University's Department of Industrial Engineering and Operations Research, it has been found that, at the Master of Science level, small applied projects for students not specializing in operations research can be carried out to yield valuable educational experience. Although the necessarily modest character of such projects precludes considering them as a substantial attack on urban problems, they can and do serve to acquaint students with the urgency and challenge of these problems and perhaps stimulate them to pursue an interest in the problems during their professional careers.

Shephard added that the complexity of urban problems was such that no one unit of engineering research could qualify to undertake responsibility for seeking solutions to such problems and that if all these units were merged with certain research components from the economics, sociology, and political science departments as a task force to work on urban problems, the advantages of specialization for education and development would be lost. However, there did appear to be opportunities for bridging the gaps engendered by specialization and between engineering and other practically oriented disciplines (such as the Industrial Engineering and Operations Research and the Environmental Design and City Planning Departments), primarily through the encouragement of students to pursue advanced studies in both departments and through cooperation on research projects.

With regard to the mechanisms for involving universities with urban problems, Shephard felt that the best way to do this was to provide financial support for research aimed at developing models and methods for studying such problems. Also, since one of the primary products of a university is the graduate student with an advanced degree, organizations with the responsibility for solving urban problems should make it their business to recruit these students and students should be stimulated to seek careers in the public sector through the support by these organizations of internships that would give them experience working on these problems.

Discussion and Comments

A number of points were raised in the discussion period following the presentation of the three papers. W. Edward Cushen of the National Bureau of Standards stressed the need for establishing closer relations with the city managers so that they could become more familiar with the advantages to be gained through using the systems approach to urban problems.

J. Herbert Hollomon of the University of Oklahoma commented, relative to Shephard's presentation, that it didn't make sense to establish a university graduate program that maintains that the present disciplines in which there is expertise and that provides educations for youngsters in depth without considering the problems with which they would be faced, and then to complain when nobody wanted them. He compared that to his days with the General Electric Company, when the company made products that nobody wanted and then blamed the customers because nobody would buy them.

Tom Stern of Columbia University said that the real problem with the university educational system is that "we have sharpened our analytical tools way beyond the real need in urban problems" -- a questionable although popular point of view that was to be reiterated at frequent intervals for the rest of the meeting. Stern added that, to date, it has not been possible to teach people how to go out and look at a large, unstructured mess, and then formulate this into a practical problem, and that there didn't seem to be any way to learn how to do this except by actually going out and doing it.

In reply to a question on long- and short-term objectives, Dr. Linvill noted that the critical thing is that "all of us in the system business are successful only if we can get somebody else to spend his money on our idea, and this means really understanding what his problem is, and not what he says it is, since he would not come to us with the problem if he understood it."

Caroline Jonah of Wayne State University, commenting on how to train people, said that most engineering students were boys interested in tinkering with something, but when you begin to deal with social problems, you have to begin to recruit into engineering those people who were not completely "thing-oriented" as children. Then the question will not be how to broaden their social horizons,

since they will already have been broadened, and will continue to be broadened by their continuing interest in the problem.

"We will then have to adapt the standard engineering curriculum to this type of people," Mrs. Jonah suggested, "rather than adapt the people to the problem. And it may be much easier to do it that way. I think that this is a good part of the problem in the coming years -- to find those people with this kind of interest who can be adapted to engineering courses and engineering ideas, and then take them back to deal successfully with the problems of the society."

Peter Colsar of Columbia identified in the discussion three conflicts that he felt the attendees should be aware of. The first was the question of whether the university's function should be to provide an education for its students or to provide research, and he felt that in most universities this conflict would heighten with the attack on urban problems. The second centered on what an engineer is and what a manager is and should the universities be training engineers or managers; the third was the question of whether apprenticeship should be a function for university or post-university education.

SURVEY OF UNIVERSITY PROGRAMS

Following the discussion of three university programs, Nicholas DeClaris, head of the Department of Electrical Engineering of the University of Maryland, reported on a survey of urban research activities at some 76 random institutions, which he had made with the assistance of Kerstin Binns of the National Academy of Engineering.

The survey sought answers to the following questions:

- How large, in scope and in magnitude, is the present system activity as applied to urban problems?

- What is the present engineering faculty manpower committed to research in urban problems, relative to what can reasonably be expected in the near future?

- How is this faculty manpower distributed within the traditional departmental university structure?

- Who is supporting financially the current research efforts?

- How academically effective, measured in terms of student involvement and degrees, is this research effort?

- Is it desirable, from the university's point of view, to increase this involvement, and, if so, in what general direction does the university community envision it to be?

- What are the main reservations and/or critical factors regarding future involvement?

Although answers to the above questions were obviously central to the theme of the workshop, it was felt that obtaining this information represented an ambitious undertaking, particularly since this was to be the first attempt of its kind.

Thus, a first questionnaire was sent to the deans of the engineering colleges invited to participate in the workshop. It sought conventional information about who was doing what, and how much, and plans for or reservations about future involvement.

After this information was received, a second questionnaire was prepared and mailed to appropriate individuals involved in systems engineering research on urban problems at the participating universities. This questionnaire represented an attempt to analyze the faculty research commitment in this area, in an effort to unveil an ordering structure for systems research in this area.

Of the 76 random schools to whom questionnaires were sent, 49 listed specific projects on which they were working, and all but one also listed additional research areas in which they hoped to become involved in the near future, and 27 schools failed to reply to the questionnaire.

During the workshop DeClaris distributed a voluminous tome of data and, in addition, presented visual material not contained in his written report. Discussions during and after the workshop indicated that the questionnaires had been interpreted differently by the various respondents and hence consistent comparisons are difficult to make, if not impossible. A typical point of misunderstanding was the confusion among systems engineering per se, urban engineering per se, and systems analysis applied to urban engineering. Therefore, the material summarized is only a fraction of the information that was actually gathered.

Ten universities reported one urban research project, and ten reported two such projects. At the other end of the spectrum, M.I.T. had 32 projects, Penn State 28, and Wayne State University 24.

The average number of urban research projects per institution was 5.35. The average number of faculty per project was 2.0, and the average number of students was 2.63. Furthermore, it appears that in the 49 responding schools there are about 500 faculty members and 750 students who are involved in urban research problems. In the past three years, 67 PhD and 416 MS degrees have been awarded to students studying urban problems. It should be reemphasized that not all systems-oriented faculty

and students are involved in urban research. Nor are all urban research projects pursued by virtue of the systems analysis approach.

As may have been expected, in the responding institutions the urban research is pursued in a variety of departments. (This is another reason why it is so difficult to collect meaningful data for an entire institution.) In Figure 1 may be seen the distribution of urban projects in a variety of academic departments.

The survey indicated that the universities are funding a good many urban programs themselves -- in fact, about twice as many as state governments, in second place. Then come private funding sources, the National Science Foundation, and the Department of Transportation. Other sources of funds are the Ford Foundation, the Department of the Interior, the Public Health Service, the Department of Housing and Urban Development, the National Air Pollution Control Administration, the Federal Water Pollution Control Administration, city governments, the National Aeronautics and Space Administration, the Department of Health, Education, and Welfare, the Department of Defense, the National Institutes of Health, the Bureau of Public Roads, the National Highway Safety Bureau, the Atomic Energy Commission, the National Academy of Engineering, and the Department of Justice. The situation is summarized in Figure 2.

The types of urban projects that universities are working on today have been broken down into five broad areas by Professor DeClaris. These are planning (infrastructure, industrial needs, human needs); environmental (resource development, administration and management, regulatory); human or social (government and politics, cultural and educational, health and social services); technological (electronic systems, instrumentation, function applications); and information systems (evaluation and simulation, regulatory, services). The associated data are summarized in Table 1 on page 20.

An analysis of survey replies dealing with future programs indicates that universities are concerned with three basic problems in their efforts to get started on urban programs. First, they are now beginning to try to get undergraduate students interested in urban problems at an early stage in their education. Brown University, for example, will shortly begin to offer courses dealing with the interaction of technology and the environment to freshmen and sophomores, and the University of Illinois is seeking

