NBS SPECIAL PUBLICATION 347

Proceedings of Joint Meeting of Government Operations Research Users and Producers

U.S.
DEPARTMENT
OF
COMMERCE
National
Bureau
of
Standards

NATIONAL BUREAU OF STANDARDS

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Office of Standard Reference Data—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Part of the Center for Radiation Research.
[3] Located at Boulder, Colorado 80302.

UNITED STATES DEPARTMENT OF COMMERCE • Maurice H. Stans, *Secretary*
NATIONAL BUREAU OF STANDARDS • Lewis M. Branscomb, *Director*

Proceedings of Joint Meeting of Government Operations Research Users and Producers

Held at the National Bureau of Standards
Gaithersburg, Maryland, June 5-6, 1969

Erling H. Hustvedt, Conference Coordinator

Mary L. Friend, Editor

Sponsored by the
Technical Analysis Division
Institute for Applied Technology
National Bureau of Standards
Washington, D.C. 20234

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ABSTRACT

Frequently government agencies are unsure as to whom to contact when they want Operations Research/Systems Analysis studies made, and many agencies know very little about what other agencies might be doing in the field of operations research. Many public and private agencies have little knowledge as to which government agencies might derive the most benefit from their kinds of expertise and experience.

The Joint Meeting of Government Operations Research Users and Producers was organized to improve the communications among Users of operations research within the government, and Producers of operations research in public and private organizations.

Government agencies were invited to report on exactly what they expect of their OR producers, what they expect to have done with the results, what the purposes and their uses of systems analysis are, and to give a general profile of their in-house work.

Universities were invited to report on their capabilities and their desires and to discuss the OR projects currently in progress on their campuses.

This meeting was the second in a planned series of meetings. It had for its purpose the longer range goal of providing more responsive and more adequate studies for improving government agency management and productivity.

Keywords:

Conference proceedings; contract research; federal government; information exchange; NBS; operations research/systems analysis studies; OR users and producers; planning.

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INTRODUCTION

Frequently government agencies are unsure as to whom to contact when they want Operations Research/Systems Analysis studies made, and many agencies know very little about what other agencies might be doing in the field of operations research. Many public and private agencies have little knowledge as to which government agencies might derive the most benefit from their kinds of expertise and experience.

The Joint Meeting of Government Operations Research Users and Producers was organized to improve the communications among users of operations research within the government, and producers of operations research in public and private organizations.

Government agencies were invited to report on exactly what they expect of their OR producers, what they expect to have done with the results, what the purposes and their uses of systems analysis are, and to give a general profile of their in-house work.

Universities were invited to report on their capabilities and their desires-- to undertake research, to perform student projects, to provide graduate interns, etc., -- and to discuss the OR projects currently in progress on their campuses.

To further increase the knowledge of both users and producers about the work that is going on in the operations research field, all participants at the meeting, and others who cared to do so, were requested to submit one-page summary sheets which included a description of their organizations' capabilities, their current OR projects and the names of project leaders, names of personnel to contact for further information or for discussion of possible project undertakings, and such other information as might be of interest to the OR community. There were 142 sheets submitted and these were bound in a volume and sent to all participants at the meeting and to other interested persons.

This meeting was the second in a planned series of meetings, which has for its purpose the longer range goal of providing more responsive and more adequate studies for improving government agency management and productivity.

This meeting was one motivated by needs stated in the Proceedings of the First OR User-Producer Conference, and reprinted here.

The following considerations underlay the planning of the conference, and our hopes for future related activities:

(1) There does not exist, but there should exist, a reference inventory of completed and on-going operations research/systems analysis/multidisciplinary research/scientific planning activities in the Federal Government, so that a technical exchange of methods, techniques, benefit measures, cost methods, etc., could be facilitated.

(a) There are methods to be applied that are not unique to one agency, e.g., tests of organizational effectiveness.

(b) There are suggestive analogies among problem types from agency to agency, e.g., a network of highways and a network of post offices.

(c) There are interaction situations, e.g., the full program benefit to one agency may be incompletely calculated due to excluding benefits arising to other Federal missions.

(2) The growth in opportunity to test the usefulness of systems analysis in new non-defense contexts underscores the importance of making sure that any initial study has the fullest possible measure of success at an early date, and this might exclude repeating exploratory work others have done. No reassuring encyclopedic memory bank exists.

(3) Each of us knows of a dozen or two other studies or groups, but the creation of new groups is making it more difficult and time-consuming to keep up to date. We need a new one-time updating.

(4) The introduction of the new Bureau of Budget Planning, Programming, and Budgeting (PPB) System (Circular 66-3) places an explicit requirement on agencies to provide systems analysis, benefit-cost studies, and supporting documentation. Some agency chiefs have asked OR groups, "Tell me what you can do to help;" the OR groups need to meet with the PPB originators on a technical basis for a fuller understanding of the substantive requirements and desires so that they can help their parent agency to respond adequately to this new system.

(5) The problem of identifying measures of effectiveness for agencies is a common one; some have made good progress in this area, and others are searching for ways to make a good start. Furthermore, many agencies have missions whose ultimate measures of effectiveness can be partly stated in common terms, e.g., stimulate the economy, improve the standard of living, etc. Aside from the recent Brookings Institution publications, Roland McKean's earlier book, the BOB bibliography of benefit-cost studies, and a few other attempts of a more nebulous nature, the best information on measures of benefit is scattered among our individual heads and in individual files.

(6) The changing semantics and connotative nuances placed on the terms, "operations research," "systems analysis," "multidisciplinary problem-solving teams," and "planning systems," are further confused by actual practice. For example, OR is frequently defined to be identical with what the statistics group does, or with the problems that are sent to the computing lab, or with the managment analysis program of an agency, or with just plain horse sense. Accordingly, there does not seem to be a good common dictionary of what to include, or what to exclude from a conference such as this. Each agency has one or more groups with something significant to contribute or gain; these groups are all talking, with greater or lesser degree of specialization, to a common problem--that of providing a rational scheme for identifying and comparing alternatives in terms of their expected payoff and resource requirements. Similar differences exist in the dimension that starts with pure methods research and ends somewhere with the "back of the envelope calculations" or "the horseback guess." We thought it better to invite all these audiences in the first round, and let the agency decide whether the conference was relevant enough to participate.

(7) With non-defense OR getting a stronger impetus, there is an obvious need to profit from the lessons learned in the defense business. There is also the need to make sure that when defense readiness is a relevant measure of effectiveness of civilian programs, it is included; the reverse is also true. Furthermore, because of the scarcity of professional personnel at the present time, it is important that the growth of non-defense OR not compromise defense requirements.

(8) Procedural and institutional problems related to starting and effectively using OR groups probably have a large degree of similarity from agency to agency. The lone systems analyst who has been instructed to prepare a plan to start a viable activity in the agency should have access to plans that have a good chance of succeeding.

(9) There are agency officials who would like to get OR started, and would like some impartial advice, but who aren't quite sure how to get it. Furthermore, they would like to see at first hand what the nature of the projects suitable for such a group might be.

(10) The agency OR groups need to have an inventory of external resources available to help him in his problem solving: universities that want graduate thesis topics and support, professors who want a sabbatical, colleges that are willing to carry out a class project on a systems problem for an agency, etc.; contractors and their strong points and experience; expert personnel resources; data sources that could be relevant and could be used; etc. We recently compiled a list of contracting agencies with a Washington office and which advertised OR or systems analysis as a specialty, and ended up with 40 on the first trial. RFP lists should be complete and relevant, and there is no good way of being reasonably sure of this at present. It is not common knowledge how much or on what basis one agency can call on another (e.g., Bureau of the Budget or Bureau of the Census) for substantive help or data exchange.

(11) Currently employed methods of quality control on OR studies could be improved if experts in other agencies were known and could be asked to participate in project design or review.

(12) There is a need for an experimentation laboratory in systems analysis in addition to the specific agency opportunities. Field experimentation has always been part of a complete analysis, yet for most purposes, a truly experimental opportunity does not exist.

(13) There will soon be a need for some analytic scheme to tackle the inter-agency program balance problem, be it a system of rebuttal and debate with common reference terms, or a government management game, or an inter-agency analysis group, or some other method.

(14) There is a need for an OR textbook suitable for government agency use.

(15) There may be a need for a explicit mechanism to rotate OR personnel among agencies, to universities and back, etc.

(16) There is a need for a census of resources including hardware, software, programs, computers, etc.

The recent rapid growth in operations research/systems analysis/multidisciplinary problem-solving teams in the non-defense agencies of the Federal Government has opened a challenge of unusual proportions to the OR community.

At issue are questions concerning the development of analytic methods, test methods, data systems, and means of drawing inferences in studies whose purpose is to improve the operations of the non-defense agencies of government. Questions related to the definition, the criteria, the measures, and the means of measuring the effectiveness of non-defense programs are but the beginnings of the work ahead. There is the problem of determining the best program mix within an agency whose missions are stated in many different ways and which sometimes appear irreducible to a single common scalar purpose. There is the question of how to determine the effectiveness of a Federal program when it is designed to assist in improving individuals, communities, states, and regions, especially since the instruments of bringing about that improvement are in the hands of many sources of power in the democratic system of rebuttal and debate that characterizes the American society.

Accordingly, operations reserach in the non-defense agencies is confronted with the unavoidable task of discussing issues that are at the heart of our democratic society. It is important that analytical, methodological, and substantive discoveries made in one agency that are suitable for use by another agency be made a portion of the government memory bank as easily and quickly as possible.