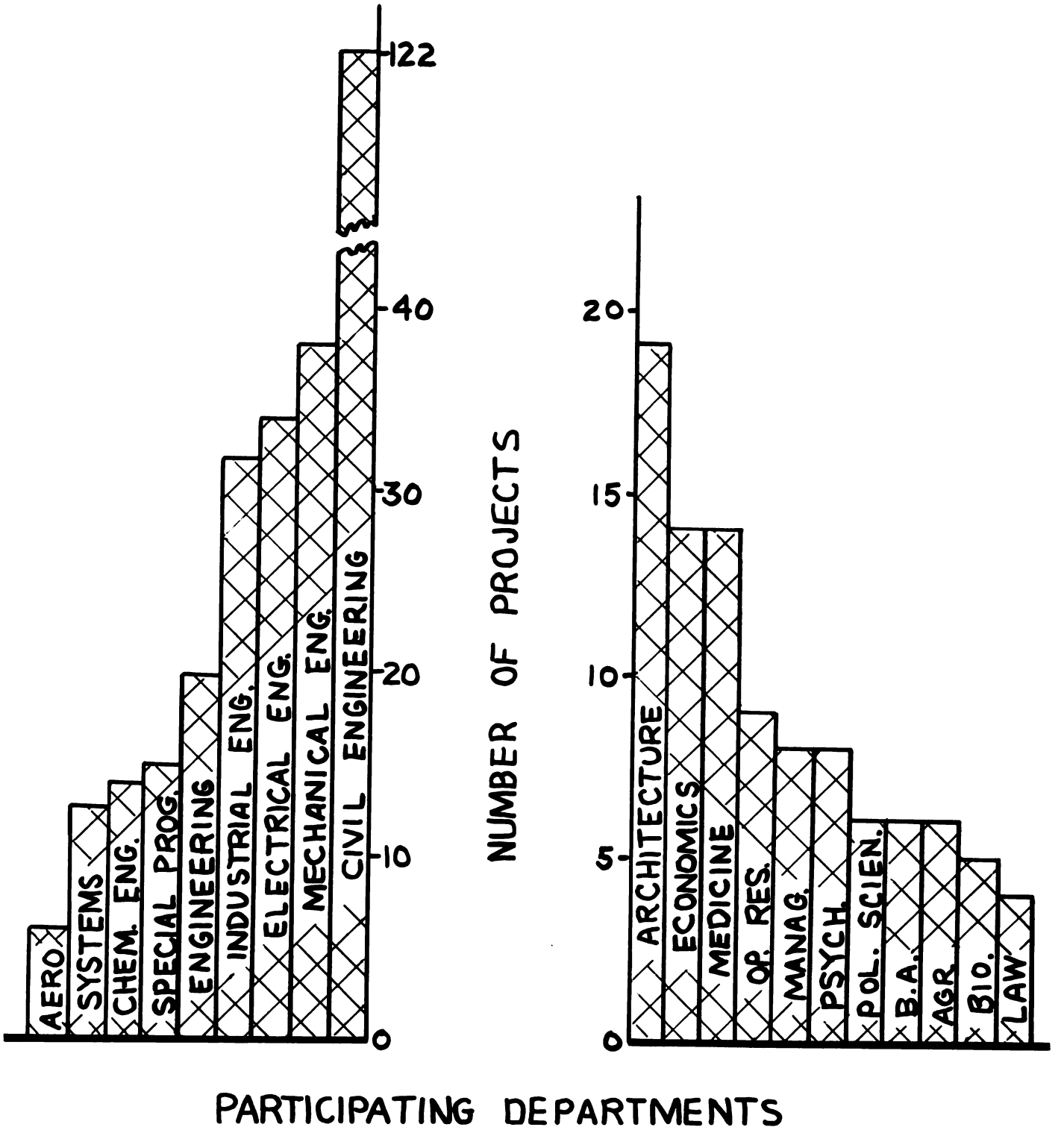
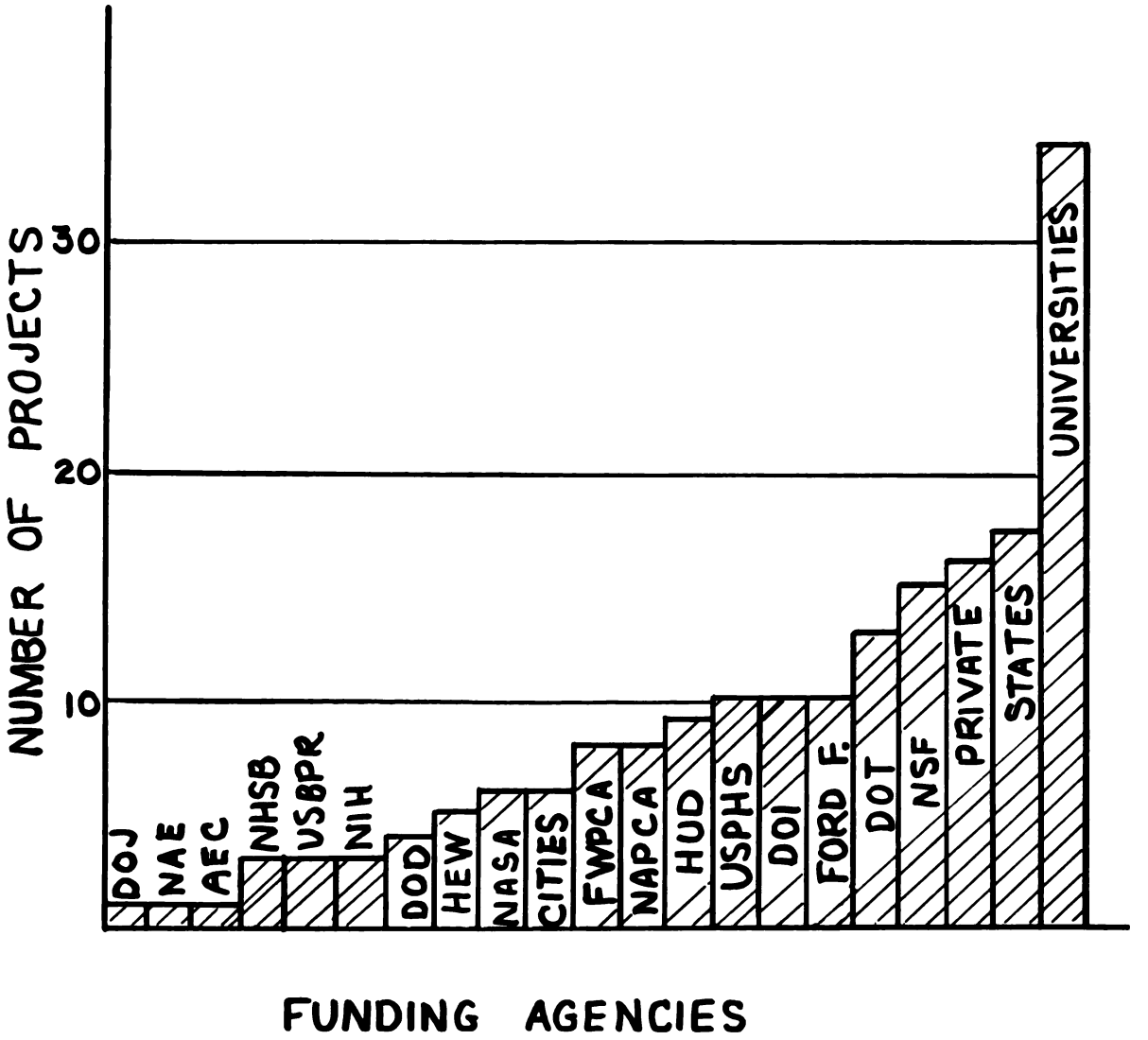


Figure 1. Urban research projects pursued in various academic departments.



DOJ = Dept. of Justice
NAE = National Academy of Engin.
AEC = Atomic Energy Comm.
NHSB = National Hwy. Safety Bur.
USBPR = Nat. Air Pollu. Cont. Adm.
NIH = National Inst. of Health
DOD = Dept. of Defense
FWPCA = Fed. Water Pollu. Cont. Adm.
DOI = Dept. of Interior
DOT = Dept. of Transportation
NSF = National Science Found.

Figure 2. Sources of funding of urban research projects in responding institutions.

Table 1

SUMMARY OF POTENTIAL INVOLVEMENT

Activity	Number of Projects	Number of Institutions
Planning	25	16
Environmental	63	40
Human (social)	21	18
Technological	8	6
Information systems	16	14

to develop means both at the graduate and undergraduate levels to permit engineering students to be involved early in urban problem studies. Wayne State University encourages its freshmen engineering students to take an urban systems design course.

Second, the need to teach the public, public officials, and even engineers how systems analysis can help solve urban problems is recognized. The University of Cincinnati, for example, indicated that one of the things it is trying to do is make clearer to engineers and laymen "what systems analysis really is and what it can do if applied properly." Meanwhile, the University of Houston is developing educational programs for public officials to teach them how to apply systems analysis to the planning, management, and operation of urban environmental systems, in the hope that eventually "the product can be used daily by trained specialists, usually subprofessional employees under conditions affordable by cities of approximately 10,000 and upwards population."

Third, and perhaps most important, there is full cognizance of the fact that any urban research program must be an interdisciplinary and interdepartmental effort. In fact, there were more comments on this point in the survey replies than on any other. Tufts University stressed the need for more effective

coordination and cooperation among the various disciplines involved in urban programs, and Virginia Polytechnic Institute suggested the importance of intermixing systems-oriented people with urban specialists, such as economists, sociologists, and particularly, urban planners. Also, Wayne State University called for an interdepartmental and interdisciplinary approach to urban research and, like some other institutions, has established a university-wide Center for Urban Studies and this has an engineering faculty member on its steering committee. The University of Illinois was seeking ways and means of developing organizational arrangements that would encourage interdisciplinary research and study.

The University of Houston noted that it has not as yet had much success in interesting people in urban problems, despite the fact that it has held a series of conferences and symposia on various aspects of environmental control and transportation during the past few years. Stimulating faculty interest in multidisciplinary, mission-oriented activities is a difficult problem, and new administrative structures may be required at the University to achieve the desired results.

EXPLORING THE CHALLENGE TO THE UNIVERSITY

Although the brief discussion following the presentation of the Linvill, Drake, and Shephard papers focused on some of the problems facing universities in their urban research efforts, the panel discussion that followed on "The Challenge to the University" attempted to define the role that the university should play in the overall attack on urban problems.

The panel was moderated by Dr. J. Herbert Hollomon of the University of Oklahoma. In addition to Professors Drake, Linvill, and Shephard, panel members were Dr. Martin Goland of the Southwest Research Institute who was chairman of the NAE symposium on The Engineer and the City that preceded the workshop, and Walter R. Hibbard, Jr., of Owens-Corning Fiberglas Corporation.