One of the aftermaths of the OR conference was an expressed need, as articulated by many groups, for the following two kinds of activity as a minimum.

(1) The convening of small, informal ad hoc discussion sessions by agencies of the government to which the OR people from other agencies are invited.

(2) The maintenance by some agency of an up-to-date mailing list of all those government agencies, OR groups, universities, and contractors, who should be informed of the relevant items, including an up-to-date inventory of on-going OR projects and people finders in government.

The Third Joint Meeting of Operations Researchers in the Federal Government and the Private Research Sector, the next in this series of meetings, was held on May 7 and 8, 1970, at the National Bureau of Standards, Gaithersburg, Maryland. For this meeting the one-page summary sheet publication was up-dated and copies are available on request to the Technical Analysis Division, National Bureau of Standards, Washington, D. C. 20234.

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Institute for Applied Technology
National Bureau of Standards

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National Bureau of Standards

Bureau of the Budget:
Dr. Jack Carlson

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Mr. John Borkman

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Post Office Department:
Mr. Donald G. Haag

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New York University:
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Northwestern University:
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George Washington University:
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Georgia Institute of Technology:
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Friday, June 6, 1969

Morning Chairman: John Locke
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Department of Health, Education, and Welfare

Consumer Protection and Environmental Health Service:
Mr. Victor C. Searle

Office of Education:
Dr. William Dorfman

Department of Agriculture:
Dr. Vernon C. McKee

Other Government Agencies:
Dr. W. E. Cushen

University of Texas:
Dr. William Lesso

University of Iowa:
Dr. John Ramberg

University of Maryland:
Dr. Rudolph P. Lamone

Massachusetts Institute of Technology:
Professor Alvin Drake

North Carolina State University:
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Oklahoma State University:
Professor James Shamblin

Polytechnic Institute of Brooklyn:
Professor Norbert Hauser

Rensselaer Polytechnic Institute:
Dr. John W. Wilkinson

Southern Methodist University:
Professor William P. Pierskalla

Stanford University:
Dr. Gerald Lieberman

State University of New York at Buffalo:
Professor Charles G. DeWald

Johns Hopkins University:
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United States Military Academy:
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Naval Postgraduate School:
Dr. J. R. Borsting

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Dr. B. Curtis Eaves

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Professor Ronald W. Shephard

University of Michigan:
Dr. Richard Wilson

University of Arizona:
Dr. A. W. Wymore

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JOINT MEETING OF GOVERNMENT OPERATIONS RESEARCH USERS AND PRODUCERS

Proceedings of a Meeting

held at

the Gaithersburg Laboratories of the National Bureau of Standards

June 5 and 6, 1969

Welcome to NBS

Dr. Howard E. Sorrows
Acting Director, Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

It is an honor to welcome you on behalf of the National Bureau of Standards to the Joint Meeting of Government Operations Research Users and Producers.

In the minds of many people the Bureau of Standards is an organization devoted principally to measurement in the physical sciences. The question must have occurred to at least some of you as to why such an organization would spend its time and resources sponsoring a conference on operations research.

The Bureau is, indeed, concerned with measurement in the physical sciences, or as we state it in the language of PPB, we provide support for the National Measurement System. It is proper and important for an organization with such responsibility to have competence and activity in the measurement of system performance. OR analysts have this skill as well as other skills which we need for our programs.

In addition to our responsibility for the National Measurement System, NBS has statutory responsibility to provide scientific advice and assistance to other Government agencies. I believe that we are the only agency with specific statutory responsibility of this type. An important part of our response to this responsibility is the assistance we give other agencies in the field of operations research/management science.

The history of operations research at NBS goes back more than a dozen years. The problems we were working on then ranged from the Post Office mechanization to antiballistic missiles. Ten years ago organizational recognition was given to OR by the formation of an OR section in the Applied Mathematics Division. Dr. Alan Goldman, whom many of you know and respect, was selected as its chief and he remains in that position. Although this group has made significant contributions to practical problems, its primary interest is the development of new methodology. Five years ago we established the Technical Analysis Division under the leadership of Dr. Cushen. The purpose of this group was to apply OR to the problems of the Department of Commerce and to other agencies of the Federal Government. This division has been very successful. It has grown from a nucleus of 13 to over 90. More important, it has developed valuable simulation models for other agencies. Still more important, it has fostered the use of OR in other agencies through a variety of activities including teaching, consulting, and performing research: it is sponsoring this conference which I hope and expect will make an important contribution in fostering the use of OR.

I have been impressed by the boldness of some OR analysts in their willingness to tackle difficult management problems. As individuals, they seem to have boundless energy and enthusiasm. I believe this is because they have skills and interests which seem applicable to most any management problem. Even when they tackle the most difficult problems, they help management develop the right questions and establish vehicles of communication. This enthusiasm and competence is certainly necessary in tackling the types of problems that arise in the Federal Government. These problems are seemingly insoluble and plagued with an infinite set of parameters. Also, simple solutions are needed instantly. If this definition of Government problems doesn't scare you, perhaps you have what it takes to work on them.

The National Bureau of Standards sponsors and hosts many conferences. These conferences are frequently the type that shape careers of individuals, channel professions and make national impacts on society. For example, I have been told that the Operations Research Society of America was an outgrowth of a symposium held at NBS under the auspices of the Applied Mathematics Division. If this conference fulfills our expectations, it will be one of those conferences that will make a major impact and that we will boast about to future conferences.

I wish you success.

Introductory Remarks

W. E. Cushen
Chief, Technical Analysis Division
National Bureau of Standards
Washington, D. C. 20234

During these fifteen minutes which precede the introduction of our first speaker, I would like to discuss with you the underlying rationale of this conference: Why did we in the Technical Analysis Division organize such a meeting, and what should we expect to accomplish in the course of this two-day meeting?

We want this conference to be a learning experience. During the next two days, we want the producers of operations research--all of you who represent public and private organizations, as well as university programs in operations research and related fields--to become acquainted with the problems for which government agencies are seeking solutions--solutions which you can help to provide. And, we hope that these agencies will learn what they can expect from those of us who offer operations research and system analysis as problem-solving techniques.

Figure 1 illustrates the general conceptual framework of the area we are exploring. Here we see a set of producers--commercial, non-profit, industrial, university, and our Technical Analysis Division--as illustrative of those persons who want to produce and use operations research methods for solving government problems. We see also approximately 200 agencies of government--agencies at all levels: Federal, State, local; departments, divisions, bureaus, and sections--whose mandate is the solution of critical social problems. The end product of the interrelations and correlations of these two groups will be the successful resolution of such problems. And, in the final analysis, the effectiveness of those groups who produce operations research will be measured in terms of our successes or failures in resolving critical national problems.

Those of you in the government agencies are, quite frequently, unsure as to whom your requests for quotation or your requests for proposal should be addressed. Your selection of a particular producer may well depend upon the nature of the problem to be resolved. Is yours a problem generated by an Under Secretary who needs an answer within 15 minutes, or does your problem reflect the concern of some highly sophisticated consumer seeking to advance the state of the art? Your selection of a particular group may well be contingent upon the constraints of your particular situation, and your location within the framework of the bureaucracy. By the same token, those of you in the producing community may have little knowledge as to which government agencies might derive the most benefit from your kinds of expertise and experience. We hope that this conference will enable both groups to become better acquainted.

To what extent do the civilian agencies of government actually employ members of our profession; to what extent do they implement operations research and related methodologies toward the solution of their problems? Figures 2 and 3 illustrate the exponential rate of growth which has occurred in the government's employment of professionals in operations research, systems analysis, human factors, economics, and related fields.

The numbers on this first chart are taken from data points created by the "White Collar Survey" which the Civil Service conducts on October 31 of nearly every year, but figures from 1963 and 1965 were unavailable. The chart shows that the numbers of professionals employed in government have increased rapidly. This fact seems to contradict the predictions of many prophets of doom--who have suggested that, even in the military, the use of systems analysis and operations research has begun "to saturate" and taper off. The facts show that exponential growth is still pronounced--even in the military establishment.

In Figure 3, we have shown the number of OR professionals in each of the civilian departments of government--as computed by the Civil Service Data Processing equipment. A tentative estimate of the total population, as of October 1968, is that there were 204 professionals. Note that--although we have included the several professionals scattered throughout NBS and the Department-at-large--our estimate of the number of professionals working in the Department of Commerce is basically a reflection of our own division's staff. Note also that the Department of Transportation (perhaps reflecting its status as one of the newer government agencies) has enjoyed a rather rapid acceleration in the use of OR analysts. The Department of Transportation is unique among the civilian agencies of government, in having OR analysts in the category of GS-18. The other agencies, by contrast, have enjoyed--or suffered--a rather "lumpy" history in the use of operations research. This chart should give you, the producers of OR methodologies, a general picture of the kinds of "receiving membranes" you can expect to find in the agencies to whom you submit proposals--a basis on which you can predict the facility with which your proposal will (or will not) be interpreted.

Figure 4, obtained from the CSC, reflects data taken on the number of economists, math statisticians, and mathematicians in the Federal structure over the same time period as indicated in Figures 2 and 3 . As you can see, we are in an interesting exponential growth rate ourselves. The economists have just gone through a redefinition of the criteria as to what constitutes acceptability for an economist. The standards are a little tighter than they used to be on that one.

We feel that, in spite of the multiple frustrations, and the diversions and discouragements involved in getting the civilian agencies to use operations research, all of us here at this conference do have a common purpose. The government agencies know they want to use these methodologies and techniques; and we, the producers, know we want to make our expertise in OR, systems analysis, human factors, cost/benefit analysis, and so on, available to government. . We have invited each government agency to "tell it like it is"--to tell us exactly what they expect of their producers, exactly what they expect to have done with the results, what the purposes of their uses of systems analysis are, and to give a general profile of their in-house work.