Dr. Goland started the discussion by stating that he was somewhat dismayed with the proceedings thus far because he had thought that people had a good idea of what the urban problem really was, but apparently this was not so. He noted that universities could approach the urban situation in two ways -- by becoming a part of the visionary theoretical attack on the problem, which would be the long-range approach, or by making a practical contribution to the urban effort. However, if the purpose of the universities was to train students to work on urban problems, and in the actual urban environment, they would have to take the practical approach and get to the pragmatics of how to get things done. This meant going down and working in the ghettos, and serving on city councils or local government committees. "There," he suggested, "you can use your engineering background, hopefully amplified by humanitarian subjects, by the arts as well as the sciences. And you need a great deal of humility. Let's not propose that we are going to solve a problem. Let's just propose that we are going to try to learn enough about various things so that we can bring our background, our training, and our culture to bear on these problems. Let's not be pompous about it. If you're serious about it,

don't sit in that classroom of yours. If you really are interested in the problem, you can be doing something about it and not just talking about it."

Dr. Hibbard agreed with Dr. Goland's point of view, adding that if solutions to urban problems were to be found, they would be found at the interface between government (at all levels), industry, and the universities. He stressed that it is very important to understand the respective roles of these three institutions. Unfortunately, he added, there were very few people who understood their roles or the roles of the other institutions.

He felt that the role of the university was to be a storehouse of knowledge, a generator of new knowledge, and an educator of "thought" leaders who would solve problems. Government's role was to determine what the problem was, legislate the methods or system or ground rules under which it would be solved, and motivate the people who should solve it. Industry, finally, was the engineering arm of society, and the things that were done or built would be done or built by industry. (Ali Cambel suggested that it could be put this way: The government knows what, the universities why, and industry how.)

In order to get anything done, he added, it was necessary to know who in each of these institutions had the responsibility and authority to get things done, and this meant knowing not only the formal objectives and organization of each one, but also the informal objectives and organization, and how things really got done. Consequently, the university, in approaching urban problems, should not only teach how a system would work theoretically, but also how it really works. In other words, if you want to get something done, whom do you go see, what authority does he have, and how do you motivate him to do what you want him to do?

In the discussion which followed these statements, Robert C. Lind of the Engineering-Economic Systems Department of Stanford University and Director of the Institute for Public Policy and Analysis agreed with Alvin Drake's comment that university resources are scarce and, since the university's fundamental role in society was education and research, it shouldn't fritter away all these resources on related activities.

Consequently, he felt that one of the things that had not yet been discussed sufficiently was the relationship between what might be called experience in the real world and research and teaching. Participation in the real world had been discussed in terms of service, rather than in terms of how such participation related to the research and teaching process, and he felt that if it did not relate to the overall theme of research and teaching, it was a serious mistake.

Drake disagreed, pointing out that no matter what type of participation was involved, whether it was going to a library to see how books were checked out, or to the United Fund to see how money was collected from different sources and parceled out to different outlets, it was all but impossible to look at the operation without working on a level of abstraction and within a kind of formal framework that is a skill completely foreign to such activities at the present time. The danger, he added, was rather to try to develop expertise in a vacuum.

Dr. Cambel asked why it was respectable to work in a university laboratory but it was not respectable to go out into the community, which in urban engineering could well be the laboratory. He felt it was perfectly respectable to go out into the community to gather data and see how theories could be applied, rather than to try to do everything within the confines of a laboratory or the sanctuary of a university office.

Tom Jones of the University of South Carolina next stressed the role of the university in taking the blinders off people and getting them to see things as they really are, rather than as they think they are. To do this, he said, it was obviously necessary to get out into the community and meet the people and actually see the problem.

Jones agreed with Mrs. Jonah on the importance of developing engineers out of the sensitive humanities-oriented person who would like to be more effective. He added that one thing the universities could do was to teach the engineer to get involved, and that it is ethically proper for him to get involved, as long as he is acting in the interest of mankind, rather than in his own personal interest.

At this point, Gordon S. Brown of M.I.T. stated with urgency that never in the history of mankind has anything that man has invented ever lasted long before it was being overtaxed and called

upon to perform at a higher level of capability than its inventors had built into it. The university, he noted, was an invention of mankind, and is now under attack, so, "I think we are asking ourselves whether we continue as we are or whether certain structural changes have to be made.

"That means we look at the university, which is more than just a trustee of knowledge. I think it also has something precious called academic freedom, and the price of the freedom is to be an active critic of what is wrong with society, and to do more than merely expose it and expound about it, and that is, because of the crisis that exists and the shortage of time to become involved."

Dr. Brown suggested there are other questions that must be asked about the role of the engineer. Should he be satisfied only with building more refrigerators or more automobiles, or should he try to do something better, such as contribute to improving the quality of life? And engineers can contribute, since engineering by its very nature is the art of organized forcing of technological change, and hence of economic, political, and social change as well.

Because of the university's trustee status, he added, it is in a unique position to evaluate what's wrong with society, and it also has a responsibility to help society right these wrongs. "I think the academic community today," he said, "is faced with the problem of whether it is willing to make a market for the marvelous collection of skills it possesses. However, I don't think you will make a market for an abstraction. That is why I think the only authentic laboratory where many of these ideas can be tested in the time scale of the emergency that exists is the city itself."

Malcolm Lewis, a student at Dartmouth College, next discussed some Dartmouth programs that sent students out into the community to work on real problems. Dartmouth's approach was problem-oriented, with students first sitting down and talking to the people involved and defining the problem, and then using engineering to help solve the problem, rather than doing it the other way around, by first learning a discipline and then going out and looking for a problem that fits it. Thus, the Dartmouth approach was a cross-disciplinary one.

Two Dartmouth students discussed programs they were working on. One involved teaching what amounts to a pre-engineering course in high school, in an effort to give people who may in the future be working on political or social problems some awareness of what engineering is and can do. Another took students to a city hospital for some operations research work. The Dartmouth-Tuskegee Institute Exchange Program was also discussed, the point being made that this program too is problem-oriented, in that it is designed to broaden students through direct interaction at another, and quite different, institution.

It was submitted that what was obviously required in engineering education was the inclusion of additional boundary conditions that have not been included before. In other words, the engineering student should be given another functional vector -- the social sciences -- as a basis for establishing boundary conditions on his problems. This would add another dimension to his capability for analysis and reasoning, which is already highly trained.

Henry N. Myrick of the University of Houston commented that his experience, and that of his students, in working with the city and in working on the Model Cities Program, indicated that present system techniques can be used very effectively to model physical systems. However, modeling social systems, and trying to predict the performance of people -- the way they generate revenues, the way they generate water demands, etc. -- is difficult with present technology. It has thus become obvious that traditional industrial engineering operations research systems, and engineering techniques in general, need new input technologically.

Jay Forrester of M.I.T. commented, relative to the discussion of university goals, that it might be well to begin by defining the terms "systems engineering" or "systems approach," which meant absolutely nothing, or at least had no one meaning to everyone at the workshop. He suggested further that such techniques, rather than being more sophisticated than necessary for urban problems, as someone had suggested earlier, were simply not applicable.

Take things like linear programming, or optimum solutions to a variety of problems. "These are branches of mathematics, and not part of management or politics," he said.

"They deal with small problems, with fragments of a situation. Even more important, they deal for the most part with linear formulations, but almost every part of our social system is nonlinear.... You cannot deal with the kind of problems we have been talking about by using old methods."

Referring to Myrick's comment, Forrester added that he was convinced that it was possible to model human reactions (as Ali Cambel put it: "People are predictable"). Of course, it would be necessary to go into high-order nonlinear multiple-loop systems that are completely outside of optimum solutions and formal mathematical solutions, to do so. There is an important body of theory that can be applied here, he noted -- principles as to the nature of the systems structure, how the system leads into dynamic behavior, etc. -- but these principles lie almost entirely outside the mainstream of American education today. These ideas should be taught at an early age, possibly even beginning in junior high school.

Don Rutger of the University of Illinois added that the students are actually pushing the universities into urban work and that the students are concerned and anxious to get into this kind of work. The question for the academics is really how to respond to the urging of their students.

Dick Shore of the University of Pennsylvania, returning to the basic question of what exactly was "the challenge to the university," suggested that there were really two challenges. First, the university had to decide its own role with respect to urban problems, and that this role would not be, and should not be, the same for each university. Second, the university would have to decide how it would accomplish the task it had set for itself.

Dr. Hollomon commented that in his view, what a university does is provide knowledge, alternatives, choices, consequences, possibilities, and criticisms. "In so doing," he went on, "it is essential, in the field of urban matters, that all of this -- the knowledge, alternatives, and criticisms -- have some pertinence to the problem at hand.

"But when we in the university presume that we set the the values of the society, rather than provide the knowledge and experience and background and scholarship so that the

society itself can make the decisions, I believe that the university has preempted a role that it does not deserve.... In my view that is not a function of the university, or of industry. It is a function of the way our system operates, of the people and the political process.

"I believe that the concern here is a very real one," he went on, "in which each of us, as individuals, is concerned about the problems of our society, and thus tends to transfer our value judgments into the value judgments of the institutions of which we are a part." This, he felt, should not be.

In summarizing the discussion, he indicated that he felt the difficulty lay in the fact that the university's knowledge structure and organization is such that it cannot even do well the job that lies before it, which is to provide for people in cities or in rural America, or for students, the nature of the alternatives, nor create a market for its product.

"That market is not going to develop by waiting for it to come to us," he stated. "It is absolutely essential that the alternatives that are based upon technology or science or knowledge be transmitted to those who will use it in a form they can understand."

Then, answering a question asked by Dick Shore as to who would pay for university urban programs, now largely supported by the universities themselves, Dr. Hollomon said that if the people, in the political process, believe that there is something that can be done to elevate their values and hopes and aspirations, they will pay for it. Otherwise, they won't.

WORKSHOP SESSIONS

When the program was being organized, it was decided to devote a portion of the meeting to a series of workshop sessions that would bring together groups of perhaps a dozen or so people (teachers, students, and government and industry representatives) to discuss specific aspects of university urban research programs. In all, eleven such groups were organized, covering five different subject areas.

Subject areas and session chairmen were as follows:

Institutional Requirements (I)
Paul Massaron, United Automobile, Aerospace, and Agricultural Implement Workers of America

Institutional Requirements (II)
J. Herbert Holloman, University of Oklahoma

Teaching: Interdisciplinary Cooperation, Faculty, and Course Material (I)
Alfred Blumstein, School of Urban and Public Affairs, Carnegie-Mellon University

Teaching: Interdisciplinary Cooperation, Faculty, and Course Material (II)
Bertram M. Gross, Center for Urban Studies, Wayne State University

City-Related Research: Conduct, Content, and Purpose (I)
H. Fred Campbell, H. F. Campbell Company

City-Related Research: Conduct, Content, and Purpose (II)
Howard Margolis, Institute for Defense Analyses

City-Related Research: Conduct, Content, and Purpose (III)
Andrew F. Euston, Office Community Development Department of Housing and Urban Development

University Goals and Their Interaction with Urban Needs (I)
Lucius P. Gregg, Alfred P. Sloan Foundation

University Goals and Their Interaction with Urban Needs (II)
Walter A. Rosenblith, M.I.T.

Service: Faculty and Student Participation in Community Action (I)
Alfred C. Ingersoll, School of Engineering, University of Southern California

Service: Faculty and Student Participation in Community Action (II)
John Ingram, Office of the Deputy Mayor of Washington, D.C.

The session chairmen were asked to provide brief reports on the discussions of their groups, along with any recommendations made, at the closing session, which also included a critique of their reports.

A full listing of the eleven working groups will be found in the Appendix.

Institutional Requirements

Paul Massaron's report indicated that the first workshop session on institutional requirements focused its attention on such things as the changes that would be necessary in the areas of institutional organization and administration, and faculty and student recruitment and retention; whether engineering schools were ready to contribute to urban research; and whether such schools should go it alone or whether the contribution should be on a university-wide basis.

The group began by noting that before even discussing the changes in institutional organization and administration that are required, the question of values must be considered, since the values of an institution are reflected in its organization,

administration, faculty, and students. The group felt that an attempt to deal with urban problems must be preceded by a drastic alteration of existing university values, social concepts, and social philosophy. Also, issues such as faculty pay, recognition, and promotion become important.

It was also generally felt that any attempt to deal with the problems of an urban society or to improve the quality of life would have to be a university-wide effort, and not carried out by the engineering school alone. Universities must train engineers as well as students in other disciplines to recognize the role technology plays in public decisions, again emphasizing the importance of an across-the-board university effort.

It was emphasized that the university should establish urban programs that relate physical systems to social systems, rather than help to create physical systems that people would be forced to adapt to. Toward this end, engineering courses should be redesigned to take into account social phenomena, and courses in other disciplines should be redesigned to relate technological advances to social concepts and social systems; the city should be used as a laboratory in which faculty and students could provide technological assistance to people trying to improve their own quality of life; and to expand the use of internships with federal, state, and local government agencies.

Massaron's report also noted that the university is under pressure from the students to work on social problems, and one of the main questions is whether the university will take the leadership in reordering its priorities and changing its values, and then make a contribution toward improving the quality of life, or plunge unprepared into urban problems. If it is the latter, it can anticipate that the student pressure that presently exists will grow until changes are forced on it.

The second workshop group dealing with institutional requirements, under J. Herbert Hollomon, generally agreed with the first group and recommended (1) that if necessary, the structure within the university should be changed to a form that would encourage studies related to urban problems; (2) that the system of rewards for faculty in particular, and possibly for students as well, both within and without the institution must be modified; and (3) that entrance requirements

for students and hiring specifications for faculty should be broadened to allow the addition of students and faculty with broader backgrounds than are traditionally found within engineering.

The group also noted that students, with faculty help in some instances, are already perceiving the interdisciplinary, generalistic nature of the drive on urban problems, and pressures are likely to continue for more flexibility and changes in curricula.

In addition, it pointed out that universities have historically followed requirements (and support) that have been made explicit by society, with the focus going from military to civil, to agricultural (through the land-grant system) and, finally, to aerospace. Also historically, institutions that enjoyed the fruits of earlier success were frequently loath to switch to new concepts and new disciplines. If this continues to be so, engineering schools that are now preeminent in aerospace may find it difficult to adapt to the challenges of urban problems, which means new centers may eventually arise to fill this need.

Other questions asked but not answered dealt with the engineer's responsibilities for the things he creates, how to attract students with a broader social outlook to engineering, and whether the engineer could function as an engineer and political decision-maker at the same time.

Teaching: Interdisciplinary Cooperation, Faculty, and Course Material

The first working group in this area, headed by Alfred Blumstein, focused on the problem of university teaching, and particularly with teaching engineers to deal with large, complex system problems that involve strong interactions among the various component parts. Even though the principal efforts of engineers will be devoted to smaller parts of the problem, they will have to take account of and be sensitive to the interactions among the subsystem parts and their effects on the larger system.

The group agreed that each institution will have to handle this in its own way, and that it can be done at the undergraduate, master's, or doctor's level, and that different schools will find different ways of doing it, depending on its own particular situation. In so doing, schools will have to provide new problem-focused educational experiences for students that will be problem-focused and will permit students to solve real problems in a real-world setting.

In so doing, universities will have to catch students early rather than late and will have to utilize new people, including experts from the public sector and industry who have experience and background in the problem area. Faculty members are also going to have to learn a lot more about the problems they are going to teach students to solve, and they will no longer be able to be completely knowledgeable about theory, but inexperienced in -- and sometimes disdainful of -- the application.

Finally, the group recommended the infusion of real problems into technical meetings like this symposium and workshop, noting that future meetings of this kind should include greater representation of people who have and know the problems. In addition, since many institutions were starting problem-solving programs of the kind they had been discussing, the group recommended that NAE start a "knowledge bank" that would pull together information about new courses and new programs and the results of individual experiments.

The second working group in this area, under Bertram M. Gross, dealt primarily with the question of whether there should be developed a spectrum of interdisciplinary (i.e., engineering-social science-management science) courses dealing with urban problems. The group felt that interdisciplinary and multidisciplinary courses were desirable but that they should be used to bolster and supplement rather than displace single-discipline courses.

The group also indicated that team teaching, utilizing professors from a number of different fields, was desirable, since information coming from different sources would help formulate ideas on how to attack urban problems. It was also agreed that not only should engineers learn about the social sciences, but also that students taking liberal arts courses

should have some exposure to engineering, and that an effort should be made to provide engineering courses for nonengineering students.

City-Related Research: Conduct, Content, and Purpose

Three workshop sessions were devoted to this topic. The first working group in this area, chaired by H. Fred Campbell, felt that the university would have to remain or become sensitive to urban problems, and should do both theoretical and practical research, on a long-term as well as short-term basis.

It indicated that although the university and not the private sector should be responsible for training students, undergraduate familiarity with and participation inthe solving of urban problems is desirable and could even become the basis for thesis preparation and even for specialized vocations in the future. It also touched on a subject mentioned by other working groups -- training interrupted and resumed after experience in the private or public sector -- and felt that people in this category could contribute measurably toward an understanding of urban problems.

A question arose as to whether more engineering courses should be structured, and the present basic teaching apparatus should be restructured, to cope with today's problems, or whether the university should just pull together its teaching resources to attack such problems. Although the question was not directly answered, the consensus was that a multidisciplinary approach would add the flexibility and expertise required.

The group added that the university should generally anticipate and attempt to solve problems and then seek out sponsors for urban research, rather than wait to be asked to solve problems that may have become unmanageable because of a lack of recognition and attention.

One other important point was made by this group: That a university should try to work on problems pertinent to specific areas of learning. One specific example that was given was an existing university problem -- housing its students, faculty, and staff. A program aimed at solving the housing problem might very well utilize almost every discipline available within

the university and, even more important, could conceivably turn out to be a prototype for the solution of other housing problems.

The second group in this area, under the chairmanship of Howard Margolis, noted a distinction between engineers useful in the city and "urban engineers," and then asked whether there is such a thing as an "urban engineer" and what sort of training would be appropriate for such a field.

With regard to the first question, it noted that a field has already developed that attempts to adapt to urban affairs the approaches to problems developed in the defense field under the names of operations research and systems analysis, and that the universities are beginning to formally train people for such roles. What distinguishes this field from more familiar branches of engineering is that the focus is essentially on how to analyze an ill-understood problem enmeshed in the complex operating environment of the real world, rather than on the application of technology to deal with a problem that is already well defined.

It is much less clear, the group observed, that this emerging field (or more precisely, some branch of this field) will be thought of as "urban engineering" for that implies that systems analysis done by engineers will, for example, be distinguished from the work done by economists or statisticians attacking the same general set of problems. It is at least possible that "urban engineering" will exist primarily as the name of a course or a program at a school of engineering, rather than as a profession distinguishable from urban systems analysis in general. But, in any event, increasing numbers of engineering students can be expected to want to expose themselves to such courses, whether or not they plan to specialize in the field after they leave school.