Because we in TAD have a prejudice which says that government agencies have been unable to respond fully to the enthusiastic offer of help from the universities, we have explicitly invited universities to come and tell us about their capabilities and their desires--to undertake research, to perform student projects, to provide graduate interns, and so on.

We have invited the commercial producers to attend. And, if this conference were long enough, we would like to have given each of you a place on the podium. We invite you, instead, to lay copies of your wares on the tables outside--and to engage in as much information gathering as time permits. We know that you are a resourceful group; thus, all of us with buttonholes have come with the expectation that our coats may be severely frayed by the time we leave!

One of the "accidental" discoveries we have made during our five years of existence is that many civilian agencies of government are quite unaware of the expertise available in the Department of Defense which can be rather easily adapted to serve civilian purposes. And, we have found that many agencies know very little about what other agencies might be doing in the field of operations research. So, we are attempting to open up the channels of information and communication.

In the library of the National Bureau of Standards, we have assembled a book display to acquaint you with some of the more informative texts concerning operations research and related areas. We hope that our display will assist those of you who are thinking about setting up your own in-house library by suggesting titles which you probably should include in your initial purchase order, and those journals which will prove a worthwhile subscription investment.

A number of the government agencies who have been invited to participate have declined to make a formal statement from the podium. Because there's a new Administration coming in, and because they are still unsure of their appropriations status, some agencies are understandably reluctant to make a definitive statement as to what you can expect as to their program of support or their implementation of systems analysis. Most of the agencies, however, have sent representatives who are somewhere on the floor of the conference. So, if you have questions to place to the representative of, say the Department of Housing and Urban Development, their representative will attempt to respond as well as he can. Some people will be speaking officially, and others will be commenting quite unofficially--you should interpret accordingly.

The conference proceedings are being taped. The transcription will be sent to each of the speakers for correction. We intend to publish the proceedings, and each of you who has registered will receive a copy. We have received from about 75 groups their one-page summary of their activities in the field of operations research. Agencies, industrial firms, and universities who have not yet sent us that one-page form are invited to do so. These summary sheets will be packaged with the conference proceedings. To the extent that it is possible, our division volunteers to try to keep those summary volumes up-to-date and to distribute them on an annual basis. We live a rather busy existence in our Division, so we cannot guarantee efficiency in this operation, but, at least, we can guarantee fidelity and interest. So, if you keep us up-to-date, we'll try to keep everyone else up-to-date.

Our next scheduled speaker is Jack Carlson from the Bureau of the Budget. Jack represents the institution who perhaps has been the largest single identifiable force in introducing operations research methods to the civilian agencies of government.

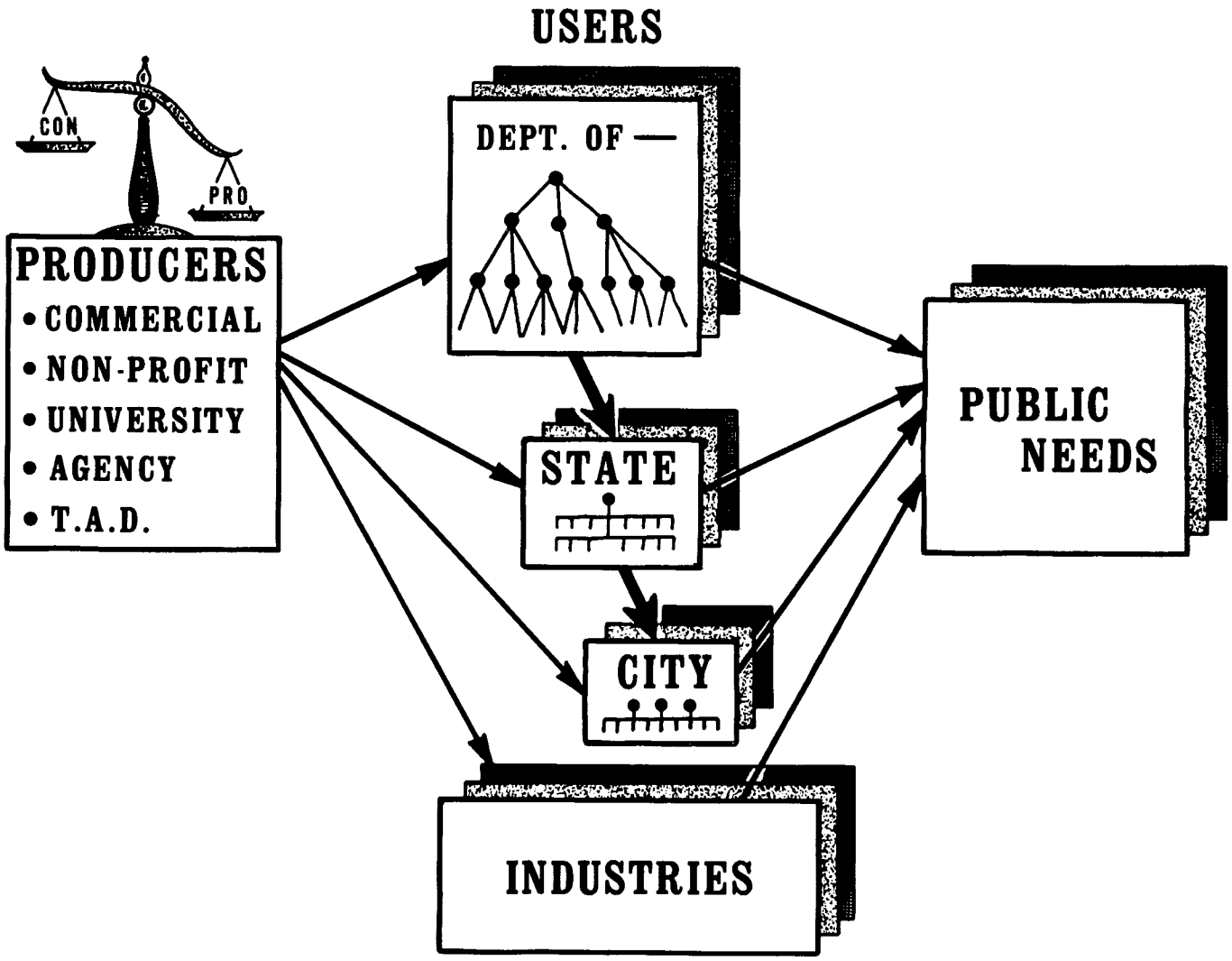
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Figure 1.

O.R. ANALYSTS GS-1515

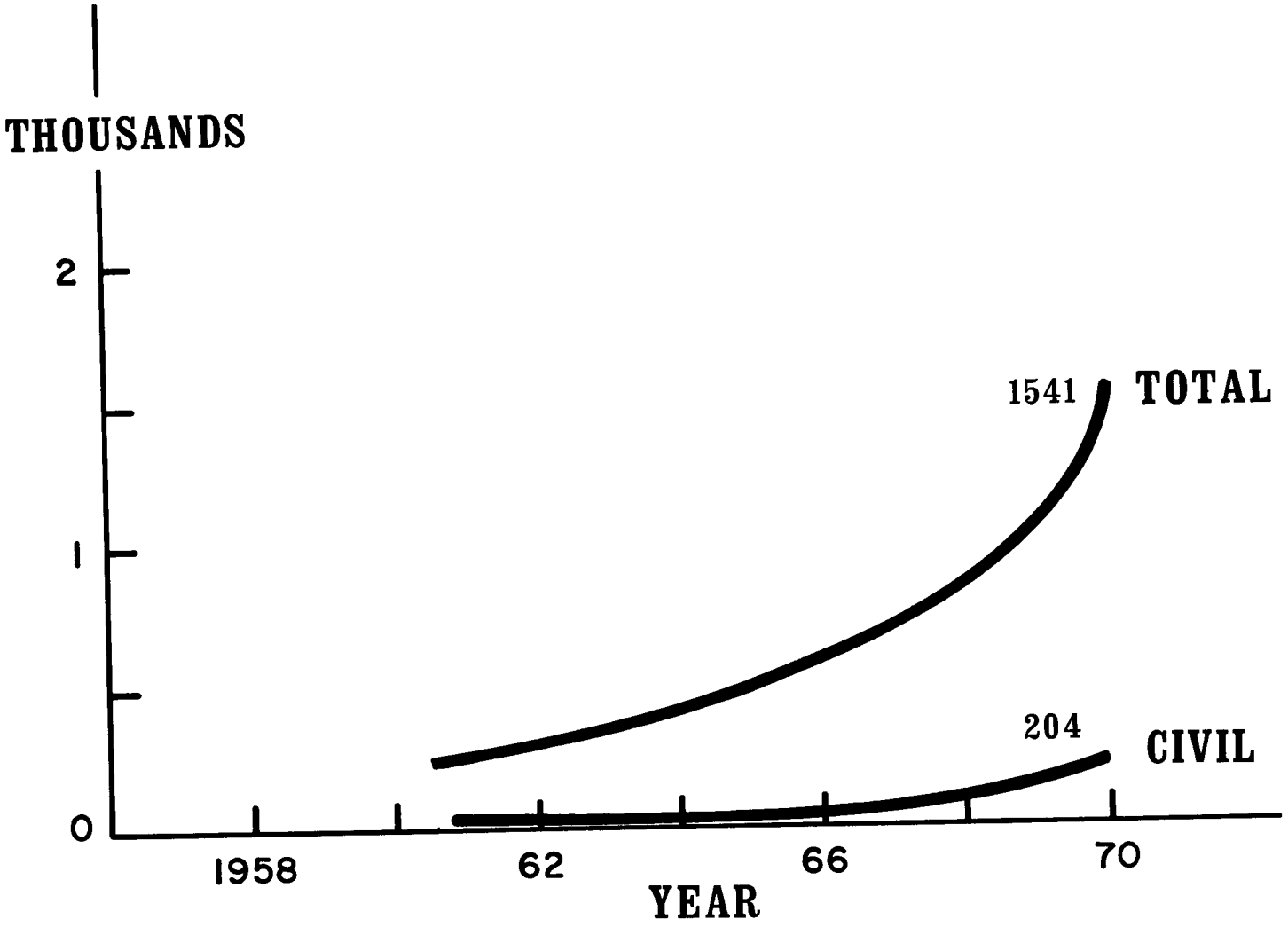


Figure 2.