The group felt that the basic issue in the question as to what the content of such courses and programs should be seemed to have been well defined during the general sessions at the meetings. The issue appears to lie between the view that university work should be focused primarily on techniques and the view that the university should make a major effort to expose the student (necessarily at a loss to the time he can spend

mastering techniques) to the real world, where success seems far more often to depend on ingenuity in applying quite simple methods of analysis, rather than on skill in the manipulation of sophisticated techniques.

There is thus a split between those who see the role of the university as necessarily focused on the science of creating and manipulating mathematical models of problems and those who feel the primary role of their courses is to prepare the student for the art of dealing with messy real-world problems. The former tend to feel that the messiness of the real world is what the student can learn about on the job, after he leaves school; the latter, that to focus on technique rather than problem solving is to prepare the student for a world that does not exist outside the make-believe realm of neat textbook problems.

Although the division that showed itself in the general sessions was also evident during this workshop session, those in the group with the most experience in urban programs tended to feel most strongly about the importance of a problem-solving orientation. Clearly, it is harder to organize a course that gives a student an appreciation for the difficulties of real-world problems and how to deal with them than it is to arrange a course in some well defined technique such as linear programming or queuing theory. However, it was noted that formal training can be effective even in dealing with hard-to-define subjects.

There was no dispute within the group about whether operations research techniques should be part of the "urban engineering" curriculum. The question was one of emphasis. And it noted that the key is likely to be whether those presiding over the new departments that are developing are primarily problem-oriented or technique-oriented. Margolis himself felt that a Darwinian process will be evident, whereby those departments that are relatively less academic, relatively less technique-oriented, and relatively more problem-oriented will tend to attract the best students and most generous financial support, and that a decade from now it will be obvious, by inspection, which side will have won out.

The third working group, under the direction of Andrew F. Euston, limited its discussions to sociophysical research issues, such as the need for new studies of the impact of the built-environment on man, for social indicators, and for research into user

needs, as well as for ways to involve the citizen in the technical processes that are shaping the physical environment in which they live.

The university's role in urban research was seen as a double one, with both short- and long-term implications, and in this regard the group addressed itself to the question of whether entirely new disciplines, or temporary, limited-life disciplines that would perform their tasks and then desist, should be established for such work.

It was noted that a critical obstruction in the path of progress is the reluctance of administrators to initiate urban research without the concensus of the faculty or existing disciplines. As a result, it must be made easier to start up, primarily through focus and funding provided by government and extra-university sources.

In any case, urban research must be approached in a new multidisciplinary way, and this may not be a workable reality in some universities, since traditional administrative structures will not do the job. One problem here is that no bridge exists between the urban employee and the university, although internships, summer jobs, etc., might provide the bridge for the student's involvement. Research itself could also become a bridge.

Short-term implications of university urban programs center on response time and the need for intuitive, quick decisions, and the level of intensity, or scale, of such programs, which should reflect the nature of three-year PhD terms, faculty size and continuity, etc. However, long-term programs are also vital, since they could help with recurrent or repetitive urban problems. It was felt that using the university as a fireman was a mistake, since it is the one place to make a start on a problem without having a lot of money, and this freedom should be preserved.

The importance of making a massive political commitment was also stressed, since the universities really cannot afford to participate in meaningful urban research without such a commitment. The problem thus becomes one of convincing the public that the technical approach will work, and the technologist must therefore truly demonstrate his capability to the people who will be affected by the technology.

The group concluded that although short-term progress at universities in this area will depend primarily upon the availability of funds, over the long-term, universities will need a combination of funds, political commitment, and clear urban-oriented university goals.

Toward this end, the group unanimously passed the following resolution:

"RESOLVED: First, that there is a problem area that is sometimes called 'sociophysical' research and that the federal government has failed to identify as a problem area. Consequently, government has failed to adequately fund and pursue progress in this area.

"Secondly, that universities have not been set up to respond to this kind of research. The university is responsible to illustrate for the federal government and for other funding sources that it is in fact prepared to do the work. It should show what it can do and on the basis of both short-term and long-term research. It is incumbent upon the university to present its case -- to present itself as useful to cities.

"Thirdly, that the need also exists for communication and information systems in this problem area with data banks and nationally centered retrieval and other kinds of information clearing services.

"Finally, that there is the need for a responsibility within the university for retooling of the disciplines and professions, creating true interdisciplinary activity and for stimulating public education focused on the impact of physical environment on society."

The group was unanimous on this resolution and felt it was very important that this assembly be on record to let the government and the National Academy of Sciences be reminded that this is indeed a critical area of funding.

University Goals and their Interaction with Urban Needs

The first working group in this area, under the chairmanship of Lucius P. Gregg, addressed itself primarily to the question of the goals of engineering schools in training students.

The group felt that the student must be trained to deal with specifications, since this will be their major responsibility in professional practice. These specifications will often be provided to him, but he sometimes has to write his own specifications in order to come up with a feasible system. The use of value judgments is implicit in writing specifications, and in making these value judgments and accepting the premise that some system models may be more optimal than others, an engineer takes a position of advocacy. There was almost a unanimous feeling in the group that engineers have a responsibility to take a position of advocacy insofar as the systems solution to a particular problem is concerned. There was also a very strong sentiment supporting the belief that the engineer must become involved in real problems and must also require his students to become so involved.

The discussion next turned to the engineer's role in linking science with society, and in this regard it was noted that it was first necessary to define these two terms, since there seemed to be some misconceptions about them. Thus, it was noted that in training the engineer to link science with society, the societal components always have been treated as an industrial component, probably because 80 percent of all engineers go into industry.

However, there is danger in assuming that the engineer who goes into the corporate sector does not in fact serve the needs of society and that the engineer in industry is not concerned with societal problems. There is also danger in the stereotype that pictures the engineer in industry as someone without a sense of responsibility to the public.

The group felt that it was important to learn the answers to such questions as: What technology is related to the social sciences? Can the engineer play a role in implementing the social sciences? Does it permit use of the term "social technology" in its application to society? By trying to structure

the knowledge of the social scientist, will the engineer also be able to challenge the social scientist and permit him to investigate social phenomena that he could not investigate in the past?

In an effort to get these questions answered, the following resolution was passed:

"WHEREAS the generally accepted goals of a university are to foster the creation, preservation, and transmission of knowledge; and

WHEREAS the raison d'être of a university is to serve society; and

WHEREAS the engineering faculty member has a special obligation by virtue of his professional standing to serve both the university and society; and

WHEREAS society is faced with urban and regional problems of great urgency and complexity: Therefore be it

RESOLVED, That the various colleges and schools of engineering be urged to commit a major portion of their resources to the education of people to develop expertise in the solution of urban and regional problems; and be it further

RESOLVED, That engineering faculty members be urged to become involved in the solution of urban and regional problems as advocates in our society; and be it further

RESOLVED, That the National Academy of Engineering enforce this position."

The second working group in this area, chaired by Walter A. Rosenblith, first addressed itself to the question of why engineers have been so notably weak in developing what it referred to as a "consequence ethos," or a concern over the consequences of a new knowledge and new technology. Although no conclusions were reached, it was felt that the university would probably continue to consider itself the agent of "rational revolutionary change."

The group agreed that the age of reformation had been reached in the universities and that changes were clearly necessary. In dealing with urban problems, for example, it might be helpful to establish urban extension divisions or "teaching hospitals" that would use not only regular professors but also what might be called "clinical professors" who would be specialists in urban problems. It might even be necessary to develop a new buffer institution that could do more than use students part-time or during the summer and could fill the need for providing real-world experience in a realistic teaching and learning environment.

The role of students in urban research is a particularly important one, the group noted, since students have the ability to infiltrate other institutions and also have shown a remarkable facility for communicating with urban populations.

The group also discussed the question of whether new institutions might not be needed to work on urban problems. In other words, what would an urban school look like? The reorganization of universities should also be studied and attention should be focused on whether entirely new institutions might be needed.

Service: Faculty and Student Participation in Community Action

The first working group in this area, headed by Alfred C. Ingersoll, also reported difficulty in defining terms -- in this case, the term "service." The controversy arose over the question of community involvement as a part of the educational program of a student or institution and over the question of academic credit for such involvement.

A basic question, not easy to answer, is: Who is to benefit from faculty and student participation in community activity? Is it the community? the faculty? the students? the university? or society generally? Within the context of the meeting, the group felt it should restrict itself to a consideration of the effects on engineering schools.

It was felt that urban programs would be helpful in general in that they would provide students with the relevance

and meaning they are seeking today. There was also broad agreement on the fact that, if the urban effort is to have any real meaning for faculty and students, it must be primarily educational. With regard to who should participate, it was felt that it might be unrealistic to make it mandatory for undergraduate engineering students to participate in urban programs.

The group recommended that universities seek socially sensitive new faculty members and restructure some of the time-honored criteria for promotion and salary increases in order to encourage faculty participation in community action. It also felt that the opportunity for internship should definitely be available to the urban affairs specialist and that in some, although not all, urban fields, it should be required.

The second working group on service, under John Ingram, first considered the question of whether universities should become directly involved in helping to solve urban problems. A majority felt that the university should not be directly involved, since its primary function is to prepare students for the outside world, and it will thus contribute to the solution of urban problems by training students for such tasks. It was also indicated that care should be exercised to ensure that the main function of the university not be affected by the direct involvement of faculty members in urban programs, with a possible diminution in the quality and discipline of the education offered.