CIVIL AGENCY O.R. ANALYSTS

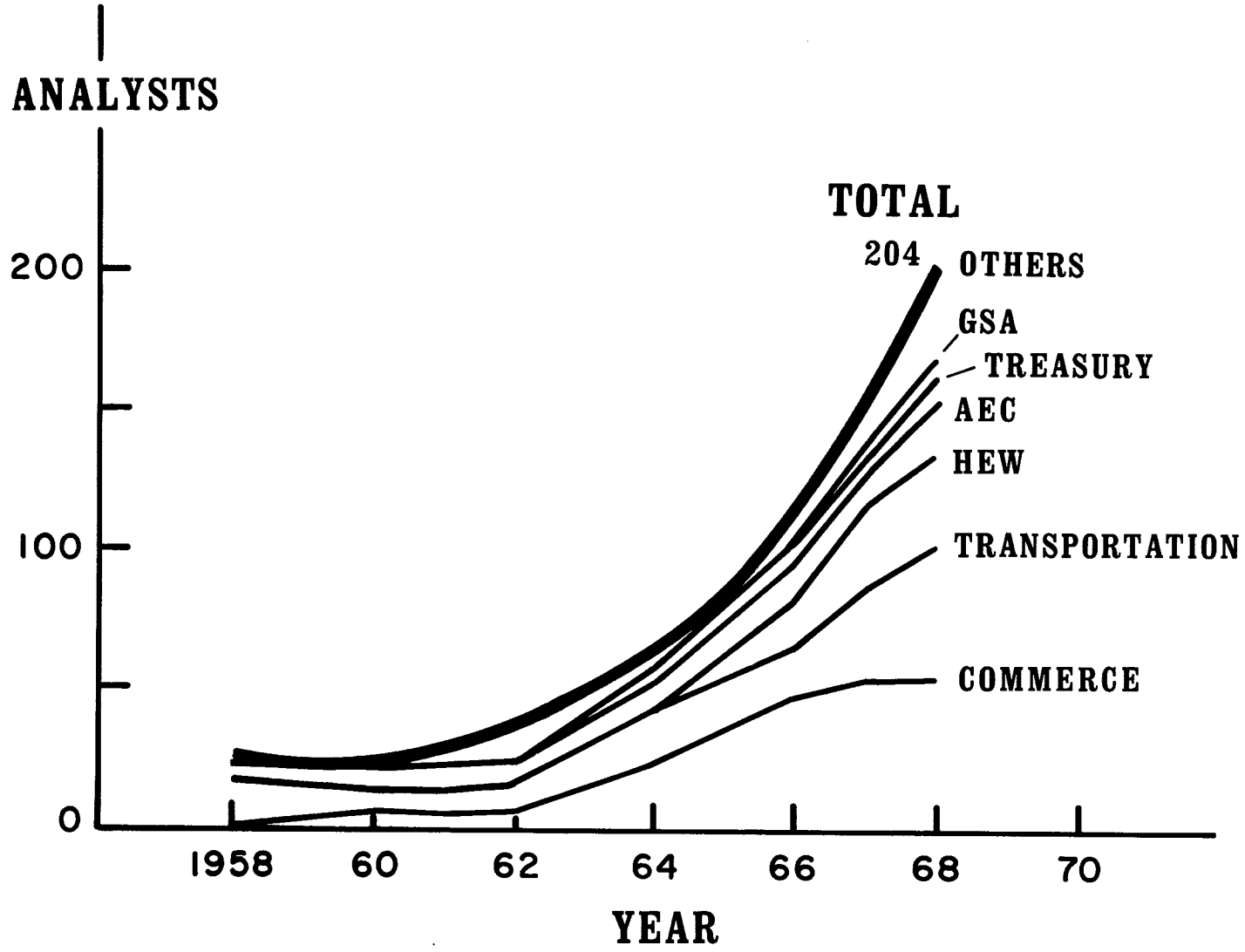
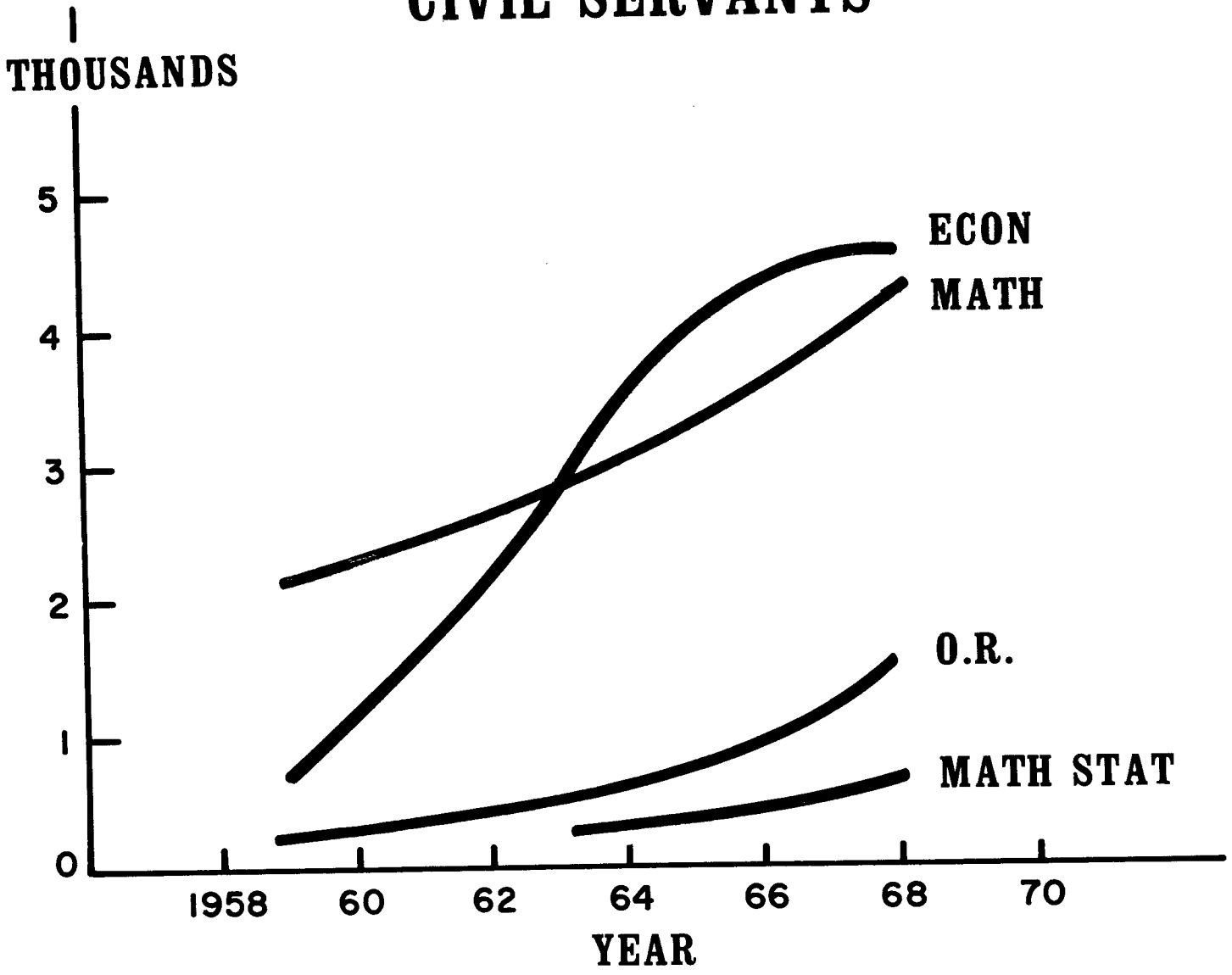


Figure 3.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4
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Figure 4.

Joint Meeting of Government
Operations Research Users and Producers

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I am pleased to accept this assignment and make some comments about program evaluation in the Federal Government. First, I would like to express strong agreement with the initial comments to the effect that the possible users of Program Evaluation and PPBS are, obviously, not just in the Federal Government but also in State and local governments. These units are increasing their expenditures very rapidly, partly because the Federal Government is redistributing some funds back to the States for their use--grant-in-aid funds next year will be about $25 billion--and also because revenues from State and local sources are also increasing rapidly. So, when considering PPBS, one must bear in mind that the system must work for users at the Federal, State and local levels.

In discussing program evaluation at the Federal level, I should emphasize the obvious, that evaluation in the Government is different from evaluation in the private sector. The major reason is that the Government usually has a more complex combination of objectives that it wants to achieve simultaneously than is normally found in private activity. In business, for example, it is convenient to have the profit motive as a model so that at least roughly all motivations work toward maximizing profit. This is not completely true, of course; the literature is full of examples where firms maximize something other than profits. Nonetheless, the number of objectives of the firm tend to be rather limited and usually related to the profit motive.

In the Federal Government, there are many more objectives and many more conflicts and complexities. Many of these are associated with what we call public goods, goods for which consumption by one person does not affect the consumption of another or for which a person providing the good cannot capture the rewards for having produced it. In such a case there are inadequate market price signals or a market mechanism available and we cannot rely upon this process to determine the optimum level of production. National defense is one of the most obvious examples here. Law enforcement is another. Most Federal expenditures do involve a public good to one degree or another.

Another public objective is to overcome spillover effects or externalities. These are benefits or costs which are transferred or imposed on one social unit by the independent activities of another. In the private sector the decision-maker often or perhaps even usually does not consider these. For example, unless forced to by the Government, a private utility or automaker is unlikely to consider pollution problems caused by his activities. His firm's cost of production is less because it uses the air to get rid of industrial waste than it would be the case if pollution were forbidden. The cost is still there, in the form of the disbenefits imposed on other users of the air. This does not mean, of course, that we should automatically forbid all pollution. One has to consider the costs of alternative methods of waste disposal as well as costs to those damaged by pollution; for example, I do not think we would want to do without electricity to avoid any air pollution, but we might be willing to pay something to avoid it.

Another public objective is the redistribution of income--that is, assistance to specific groups such as the poor, the aged, and the disadvantaged. Redistribution may be effected by the transfer of money, future income, or by the provision of goods and services; examples are: public assistance programs, public investment in education programs, and food distribution programs, respectively.

Also, a public objective is the removal of imperfections in the operation of the private market or the alleviation of their effects--for example, providing a competitive standard for public enterprises where none would otherwise exist; improving market information for consumers, producers and workers where the market would otherwise work badly; developing large-scale projects where significant economics of scale exist.

The complexity inherent in the multitude of public objectives is compounded by the fact that there are many participants in the decision making process and many conflicts between them as to the relative importance of different sets of objectives. If one is doing analysis for a particular bureau chief, one must worry about the objectives he thinks are important. But it may turn out that the objectives of his boss or those of the President or the Congress are all different, or at least have a different weighting. It is obvious, therefore, that the results of analysis cannot automatically identify the "best" decisions.

Sometimes experts will argue for spending solely for the purpose of producing as many new goods and services as possible irrespective of who receives them. However, in real life, national income maximization may be one of the lesser objectives of the Federal Government. People are always trading off efficiency considerations for equity ones, and perfectly rightly so.

Let me give you an example of the possible tradeoffs in terms of Federal manpower programs. We have a Manpower Development Training Program (MDTP) and a Neighborhood Youth Corps, (NYC), out-of-school program. Now, within the limits of the rough estimates that one can make, it appears that MDTA On the Job Training (OJT) Program might have, and I emphasize might, benefits that are 290 percent of costs, and NYC benefits of 170 percent of costs. Obviously, MDTA is a better program on that criterion. However, in the MDTA Program only 65 percent of the trainees are from poor households. The corresponding percentage in NYC is 97 percent. So if the objective is to help poor households then the NYC program is better than the MDTA. Or one can look at the programs in terms of the age of the participants. In the MDTA, 40 percent of the trainees are under 21 and in NYC all of them are under 21. So which program is better depends upon what one sees as Federal objectives. There may be three, four, or five different objectives. In the course of the political process to produce the program different groups of supporters may have had different ideas about the real purpose of the program. Consequently, one must know the weights of the decision maker to know how he will come out after the measurement of each objective is made.

To complicate it even further, often we do not know our objectives before we start analysis. This sometimes makes analysts uncomfortable; they would like to have someone tell them what the objectives are for a particular program when the decision maker often does not know at the time the analysis is started and may be interested primarily in having the analyst tell him which objectives are open to him. Evaluation of the Federal Government works best when it is seen and used as an iterative process whereby analysis produces information that helps the decision maker determine his objectives which then helps the analyst do a better job introducing more refined information. One often finds that the initial analysis and the definition of objectives are completed at the same time. While this may seem aberrational to the purist, I assure you that the reasons I have given for it are good ones in the context of Federal Government decision making.

Despite all the difficulties of analysis, the Federal Government is very interested in analysis and planning and strongly supports it. The reasons for this are pretty self-evident, I think. Next year, for example, is going to be a tight budget year, which is following an already tight budget year. On the basis of a maintenance of effort in existing programs and policies, without any new initiatives, the budget could be higher than it is possible to have it. So we are compelled to reduce existing spending levels which is difficult to do. If one allows for new initiative then something in the present spending level must be cut

to make room. Nonetheless, despite this situation, the Director of the Budget Bureau sent a letter to every agency head and said: "take time, look and see if your analytical and planning resources are adequate and let us know the results." Anyone in the budget game knows that this is a hint that the Bureau of the Budget, not known for its great leniency, might be more lenient in ensuring that manpower and resource needs for program evaluation and planning are met. This is one of the few areas in which the Bureau has shown that kind of softness this year. We hope that we do get feedback from the agencies on the adequacy of their evaluation and planning resources.

In addition, the Federal Government is pushing evaluation on several other fronts. First, we are trying to identify the major policy issues that will face the Federal Government during the next year or two, those that have the greatest impact on Federal expenditures or social policies. The rough guideline on these issues was to choose only those that have a $50 million impact on the coming budget and $500 million impact during the next five years, or a comparable social impact. Because we are interested in maximizing social welfare rather than merely the Federal budget, we felt it necessary that this definition take account of programs which may be small in dollars but may have great impact on the private sector.

It was also important that the issues be limited in number. In the past, we have been more optimistic about the number of studies that could be done than were justified by available analytic resources. This year only 75 issues were identified for analysis whereas about 380 were identified last year. In the past, the large number of issues resulted in the available analytic talent being spread too thinly. About half the issues were not analyzed at all and the half that were tended to be descriptive material telling about the program rather than analysis of options and alternatives. Only about a fourth were adequately to excellently analyzed. This year we decided to identify far fewer issues and to define them more precisely so that we could be sure that the analysis would help in providing real choices for decision makers.

It is also an advantage this year that the constraints on a new Administration are less than on an old one. There are not so many sunk costs in terms of previous decisions which people feel bound to protect.

Second, we are attempting to summarize our knowledge and ignorance about the impact of programs on society. The Program Overview Project is the experimental effort. What it does is take a particular program area and try to identify the costs of the various programs, the outputs, the beneficiaries and in some cases the benefit-cost ratio. For example, the outputs for manpower programs might be man-years of training or average weeks of training per participant in the program. For health, an output under the Hill-Burton program might be the number of beds provided or the number of outpatient care services performed under Medicaid. Transportation units of output might be lane-miles of highways. While these are crude measures, as we well know, it is useful to have some estimate of the physical units of service provided. The projects portray beneficiaries by income, age, race, location by city size and by region.

The Program Overview Project attempts to show how programs in a general area are related to each other irrespective of the agency that operates them and how they relate to national objectives. It is intended to give decision makers an opportunity to look at an array of data and place their own weights so as to judge which program they might favor. Also, it helps to identify the paucity of program evaluation data.

We are going to push this type of analysis further. It introduces some rigor and discipline into our measurements of what programs are doing and provides some basis for comparison. This should be helpful both to agencies and to the Bureau of the Budget and the White House in making decisions.

Third, we want to have a decision process that demands good analysis, and at the same time be sure that relevant analysis is done in time to be useful. This requires both decision makers and analysts to see problems that are coming up and to get started early enough to make analysis useful. This is one of the main purposes of the Planning-Programming-Budgeting System adopted by the Federal Government. The new Administration is of course extremely interested in long-range planning and programming, and supports the PPB functions. While the acronym bothers many people, including myself, and might be changed some time, the functions are here to stay, and the main emphasis will be on improving the substance of the process. Unfortunately, in many agencies we have all procedures and no substance. In a few, we have a little substance and a little procedure and in some we have lots of substance and almost no procedure. We are trying to improve this and make sure that we have a balance--enough procedural requirements to insure that good analysis gets used and enough substance to ensure that we have more than a paper mill. Both are necessary if analysis and evaluation are to be useful. After all, one must keep one's eye on objectives and the objective here is to provide more feasible options to the decision maker and to help him make better decisions.

For those of you who are connoisseurs of the mechanics of PPBS, this means the program structures will be improved in the coming year. The issue process, as I stated, has been limited to a smaller number of issues and greater stress is being placed on actually getting results. In fact, if an agency feels that it cannot touch an issue or does not have the capability, we may need to get it done elsewhere. The program memoranda will be improved; again, we will emphasize that we are interested in a brief statement of substance rather than a long descriptive summary of the program. The Program and Financial Plan needs considerable improvement. We plan to discuss possible changes in this in some length with the agencies and then decide on a more useful form for it.

Generally, we plan to stress building up capability, and, as the previous speaker mentioned, it is vital to have consumers of analysis who know what it can do for them and who can help state the problem in a way that indicates what form of analysis would be most useful. The toughest skill, the skill in shortest supply, is the ability of people to phrase the question. Often we ought to spend a fourth or a half of our time learning how we wnat to state a problem and considering the research design before actual research starts. Often this is given short shrift. Also, sometimes someone outside the decision making process is asked to specify the problem and it turns out to be a beautiful piece of irrelevant analysis. It may be good for journals, or help make reputations, but it is no good for decision making.