There was considerable discussion of student, rather than faculty, involvement in urban programs, but no general agreement was reached. Students in the group expressed strong support for internship programs and direct involvement in working with the community on urban programs. However, some faculty members felt that work of this kind might be less demanding than the more traditional courses, and the educational experience could therefore be lessened.

The students and some faculty members expressed the thought that universities located outside of urban areas should offer student internships in urban areas and that universities in urban areas should at least develop projects for student involvement. These projects were felt to be necessary because the new generation wants to know about the practical side of

urban problems. Additionally, such experience will help the student learn how decisions are made and what factors other than engineering factors go into the making of those decisions. Also, experience in cross-cultural situations is required so that students and faculty alike can obtain an appreciation of the problem of communications among different groups and particularly between the poor and the nonpoor and between professionals and lay people.

There was some discussion as to the desirability of universities involving students and faculty formally in urban problem-solving, as opposed to serving as a vehicle for bringing together volunteers and service needs. It was felt that the university could play a useful community role by providing a vehicle for students to do volunteer work such as tutoring in urban areas.

In the course of discussion, the point was raised that it was difficult for whites to appreciate problems as seen by blacks. It was noted that there were no black participants in this particular group, and the thought was expressed that the universities could help solve this problem by actively recruiting more black students. It was pointed out that black graduates of certain secondary institutions might come to the universities less well qualified than their white counterparts and that unless something positive were done in relation to this situation, this would have the result of lowering educational standards. Several faculty expressed the feeling here that this was a role in which the university could make a positive contribution by providing supplemental educational experiences for graduates of poor secondary school systems.

In conclusion, it was observed that universities had served well in the agricultural extension service and had provided many agricultural extension agents. The question was raised as to whether this vehicle might be examined as a potential model for urban involvement of universities, through the development of urban engineering extension agents, since the agricultural extension agent was an agent for change in rural America, and an engineering extension agent might have the potential for doing the same in the city.

Critique of Working Group Recommendations

Following the presentation of working group recommendations, a four-member panel provided a critique of the recommendations. Members of the panel were Gordon S. Brown of M.I.T.; Thomas F. Jones of the University of South Carolina; Alan A. Siegel of the Office of Utilities Technology, Department of Housing and Urban Development; and Myron Tribus, Assistant Secretary for Science and Technology, Department of Commerce.

Dr. Tribus began the discussion by noting that from what he had heard at the meeting, a quotation from Pogo seemed applicable: "We have met the enemy and he is us." Also, he added, the working groups' proposals for action reminded him of a prayer he had heard: "Lord, use me in this service in an advisory capacity."

He observed that the problems that had been the concern of the meeting already existed elsewhere in the world. In Calcutta, for example, it was said that the processes of government and service were likely to break down any day now, and the only question there seemed to be: When it happens, how will people know?

"We are all agreed that we are seeking solutions to social problems," he said, "and these problems are primarily software problems, in that they lie in the design of institutions and procedures that will enable us to apply the technology that we have. Therefore, it is obvious that we are seeking software from hardware-oriented people. However, our experience in the computer age has taught us that hardware-oriented people in general cannot develop software, will not develop software, and look down upon those who do develop software."

Now, however, everyone wants to change all this, through a kind of social self-analysis, and Dr. Tribus thought that this would not be easy, but it could be done. "I have heard no expression whatever from anyone that indicated he was confident about how to make these changes," he went on, "other than the intuitive and, I think, correct proposal that we get involved and that we forget for awhile

our obsession with our ability to describe precisely, to define precisely, and to know precisely what we are talking about before we try to do anything. There is, I think, in our hesitation a certain fear that perhaps a loss of innocence, a loss of academic purity, must be overcome as part of this self-analysis ... (but) I express my confidence in you and in us."

Alan Siegel commented that the main thing he had gathered from the meeting was the fact there now is a new field of engineering. The big question was whether it should be called urban systems engineering or just urban engineering. He preferred to think of it as engineering for people, or domestic engineering, since it would have to take into account the effect of new systems on people. Thus, engineers would now have to become sensitive during their training and thereafter to the consequences to various different groups of people of any program they worked on.

Siegel also cautioned on the engineer's role as advocate, pointing out that when an engineer goes to untrained people and says, "Here's the best answer," either you have to indicate very clearly why this particular solution is the best one; or give them their own engineers, who will be able to say that there may be other alternatives; or present a set of alternatives and let them pick the one which best fits their particular problem, and then build whatever they want.

With regard to training, he agreed that students, as well as faculty, would have to be exposed to urban problems and that internships in state and local governments, which badly need technically trained personnel who can recognize the problem and ask the right questions, would be most helpful. However, he also questioned the wisdom of going overboard on teaching students how to solve today's problems, since the universities owe it to their students to train them for a lifetime of capability and service.

Dr. Jones began by warning against overselling or making too many promises about what the university could accomplish in this area, and noting the danger of becoming

overenthusiastic. He said that, if the universities could do one-tenth of what had been said at the meeting, they would solve some very important problems.

He also stressed the importance of developing the social sciences in the university as a first step toward the kind of interdisciplinary relationships necessary to solve urban problems. In many areas, the social sciences were simply not prepared to meet the challenges of the times and the kind of problems which had been discussed at the meeting. To help the engineer do the kind of things that had been talked about and dreamed about at the meeting, he added, would require considerably increased funds for the social sciences, so that larger graduate programs could be established and the faculty of the future trained.

However, he felt that the interaction of engineers and social scientists would in itself be helpful. A noted sociologist had recently told him that among his favorite recruits for sociology were engineers who had "gotten the bug," since their quantitative preparation made it a much simpler process to turn them into people who could get and interpret the statistics that are so important in this area.

He added that most social scientists today seem to be extreme purists, i.e., basic researchers only, and they may benefit from their relationships with engineers and scientists, who have developed a way of converting basic knowledge into marketable realities which change the way of life. The engineer-social scientist relationship can be used to generate job descriptions or career patterns for people who would be the sociological counterparts of the research scientist, the research and development engineer, the design engineer, the production engineer, the technologist, and even the marketing force that takes the product into the field and makes it a reality in society.

One other thing that was often overlooked, he believed, was research on what would happen to the people involved if a system was changed. In the past, vast system changes had been made with almost no understanding of what the ultimate change would be in terms of people. He recommended that pressure be brought to bear on governments to set aside funds for what he called "social engineering" on future urban programs.

Gordon Brown felt that there had been some loose talk about "training" and "education" at the meeting and suggested that it was time to ask exactly what was meant by the words. "I think we still need scholarship," he said. "I think we will need to continue our attention to the existing disciplines. But I think there is something new that will have to be brought into the mix, perhaps something like Walter Rosenblith's adjunct or 'clinical' professor."

He suggested that the word "urban" had also been overused at the meeting and objected particularly to its closed-ended context. He felt the problem was much broader and more important and that it centered on the entire quality of life. For this reason, the issue of values was to him the central, total, and whole problem, and in this area he was impressed with the degree to which the students at the meeting had influenced the faculty by their comments.

"The problem to me is not an engineering problem," he said. "It is a university problem. It is across the board with respect to the university, and I am convinced that it is going to redefine the role and the image of the university.

"Moreover, I am sure now that the patron for what we have been discussing must be the federal government. The client is society. And maybe we will end up with new kinds of institutions to do the job."

In adjourning the meeting, Dr. Cambel remarked that "I have come to the conclusion that we do indeed have a problem here, but we don't know what the solution is. I think we have to get into this area and really work at it. I am not satisfied by saying that these are not engineering problems, so let the social scientists do them. I think the engineers have a legitimate role to play in this job if we are going to change society and if we are going to change our universities."

On that point at least there could be agreement.

CONCLUSIONS AND RECOMMENDATIONS

Owing to the press of time, the workshop did not convene in executive session to identify categoric conclusions and to formulate specific recommendations. However, in spite of the spirited discussions and the friendly disagreements, certain points of agreement did come to the surface. Equally, if not more important, were the deliberations of the individual workshop sessions. Here students, teachers, government officials, and industry and union leaders had met to discuss the ramifications of urban studies in an informal and intimate atmosphere. It is probably fair to suggest that the following conclusions and recommendations constitute the prevailing quality of all deliberations during the entire workshop.

(1) The urban sector of the nation is undergoing serious convolutions that must be remedied with dispatch. In doing so, engineers can contribute to improving the quality in at least two ways: First, as citizens who participate in the democratic governance of their community and city government. As educated professionals, engineers have as much to contribute as ministers, lawyers, and physicians. Second, engineers can bring their training to bear on the solving of urban problems. They can do so not only through designing of urban hardware but equally, if not more important, by virtue of applying their managerial skill and by developing the appropriate software. There is indeed a body of expertise that can legitimately be called "urban engineering." Now in its embryonic stage, there is every indication that in the not too distant future this will be an acknowledged branch of the engineering profession. As in any human service profession, urban engineers will have to work together with their scientific and societal counterparts.

(2) Before urban systems engineering is fully accepted by the body politic, it is necessary that educational institutions initiate a wide spectrum of innovative and pioneering programs.

These may include new multidisciplinary courses that may at times be taught through the instrumentality of team teaching; internships where students and/or faculty members go out into the field -- the city -- and bring their expertise to bear on existing problems much in the way that a young medical intern works in the emergency room of a city hospital or the young social worker cooperates with the infrastructure in the inner city and the ghetto.