In fact, there is a general problem of relevance in the academic community. In economics, we used to teach public finance from the revenue side, with nothing about expenditures. We spent time on revenues partly because the data were there and people were not sure what was happening on expenditures anyway. From my present point of view, I realize how much more we need to know about analyzing the expenditure side. So, in the field of economics they are starting now to look at evaluation of areas like health programs or education or manpower. I think this is a very good sign.

One offshoot of this trend has been that a connection is being forged between economics and some of the disciplines that have been most backward in the area of considering resource allocation questions, such as law or medicine. At Harvard, the medical school and the law school are now willing to have some students take time to study the theory of resource allocation.

I will conclude my introductory comments and answer any questions you have.

Dr. Cushen: I have a couple of questions here, perhaps to set the pace for the kind of things that I think you ought to be asking these people.

For those of you who are not subtle about the Bureau of the Budget--in the first place, those of you who have heard Bureau of the Budget talk before--will realize what a degree of informality has been achieved this morning by Jack Carlson. We deeply appreciate that.

Can you tell these people whether or not it makes sense to send proposals to do systems analysis or operations research to the Bureau of the Budget to be paid for by the Bureau of the Budget, perhaps out of the President's Management Improvement Fund?

Dr. Carlson: The style of administration in the Federal Government does not lend itself to the Executive Office conducting many studies on its own; therefore, a study initiated and directed by the Budget Bureau is the exception rather than the rule. In the Federal Government, the mission agencies are the ones who plan and manage programs and consider alternatives. Consequently, most studies are funneled through them. Even when we do take an interest in a study, as we will on occasion, it is done with the relevant agency. Consequently, the point of contact is the mission agency, not the Bureau of the Budget, Council of Economic Advisors, Office of Science and Technology, or the White House staff. We will, of course, urge the agencies to do analysis and we sometimes give analytic help to agencies in areas where we think analysis should be pursued.

Dr. Cushen: When you have urged the agencies to start improving their analytic skills, presumably you are targeting on the Department level for the most part. Do you visualize that they mean build an in-house staff or do things commercially? Do you have any feelings about whether a Department really ought to try to train and retain a captive group much in the tradition of the non-profits or do you prefer to leave that to the Department?

Dr. Carlson: I think it is imperative that the agency head or the bureau chief have an analytic staff reporting directly to him. This is vital for phrasing policy issues and for interpreting the results later on. The Planning, Programming, Budgeting System has stressed the need to have an analytic staff assigned to the Secretary's office. Preferably, this will be in the form of an Assistant Secretary in charge of Analysis or Planning and Programming or Planning and Policies, whatever the name might be. This is still our policy, and I might add, with reference to your previous question, that we support the initiative by the Congress of earmarking a small percentage of the program monies for program evaluation. This is a very useful practice and it has occured in about six or seven programs. We will be pursuing it through the year.

In addition, it can be useful and necessary at times to request assistance from non-Federal research or consulting companies. The frequency of use or relation to each Department should and does depend upon the needs and desires of each agency.

Dr. Cushen: Do you have any early warning signals or any early readings on the reactions of the House Appropriations Committee to that suggestion?

Dr. Carlson: Well, it has been passed in six legislative acts, both in terms of the authorization and the appropriations. As for initiating it elsewhere, I think we will have to wait and see. I would not want to mislead you. You know that Congress presents a mixture of attitudes about PPB, though the dominant one is indifference. In some cases, where the analysis might show progress toward objectives that are not now popular with public opinion, they might frown upon analysis. In other areas, I think there is a positive stimulus. In fact, the Joint Economic Committee has been putting a lot of pressure on the executive branch to do more in the area of evaluation.

Question from Floor: Do you visualize Congress as starting any type of an evaluation program of this kind of their own?

Dr. Carlson: I would hope that they would. Dr. Elmer Staats, who is head of the General Accounting Office, has told the Joint Economic Committee that he intends to expand GAO's efforts to examine the effectiveness side. He has been doing this in the Manpower area and he intends to do it in some other areas.

I think this is worthwhile. The Bureau of the Budget has about 225 professionals. There are about three thousand professionals in GAO, generally looking at control of funds as opposed to effectiveness of funds, and I think this is an imbalance. The Library of Congress is interested, too, and we also need more analysis on the staffs of Congressmen and Congressional Committees.

Question from Floor: The Bureau of the Budget is sometimes slow to implement the results of research and analysis. Why is this?

Dr. Carlson: Contrary to some opinion, the decisions in the executive branch are made primarily by bureaus and departments, not by the Bureau of the Budget. If I had to give a ratio, I would say that--in dollar priorities--80 percent of the decisions made by agencies come through unscarred, and maybe 20 percent are modified by the Executive Office. So the big muscle, the big determinations, are confined to the agencies. This means that studies should be helpful to particular agencies. For example, the recently completed cost-benefit analysis of the U.S. breeder reactor program, a $4 billion investment during the next 20 years to reduce the cost of civilian electricity was very useful. It identified the rate of return as being, if you are willing to accept the assumptions the agencies made, about 7 percent. Many people had thought that this program had a negative rate of return and some thought that it had very high rate of return, so the analysis was useful in making agency and Presidential decisions on the budgets for this particular program.

As I said before, one problem is that a lot of analysis is more appropriate for a professional journal than for decision making. Often, the most interesting questions are not looked at because the data are not there and an analyst cannot display the use of the tools that he has carefully developed over the years. But the elaborate tools are not always necessary, because sometimes the precision does not need to be very great.

As an example, I can refer to the provisions of the Clear Air Act of 1967. One of the big questions was whether to have a national emission standard, and ask everyone to abate back to it. I was with the Council of Economic Advisors at the time, and we were concerned with this. First, we looked around to find out what the costs looked like. No one had done this systematically. However, there was one popular figure that had to be used and extrapolated since 1913. The emissions from smokestacks in Pittsburgh had put soot on public buildings, and it cost $x to clean off that soot, and this cost had been extrapolated for all of Pittsburgh, inflated to match current prices, and then extrapolated across the rest of the United States; the result was $11 billion.

We thought we might be able to do a little better than that. We finally found that there was an emission model for the city of New York, but New York did not have an air flow model. However, we had an air flow model for St. Louis, but no emission model. So we took St. Louis' meteorological model and put it with New York's emission model. Naturally, there were a few problems. New York is bigger than St. Louis, so we had to shrink down New York. Then we looked at abatement strategies and found out what a given strategy would produce, and what the cost would be for the different industries, given their ability to reduce pollution through various means. Then we found what proportional reduction would do. We found out that proportional reduction could be four times as expensive as trying to identify and limit major polluters. So we decided that the national emmission type standard was not very wise. It would be extremely

expensive to go that route.

Now on that kind of quick and dirty analysis, I think we were within the ball park on minus 50 percent and plus 300 percent, and that is as close as we needed to be about air pollution for those initial policies. That kind of analysis will never make a reputation for Government personnel in a scholarly community, but it is relevant for decision making. Sometimes that is the kind of analysis that we need. That is often the kind of analysis you gentlemen are not willing to give. So that is one concern we have: to make sure that our analysis is relevant--sometimes quick and dirty and other times more precise.

Joint Meeting of Government
Operations Research Users and Producers

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Since the Office of Emergency Preparedness (OEP) is not well known, I'll take a second or two to describe its job.

The Director of OEP assists and advises the President in coordinating and determining policy for emergency preparedness activities of the Federal Government. The Director is also a member of the National Security Council. We in the Systems Evaluation Division like to think we assist and advise the director. This provides us with many opportunities for the application of systems analysis to a number of programs and operations. Unfortunately time pressures are such that in many instances the analysis is very limited.

One of OEP's primary responsibilities is Federal assistance for disasters, in which the Federal Government organizes and provides money for the immediate relief for economic recovery. Another OEP responsibility is to insure an adequate supply of raw materials in emergencies. This is done through the national stockpile of critical and strategic materials and trade policies, such as protective tariffs and quotas rationalized on the basis of security. We are also concerned with the development of survivable communication and transportation networks.

The Systems Evaluation Division of OEP is a relatively new effort, less than two years old, and now composed of eleven professionals. Among these we have three control systems engineers, 2 mathematicians, 2 economists and four "greybeards," no longer classificable, although they originally began their careers in the physical sciences. Through a little bit of chicanery, last summer we were able to double our staff through a Summer Institute. This was done by hiring our academic consultants for the summer during what would be their normal vacation. They were electrical engineers and mathematicians who specialized in network theory. This Institute paid off handsomely, ten papers were published, valuable computer programs developed and applied to the design of a gas pipeline. In addition they offered a Network Symposium last fall. One of the reasons that the summer seminar made so much progress is that it concentrated on methodology rather than upon applications. This is in contrast with the rest of the Systems Evaluation Division which is trying to apply systems analysis within our Agency. The going is slow. The problem is that it takes months of study to determine which variables are relevant and significant. Once that is accomplished the problem of convincing the customer takes even longer.

One of the more rewarding areas in which we are occasionally involved are those very quick analyses similar to those that Jack Carlson mentioned. These problems arise through our National Security Council relationship and have to be very quick, fast and naturally dirty. They are rewarding in that as a systems analyst you get close to the decision maker. Of course, we feel somewhat queasy about this work because there isn't a chance of looking at the problem carefully enough. It's a question of thoroughness or timeliness, and you can't have it both ways.

Our biggest success, as I have mentioned, was the Networks Analysis Study. The United States is spanned by vast networks for the communication, transportation and distribution of goods, information and energy. The viability of our Nation in an emergency situation depends, to a great extent, on the proper functioning of these networks. OEP requires the capability to predict the effects of enemy attack or the effects of a natural disaster upon these networks. Knowing these effects, we can encourage the construction of networks which can be less vulnerable

to such disasters. In order to test their methods and develop the necessary data base for vulnerability studies, the network analysis group offered their services to other government agencies. The Federal Power Commission asked if network analysis would be of use in reducing the cost of the offshore natural gas pipeline systems. The network techniques were able to solve more efficiently than ever before, such problems as, the optimal selection of pipe sizes for a given pipeline configuration, the minimal cost design of the pipeline system given present gas field locations, and the minimal cost designs which would allow for optimal expansion of an existing pipeline network when full requirements are projected. The technique has been successively implemented by many gas transmission companies and will result in many savings, to taxpayers through lower subsidy requests and to consumers through lower rates.

This Pipeline Study has been published as our first report. The Network Analysts are now working on a GSA problem, the Federal Telephone System. The Federal Government leases thousands of telephone lines and the annual bill is well over a billion dollars. The network is large and amorphous with many changes occurring every month. It is a major task to keep track of the system and little effort has been made to optimize the configuration in such a way as to minimize the bill. A quick pilot study by the network group indicates that it may be possible to save millions of dollars a year and with no loss in government services. Therefore, our group is developing algorithms for GSA which will allow them to lower costs for the Federal Telephone System with no loss in service. The present direction of the network studies is towards OEP oriented problems, the design of survivable networks.

Now for some of the areas where the going has been rough. This is where we are looking into OEP's responsibilities. Here the problem is that it is very difficult to define objectives, no less measure them. The problem lies in interpreting and applying national security to the many government programs which claim it. Most of these programs have multiple and conflicting objectives which are different for different groups within our government. The traditional mode of operation within the agency has been to gather and present the multiple and conflicting objectives for a decision maker without searching for alternative programs or solutions. In addition, little effort has been given to assembling the appropriate cost data needed for decision making. Thus, we find ourselves in a missionary role preaching Planning, Programming, Budgeting System within OEP. We try to sell PPBS by demonstration applying it to OEP operations. Large studies are broken down into small manageable parts for which we can get data. The demonstration studies are designed to be components upon which more comprehensive systems analysis can be constructed. The stockpile study is an example. The government has accumulated a large inventory of commodities that have been identified as strategic and critical materials which might be in short supply during a national emergency. We would like to analyze the usefulness of this stockpile as an instrument for assuring supply of these commodities. However,the necessary data are not available and the amount of time which our staff could spend on this problem was limited so we concentrated on just two portions of the problem, program costs and the scrap value of the current inventories. Since it is an existing program we wanted to estimate the recovery value of our investment to see if other alternatives are worth considering as, for example, increased Anti-Submarine Warfare forces to protect shipping lines.

When we tried to estimate the cost of the stockpile program, we found that the only cost data available was bookkeeping data and not of much interest. Most surprisingly, we found that no one had ever looked at the interest charges on the large stockpile investment. This investment was about seven billion dollars at one time. Neglecting interest costs, in effect, makes the stockpile program cost less and thus no alternative programs need be examined. We think that implicit costs cannot be ignored and are now trying to convince our decision makers also. We feel another important cost needed is the current value of the stockpile investment--its liquidation value. To this end we developed models for estimating the maximum return when such large quantities of materials are sold that market prices are lowered. The models

were also applied to surplus stockpile materials which the government is trying to sell. In addition, the analysts examined the legislative rules which apply to surplus sales and found that they conflict with economic realities. If the rules are followed, little can be sold in normal economic situations. By changing the rules our studies yield some estimates of the value of changing portions of the disposal legislation. The stockpile study is now studying measures of effectiveness.

Another area that the division has been studying is the effects of a large or so-called superdisaster. We have simulated the befalling of a large disaster upon New Orleans in order to look at the effectiveness of ensemble of Federal assistance programs. This included a history of the Federal Disaster Assistance and a disucssion of the long-range consequences of disasters. We are continuing studies in that area.

In the economics area we are developing macroeconomic models to predict the effects of the government controls, given military demands upon the economy. We are also examining the social costs of trade restrictions. As you may know, the government is frequently asked to enact trade restrictions, such as tariffs, quotes and price parities, for the purpose of achieving greater security of supply. In general once the spectre of national security is raised, there is a tendency to overlook social costs. We have been contributing to the Cabinet oil task force which is now looking at the Oil Quota Program.

Lastly, we are giving a cursory look into communications and information systems. The low effort is a funding restriction rather than a value judgment. The problem is that parts of the government are not aware of the latest software advances in information system processing and management information systems. We are trying to inform them of these developments. There is also a tendency to believe in hardware solutions without appreciating that the problems are not that simple.

Dr. Cushen: Thank you very much. I have two quick questions here. Number one, the studies that you have described are obviously of great interest to a large number of people. Can you give us the name and mailing address of the person to whom to write for such information.

Mr. Borkman: I did not come prepared with a list of available reports. They can be obtained from our Division Chief, Dr. Robert H. Kupperman, Systems Evaluation Division, Office of Emergency Preparedness, Executive Office Building Annex, Washington, D. C. 20504.

Dr. Cushen: Number two, in reading the Congressional Appropriations Hearings, I get a kind of a sense that the Congress would like for you to develop a larger in-house capability rather than expanding a contract program. Is this true?

Mr. Borkman: It must be true because we are expanding. In two years, we went from one person to eleven and as far as I know we are still hiring.

Dr. Cushen: Are there dollars available to commercial producers if they send a proposal?

Mr. Borkman: No. I think Jack Carlson answered that one.

Joint Meeting of Government
Operations Research Users and Producers

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I would like to tell you something about our Technical Analysis Division (TAD), to describe the way we in TAD view our role, to tell you something about our mode of operation, and to tell you how we see our future -- the kinds of work we'd like to be doing in the coming decade.

The Technical Analysis Division is listed among the producers of operations research. We see ourselves as providing an essential service to the civilian agencies of government--assisting them in the introduction of operations research into their modes of thought, as well as their modes of operation. We are guided in our operations by the Bureau of Budget Circular No. A-76, which states that we may not compete with either the private sector or the non-profit agencies. Thus, our missionary task is limited, so to speak, to providing services which might be of a special nature or of general use to the government. We feel that our most useful service should be one of advancing the state of the art in using the field of operations research analysis, and so on.

The monetary facts of life of our division are that we receive a relatively limited continuing appropriation. Thus, nearly all of our operating fundings are transferred from the agencies of government for whom we are performing some specific applications service. Our explicit work program is given in the handout. Emphasis is on simulations, human factors, economic analysis, and systems engineering.

Let me forewarn you, then, that when you come to visit us, you should not come with the expectation of receiving--from TAD--funding to support your endeavors. Our financial concern is primarily one of keeping TAD alive and actively functioning.

We do transmit about $100,000 of contract money to universities who are pursuing graduate research in fields relevant to our Northeast Corridor Transportation Project. This money comes to us from the Department of Transportation. And, we have held some minor subcontracts with producers known to have more or less proprietary information relative, again, to the Corridor Project. This is the only work, however, which reflects our limited ability to transmit funding back into the private sector.

Although we can't promise you money, we do guarantee a cordial reception, and we invite you to visit us while you are here. We also invite you to explore any of the reports from the producing community which are crammed into five--very full--filing cabinets in our library. The information in our library has been key worded by a coordinate indexing system. The system was developed by Cleve Hopkins, who is sitting in the back of the audience. This is temporarily an inefficient system because it is operated on a spare time basis.

When you think of TAD in the future, please feel free to send us your questions. I know that usually when you address the Federal bureaucracy, you are frustrated because they don't seem to have time to answer your questions. We may give you an answer which isn't quite adequate, and it may take time for us to get the information to you--but we will do our very best to search out the answers to any questions you may send us.

Please do send us students. We can hire students on a part-time basis on summer appointments. We can hire faculty members on sabbatical, and we have an ability to monitor post-doctoral research associateships for a period of a year.

How do we see our future? We believe that we can best fulfill our mission if we continue to operate in a service capacity in an applications context. We want to be in the forefront in finding solutions to the problems which government agencies encounter in attempting to put operations research to work. We see ourselves as missionaries, using our experience and our expertise to introduce operations research and systems analysis into those areas in which there has been no explicit recognition of need or any conceivable source of funding.

We would like to define a criterion for the measurement of public services. We would like to assist State and local governments to introduce operations research into their programs. And, we would like to be moving into totally new areas--before anyone has realized that they are new--so that operations research and systems analysis may be working forces from the very beginning. We want to ensure that systems analysis sustains our democratic system of government--so that it enhances the process of rebuttal and debate, rather than replacing it by a monolithic computer-based decision maker. We are interested in the use of OR as a communications vehicle to connect multiple agency interests in urban problems.

We are interested in the questions of technology and social change, and in the debate concerning guns and butter priorities. More generally, we are interested in a systems analysis of the informal power structure.

We invite you to tell us, at the conclusion of this conference, what you think are the most needed services, what we in government should be doing for you, and what you can be doing for us.

This concludes my very cursory discussion of our Technical Analysis Division.

Now, for a discussion of the use of systems analysis by the Department of Commerce, as a whole. We have not yet gone through the appropriations process for this year, so the Department is still firming up its policies. As you probably know, the Environmental Sciences Services Administration has been sponsoring operations research studies in weather operations for a number of years. The Economic Development Administration has been sponsoring regional economic studies for quite a long time--in an attempt to develop criteria against which to measure economic development programs within specific regions, and in general.