(3) Contrary to some prevailing public opinion, it is not true that urban problems will be solved by declaring a moratorium on science and technology while allowing society to come abreast with the present state of the technology. If engineers are to make meaningful contributions to eradicating our urban ills, they will have to develop new bodies of knowledge and new techniques.

It is not all all clear that existing science and technology can be applied readily to the urban sector. Indeed, quite the contrary is true. There are several reasons: (1) Until now modern technology was developed because there were enunciated national objectives and specific requirements based on physical laws that could be formulated. This situation does not yet obtain in the urban sector. (2) In previous situations the user (e. g., the Apollo astronauts) constituted a very small group of persons who could be exquisitively trained. In the urban sector this is almost impossible because some 150 million or more people live in cities of the United States. They cannot be trained like pilots or astronauts but they are the ones who decide whether the attempts of the engineer to improve the quality of life are truly acceptable. Thus, when entering the city arena, the engineer must be familiar with the needs of the populace and he must realize the social-political-economic restrictions under which the policymaker (e. g., the mayor of a city) must function. The urban engineer must develop the sophisticated knowledge and compassionate acumen to function as a bridge between science and society so that he can exploit the former for the betterment of the latter. What this all says is that urban engineering must be practiced in an interdisciplinary and intersectorial manner horizontally as well as vertically.

(4) In general, urban engineering will probably be emphasized on the graduate level leading to postgraduate degrees. Nevertheless, to develop student interest and awareness as well as to respond to student demands there will continue to be developed courses and seminars on the undergraduate level.

(5) The graduate research may be pursued by making a contribution to a typical city problem with all of its reality. If so, the researcher will probably realize that certain data are not available and that solving a merely physical problem is usually easier than a problem that involves interaction with human beings. Urban research could also be pursued in the sanctuary of the ivory tower and may well lead to broad and general solutions applicable to a wide range of problems. Even so, the researcher in urban problems should not allow himself to be isolated from real-life situations, although like any researcher he may seek times when he would like to be insulated from the daily hurly burly and the vested interest arguments that accompany any human relation problem.

(6) It is clear that the education of urban engineers requires an understanding of systems analysis and operations research as well as economics and other social sciences. Of course, the extent will depend on the particular needs of each school and its intention to emphasize urban systems hardware or urban systems software.

(7) In developing programs in urban engineering, schools will have to reexamine their attitudes as well as their institutional structures. Paramount issues that require resolution are:

(a) The acceptance of the "service" function to the urban community, in other words, "activism," as opposed to the traditionally accepted "teaching" and "service" or "scholarship."

(b) The relaxing of institutional policies, rules, and regulations to allow cooperation across departmental boundaries.

(c) Instrumentalities whereby established curricula can be relaxed to allow the student to take urban-related courses and to pursue research under the guidance of faculty members from different areas. Associated with this must be the realization that at times the changes will be suggested by the students and that the faculty and administration should maintain an open ear, yet quizzical mind. Indeed, there may be times when a student can get more pertinent advice at a neighboring organization while retaining his loyalties to his own school. Also, it is conceivable that in pursuing his research the degree candidate may get invaluable advice from an expert outside the academic community, such as a mayor, hospital administrator, or commissioner of recreation and parks.

(8) There does not now exist and there probably will never exist a rigid discipline called "urban engineering." Each school will have to develop its own plans. Furthermore, the demands on urban engineering change with time and location. This suggests the excitement of variety as different institutions develop their respective programs.

(9) Each of the two workshop sessions passed a resolution. These are the following:

(a) "RESOLVED: First, that there is a problem area that is sometimes called 'sociophysical' research and that the federal government has failed to identify as a problem area. Consequently, government has failed to adequately fund and pursue progress in this area.

"Secondly, that universities have not been set up to respond to this kind of research. The university is responsible to illustrate for the federal government and for other funding sources that it is in fact prepared to do the work. It should show what it can do and on the basis of both short-term and long-term research. It is incumbent upon the university to present its case -- to present itself as useful to cities.

"Thirdly, that the need also exists for communication and information systems in this problem area with data banks and nationally centered retrieval and other kinds of information clearing services.

"Finally, that there is the need for a responsibility within the university for retooling of the disciplines and professions, creating true interdisciplinary activity and for stimulating public education focused on the impact of physical environment on society.

(b) "WHEREAS the generally accepted goals of a university are to foster the creation, preservation, and transmission of knowledge; and

WHEREAS the raison d'être of a university is to serve society; and

WHEREAS the engineering faculty member has a special obligation by virtue of his professional standing to serve both the university and society; and

WHEREAS society is faced with urban and regional problems of great urgency and complexity: Therefore be it

RESOLVED, That the various colleges and schools of engineering be urged to commit a major portion of their resources to the education of people to develop expertise in the solution of urban and regional problems; and be it further

RESOLVED, That engineering faculty members be urged to become involved in the solution of urban and regional problems as advocates in our society; and be it further

RESOLVED, That the National Academy of Engineering enforce this position."

(10) Presently the universities are meeting most of the costs of urban engineering. It is highly unlikely that they can afford to do so for a long period of time. Furthermore, the universities have only limited funds, and urban problems require a massive infusion of new bodies of knowledge. This will be possible only if the federal government decides to make large sums of money available to universities for urban study and research. After all, remedying urban problems in many cases constitutes social benefits and hence cannot be readily expected of the private sector, which is in business to make a profit for stockholders.

Large sums of national monies are necessary not only to initiate urban research, they are also necessary if faculty members are going to be allowed to reorient themselves. The latter is necessary if a viable educational program in course work is to be developed because this is necessary if we are to educate a cadre of engineers who can be employed on jobs benefitting the urban sector.

(11) In establishing urban engineering programs, engineering schools should not be parochial and should appreciate the contributions that other sectors of their parent universities might make. They can learn from the others; they can teach the others. This open-mindedness should prevail not only in developing courses and in organizing research. It must prevail also in faculty and student recruitment. Urban engineering will be truly meaningful only if urban engineers are versatile and intellectually promiscuuous like the men of the Renaissance. Of course, superficiality under the guise of interdisciplinary pursuits would be devastating. What the urban sector needs are engineers who are excellent in at least one thing and good in everything else. If such engineers can be educated and nurtured, we may well usher in the Golden Age of Engineering. Indeed, nothing less will do.

Today, more than ever, the prophetic words of President Woodrow Wilson apply: "It is ... the spirit of service that will give a college a place in the annals of the Nation. It is indispensable ... that the air of affairs should be admitted to the classroom. The days of glad expansion are gone, our life grows tense and difficult; our resources for the future lies in careful thought, providence and wise economy; and the school must be the Nation."

APPENDIX: WORKING GROUP

Institutional Requirements (I)

Chairman: Paul Massaron, Community and Membership Relations, Region IB, United Automobile, Aerospace, and Agricultural Implement Workers of America, Detroit, Michigan

Participants	Area of Special Interest
Gordon S. Brown, Massachusetts Institute of Technology	Electrical engineering
S. William Gouse, Office of Science and Technology	Program management
W. Edward Cushen, National Bureau of Standards	Technical analysis
Daniel F. Drucker, University of Illinois	Civil engineering
Charles W. Garrett, National Academy of Engineering	Biomedical engineering
Ronald L. Gue, Southern Methodist University	Computer sciences
E. T. Guerrero, University of Tulsa	Chemical engineering
Robert G. Hennes, University of Washington	Transportation economics
Hugh J. Miser (Vice Chairman), University of Massachusetts	Social systems analysis

B. Baumberger, Wellesley College (student)	Political science
Arthur T. Thompson, Boston University	Administration
Benjamin Wright, Dartmouth College (student)	Electronics engineering
Alan A. Siegel, Department of Housing and Urban Development	Utilities technology
Ray E. Bolz, Case Western Reserve University	Administration

Institutional Requirements (II)

Chairman: J. Herbert Hollomon, President, University of Oklahoma, Norman, Oklahoma

Participants	Area of Special Interest
Arley T. Bever, National Science Foundation	Technology and program management
Wayne S. Brown, Univeristy of Utah	Mechanical engineering
Theodore W. Cadman, University of Maryland	Chemical engineering
Paul Ebaugh, Pennsylvania State University	Research management
David S. Hatcher, Washington University	Urban systems engineering
George Luchak, Princeton University	Systems engineering
David Mitchell, Dartmouth College (student)	Mass transit

Bruce S. Old, Arthur D. Little, Inc.	Research administration
Robert M. Ragan, University of Maryland	Civil engineering
Paul W. Shuldiner, Department of Transportation	High-speed ground transportation
Alvin J. Schultz, Johns Hopkins University	Applied physics
Wayland P. Smith, State University of New York	Engineering
Fred Manasse, Dartmouth College	Electrical engineering
Karen Ludington, Wellesley College (student)	American studies
D. Boyer, National Science Foundation	Engineering program direction

Teaching: Interdisciplinary Cooperation, Faculty, and Course Material (I)

Chairman: Alfred Blumstein, Director, The Urban Institute, School of Urban and Public Affairs, Carnegie-Mellon University

Participants	Area of Special Interest
Bennett L. Basore, Oklahoma State University	Systems design
Eugene Chesson, University of Delaware	Civil engineering

L. R. Daspit, National Academy of Sciences - National Academy of Engineering	Housing
Liang-Tseng Fan, University of Kansas	Systems engineering
Clinton Harris, Dartmouth College (student)	Ocean engineering
James D. Horgan, Marquette University	Biomedical engineering
C. L. Miller, Massachusetts Institute of Technology	Urban systems
Anne Nelson, Wellesley College (student)	Economics
P. S. Symonds, Brown University	Engineering
Eben Vey, Illinois Institute of Technology	Urban transportation
J. D. Waugh, University of South Carolina	Administration
Lyle C. Wilcox, Clemson University	Electrical engineering
Leland D. Attaway, RAND Corporation	Systems sciences
Myron Tribus, Department of Commerce	Science policy
N. J. Palladino, Pennsylvania State University	Energy

Teaching: Interdisciplinary Cooperation, Faculty, and Course Material (II)

Chairman: Bertram M. Gross, Director, Center for Urban Studies, Wayne State University, Detroit, Michigan

Participants	Area of Special Interest
Charles H. Bonney, Vanderbilt University	Civil engineering
Lewis O. Conta, University of Rhode Island	Administration
John R. Davis, University of Nebraska	Water resources
Anthony Donigian, Jr. Dartmouth College (student)	Housing and transportation
G. P. Fisher, Cornell University	Environmental systems engineering
William L. Grecco, Purdue University	Urban planning
William C. Kelly, National Research Council	Scientific personnel Administration
Herman E. Koenig, Michigan State University	Electrical engineering
Lewis G. Mayfield, National Science Foundation	Technology and program management
Susie Nelson, Wellesley College (student)	Economics
Joseph Pistrang, City College of New York	Systems engineering
Chauncey Starr, University of California at Los Angeles	Engineering physics
John Shapleigh, Dartmouth College (student)	Sociology

Service: Faculty and Student Participation in Community Action (I)

Chairman: Alfred C. Ingersoll, Dean, School of Engineering, University of Southern California, Los Angeles, California

Participants	Area of Special Interest
J. K. Baltrukonis, Catholic University	Mechanical engineering
Robert Borofsky, Dartmouth College (student)	Engineering
Anthony J. Cantanese, Georgia Institute of Technology	Urban planning
Deirdre Chu, Boston University (student)	Journalism
Stephen I. Davids, Wayne State University	Research administration
James W. Gentry, University of Maryland	Chemical engineering
John B. Heagler, University of Missouri	Civil engineering
J. V. Leeds, Rice University	Environmental health
George Leppert, Clarkson College of Technology	Systems design
M. G. McLaren, Rutgers University	Metal systems
John M. Richardson, National Academy of Engineering	Urban telecommunications
Thomas E. Stern, Columbia University	Electrical engineering
Robert Lamson, National Science Foundation	Program management
Ronald W. Shephard, University of California at Berkeley	Operations research

Richard E. Thomas, University of Maryland	Aerospace engineering

Service: Faculty and Student Participation in Community Action (II)

Chairman: John Ingram, Executive Assistant to the Deputy Mayor, Washington, D. C.

Participants	Area of Special Interest
Ernst O. Attinger, University of Virginia	Social systems analysis
Murray Aborn, National Science Foundation	Social science program management
Jeffrey M. Bruggeman, Peat, Marwick, and Mitchell	
Kan Chen, Stanford Research Institute	Urban development
Bruce M. Davidson, Washington State University	Environmental health
S. L. Dickerson, Georgia Institute of Technology	Automatic controls
Robert Garman, Dartmouth College (student)	Electronics engineering
E. Trimble, Wellesley College (student)	History
Roger A. Holmes, Purdue University	Electrical engineering
Thomas E. Stelson, Carnegie-Mellon University	Civil engineering
Winfield W. Tyler, Xerox Corporation	Research administration

Walter C. Vodrazica, University of Texas	Highway systems engineering
Jay W. Forrester, Massachusetts Institute of Technology	Management
Mihajlo Mesarovic, Case Western Reserve University	

City-Related Research: Conduct, Content, and Purpose (I)

Chairman: H. Fred Campbell, Chairman of the Board, H. F. Campbell Company, Detroit, Michigan

Participants	Area of Special Interest
Eugene T. Booth Stevens Institute of Technology	Research administration
Samy Elias, West Virginia University	Industrial engineering
Salah E. Elmaghraby, North Carolina State University	Operations research
J. Ernest Flack, University of Colorado	Urban engineering
Frank A. Gerig, University of Missouri	Urban problems
Louis M. Laushey, University of Cincinnati	Civil engineering
Earl Lindvelt, National Academy of Sciences - National Academy of Engineering	Housing
W. R. Lynn, Cornell University	Sanitary engineering
Brian W. Mar, University of Washington	Systems engineering
Elias Schutzman, National Science Foundation	Technology and program management

R. G. Shuttleworth, South African Embassy	Scientific liaison
Lynn Tatum, Wellesley College (student)	Economics
Mark Werre, Dartmouth College (student)	Civil Engineering
Paul C. Yuen, University of Hawaii	Research
Gary Mason, Dartmouth College (student)	
Alvin Drake, Massachusetts Institute of Technology	Systems engineering

City-Related Research: Conduct, Content, and Purpose (II)

Chairman: Howard Margolis, Institute for Defense Analyses, Arlington, Virginia

Participants	Area of Special Interest
Fred J. Benson Texas A & M University	Administration
Andrew Brown, Jr., Wayne State University (student)	Engineering
J. E. Cermak, Colorado State University	Fluid mechanics
Gordon Clark, Ohio State University	Systems engineering
Nicholas DeClaris, University of Maryland	Electrical engineering
Steven Ebbin, National Academy of Sciences - National Academy of Engineering - National Research Council	Environmental studies

Irving N. Einhorn, University of Utah	Materials science
R. E. Rostenbach, National Science Foundation	Science program direction
John M. Ide, National Science Foundation	Technology and program management
Roger Levien, RAND Corporation	Systems sciences
Earl Phillips, The Urban Coalition	Urban problems
George W. Reid, University of Oklahoma	Civil engineering and environmental science
Peter Roitman, Dartmouth College (student)	Computers
Rahul Chattopadhyay, University of Hawaii	Urban systems Analysis
Michael Gaus, National Science Foundation	Engineering program direction

City-Related Research: Conduct, Content, and Purpose (III)

Chairman: Andrew F. Euston, Office of Community Development, Department of Housing and Urban Development, Washington, D. C.

Participants	Area of Special Interest
Edward Blum, New York City-Rand Institute	Systems analysis
J. B. Chaddock, Duke University	Urban transportation
Ronald J. Hensen, University of Denver	Civil engineering

Stothe P. Kezios, Georgia Institute of Technology	Heat transfer
Louis F. Kozda, University of Michigan	Information engineering
Malcolm Lewis, Dartmouth College (student)	Systems analysis
Bobbi Lindberg, Wellesley College (student)	Economics
J. K. Parkinson, Johns-Manville Corporation	Research administration
A. J. Pennington, Drexel Institute of Technology	Technology and program management
John J. Turin, University of Toledo	Administration
William Wallace, Renssalaer Polytechnic Institute	Urban and environmental studies
Melvin M. Webber, University of California at Berkeley	Urban planning
R. D. Worrall, Peat, Marwick, and Mitchell	Traffic research
Martin Goland, Southwest Research Institute	Technology and program management
Benjamin Linsky	Air pollution

University Goals and Their Interaction with the Urban Needs (I)

Chairman: Lucius P. Gregg, Program Officer, Alfred P. Sloan Foundation, New York, New York

Participants	Area of Special Interest
Walter R. Hibbard, Jr., Owens-Corning Fiberglas Corporation	Research administration
Richard E. Balzhiser, University of Michigan	Chemical engineering
Donald S. Berry, Northwestern University	Transportation engineering
Harry K. Bourne, United Kingdom Scientific Mission	Scientific liaison
Ben B. Ewing, University of Illinois	Environmental quality
Linda Harris, Wellesley College (student)	Economics
William W. Hines, Georgia Institute of Technology	Operations research
Warren E. Ibele, University of Minnesota	Mechanical engineering
Thomas McWhorter, Dartmouth College (student)	Fluid mechanics
David V. Ragone, Carnegie-Mellon University	Urban affairs
Robert Saunders, University of California at Irvine	Administration
S. R. Stearns, Dartmouth College	Civil engineering
Thomas F. Jones, University of South Carolina	Administration
John W. Dickey, Virginia Polytechnic Institute	Civil engineering

R. S. Goodrich, National Science Foundation	Engineering materials
Murray Kamrass, Institute for Defense Analyses	Program direction

University Goals and Their Interaction with the Urban Needs (II)

Chairman: Walter A. Rosenblith, Associate Provost, Massachusetts Institute of Technology, Cambridge, Massachusetts

Participants	Area of Special Interest
Robert A. Burco, Stanford Research Institute	Operations analysis
R. J. Churchill, Colorado State University	Electrical engineering
Herman L. Danforth, University of Arizona	Public works
Andrew Haynes, Syracuse University	Urban policy
Caroline Jonah, Wayne State University (student)	Mechanical engineering
Seymour Kaplan, New York University	Economic modeling
Robert Nathans, State University of New York	Urban engineering
R. L. Patterson, University of Florida	Public systems analysis
Sidney Shore, University of Pennsylvania	Civil engineering
John R. Russell, Harvard University	Business administration

Gordon K. Zenk, General Research Corporation	
William Felling, Ford Foundation	Program management
Carl Phillips, Dartmouth College (student)	Electrical engineering
William K. Linvill, Stanford University	Engineering systems