The Maritime Administration (MARAD) is one of the largest agencies in the Department. MARAD has been a very sophisticated consumer--and producer--of operations research. It is with a great deal of pleasure then, that I introduce the representative from the Maritime Administration.

Joint Meeting of Government
Operations Research Users and Producers

Dr. Herbert L. Myers
Maritime Administration
Department of Commerce
Washington, D.C. 20235

My name is Dr. Herbert Myers; I'm with the Maritime Administration, Office of Program Planning. My boss, Mr. Carl Weir, head of the Office of Program Planning, reports directly to the Maritime Administrator, Mr. Andrew Gibson, who in turn reports to Secretary of Commerce Stans.

Now I'd like to talk briefly about three topics. First I will identify for you the mission and nature of the Maritime Administration; secondly, explain the analysis and planning function and how it is handled in the Maritime Administration; and lastly talk about activities in the Office of Program Planning as they relate to specific studies.

Let me say that the Maritime Administration has to do with the promotion of the U. S. Merchant Marine. The Maritime Administration is not always understood in the sense that we understand the Department of Defense because the Maritime Administration is a small organization. It doesn't get the public eye as much, so I want to be sure that you really understand the Maritime Administration and its mission.

The Maritime Administration promotes the U. S. Merchant Marine and has a dual responsibility. The primary area of interest of course, is to promote the development and operation of ships that haul cargo and people, primarily cargo, on the high seas but also in the coastal area.

The second function is an emergency response function where these cargo ships become available to support the Defense Department. In the case of South Vietnam, I think the figures show the Maritime Administration-sponsored ships carried 92 percent of the cargo. Thus we have a dual interest in ocean transportation, both in the marketplace, as it were, where we are interested in the rate of return on investment, and in the military sphere where we are interested in cost effectiveness among other considerations.

I think it's easier to get a clear picture of the agency if you can somehow or other sample the flavor of the spirit of the new group of people who are running it. To get this flavor I will refer briefly to a speech made by the new Maritime Administrator, Mr. Andrew Gibson, in his comments to a graduating class from the Kings Point Academy that trains the officers for the U. S. Merchant Marine. In his comments to this graduating class, Mr. Gibson said, "You are entering the Merchant Marine at a propitious time for achieving a Merchant Marine adequate to the present and projected future needs of our nation. As I have said on previous occasions, this Administration from President Nixon on down recognizes the value of a Merchant Fleet to the nation. It recognizes the Fleet's present state and it has placed the reversal of the fortunes of the Merchant Marine among the top priorities for attention." In proclaiming National Maritime Day this year, President Nixon told the nation, "The American Merchant Marine must project the nation's economic strength throughout the world in peacetime and give mobility to our national defense in times of emergency. Its vessels enable us to compete effectively in international trade and to transport and supply our armed forces in the defense of freedom, and a strong and profitable Merchant Fleet is vital to America's economic welfare and defense capability." This gives you a little bit of the general flavor of the people who are running the Maritime Administration today.

I'd like to say just a word or two about the analysis and planning function of the Maritime Administration. There is a fairly sizeable chunk of money that is put into systems analysis contracts each year and these are handled by the Office of Research and Development. I think it's important to know that they are in process of laying out a five-year plan that anticipates an increased amount of bucks for research and development; one major part of this is systems analysis studies. A fellow named Jim Higgins, who works in the Office of Research and Development has that type of contract under his management. In addition to Research and Development, the Office of Program Planning and some of the other offices to a lesser extent have both in-house and contract studies that fall in the general category of systems analysis. In the case of the Office of Program Planning, Carl Weir is chief of the Office and he is a point of contact for the kind of systems analysis studies that might occur in that organization.

I'd like to say a few words in particular about the activities with which I have some direct contact, namely, operations research in-house studies. We have completed a number of studies which deal with a variety of subjects; for example, preferred ship systems for a given trade. These studies tend to get into rather specific areas. The one we most recently completed had to do with the question of which was the preferred shipping system in hauling iron ore from South America to Sparrows Point, Maryland. This particular topic may not tell you the whole story but the problem of hauling iron ore is akin to hauling a product in a dry bulk ship like ore or wheat or something of this sort. We are at a point where the nation either gets more dry bulk ships now, or phases out of the business. The new program for the Maritime Administration anticipates the construction of some dry bulk carriers. It's a kind of preferred systems study in which we are interested in both the commercial application of ships and their reserve military application in the case of military emergency.

Another study has to do with Maritime Marketing. You may not be aware of it but each year the foreign trade volume has increased and the U. S. Merchant Marine share as a percent has decreased. It's one of the main objectives of the new Administrator to change this trend.

Another study has to do with ship voyage simulation. In this particular study we received considerable assistance from the National Bureau of Standards, Technical Analysis Division. I think that you will find also a variety of in-house studies undertaken by the Office of Research and Development, which are in anticipation of new contracts. These tend to be in areas of preferred systems market forecasts by some definition and similar types of subjects.

Maritime Administration will entertain unsolicited proposals from universities, and the point of contact is the Office of Research and Development, Maritime Administration, which handles the contract money.

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James L. O'Brien
Census Bureau
Department of Commerce
Washington, D.C. 20230

Although the Census Bureau may be world famous to some, I suspect that many of you may be unfamiliar with its work. So perhaps a brief description of what it is and does would be appropriate.

The Census Bureau is a general and special purpose statistical fact-finding organization. Its mission is to collect, process, and publish important information in a wide variety of economic and demographic areas. The economic fields of interest include foreign trade, construction, business, and industry; demographic reporting covers population, housing, agriculture and governments. Data usually are collected by censuses or surveys, generally in the form of questionnaires completed by respondents or by enumerators. Between collection and publication the data are classified, "validated," and summarized through the application of clerical, computer and professional resources.

The Census Bureau's orientation is distinctly that of the professional producer of statistics. There is a long tradition of using relatively sophisticated mathematical and statistical techniques, especially in the areas of sample survey design and methodology. The Bureau, in fact, offers a consulting service in the area of statistical methods and sampling methodology. Operations Research at the Census Bureau has generally concentrated on processing operations rather than on the collection of data, and there is a special emphasis on automation of clerical and professional activities.

Two or three current projects which may convey some of the flavor of our interest are the following:

1. A project to develop computer programs and systems for matching uncontrolled inputs with reference files. Viewed in one sense this problem is similar to that of language translation. Our primary interest is to provide the capability for assigning codes automatically by computer; these codes may be geographic, industrial, or occupational. Basically, the procedure takes uncontrolled input, compares it with the reference file that we have stored and assigns codes or takes some action on the basis of the comparison. We believe that this project will have its most important payoff when optical character recognition equipment for uncontrolled input becomes operational. At present the cost of preparing the input in machine-readable form is roughly equal to the cost of manual coding.

2. We have been successful in developing a computer system for map encoding and editing which provides the capability for the graphic display of Census data at a rather fine level (individual block faces) on a national basis.

3. We are also concerned generally with the development and validation of cost models for mixed clerical and computer operations.

Some other areas where operations research techniques or appropriate experience would be of interest to us include the following: (As was indicated earlier this morning, these are not precise statements or requests for proposals, but rather suggested areas where we are trying to benefit from your experience or methodologies you can contribute.)

1. We are concerned with improving the operation of a large computer system, and are considering use of a commercial simulation model for this system. We would like to know of any experience which indicates that in fact important improvements have

resulted from the application of simulation techniques to an existing computer system. We would be interested in the costs, the problems, the special skills that were involved, the time frame, anything else that is relevant.

2. We are about to embark on a rather ambitious program of assigning coordinates to every bend in every road, to every intersection in every street in every town of any size in the country. This program will extend over several years with available machines, and the experience of others indicates that it may become quite an expensive operation. We would welcome any Operations Research ideas based on topology or heuristic programming which would permit us to do this digitizing cheaply and detect errors at an early stage.

3. We are interested in new applications of quality control theory or production techniques for controlling large scale clerical operations, particularly automated comparison techniques or successful uses of remote terminals for large scale record keeping in operations of this kind.

4. We are concerned, as are many others, with the problem of measuring programmer effectiveness. There are approximately 200 programmers at the Census Bureau. Records have been kept for years on runs submitted; supervisors have rated all programs in terms of difficulty and we are really not much farther ahead than when we started in terms of objective bases for measuring programmer productivity.

5. As the Census Bureau moves generally toward taking advantage of the higher level of literacy and education of the American people in gathering survey and census data, we will probably tend to use mail more and individual enumerators less. However, since everybody doesn't return his mailed questionnaire, we have to go out and contact personally those who don't. The problem here is, "How should an enumerator choose his route to pick up the questionnaires that have not been returned?" It resembles the classical traveling salesman problem, but is complicated because there are varying probabilities that the enumerator will be successful in contacting the respondent, depending on the time of day or night, the area where he is working and probably on other information which we don't know yet. At present, all we give him is a map, a pencil, and a pat on the back, and we're sure we can do better than that. There are other problems of this kind where our people travel to various State capitals to gather census information which becomes available at different times according to schedules beyond our control. At present, we don't even give them the map and pencil, only money for a phone call. When they finish one job they call Washington, where someone else looks at a map and picks out their next assignment. Again, we are sure we can do better than that.

6. We're interested in any information that is available on the benefits that result from graphic display of data. With the advent of computer systems, and particularly with the availability of detailed geography, we now have the capability of displaying data at a much finer level than before. There are two schools of thought on this question--one holds that people who really want specialized displays will use the data to produce their own displays; the other believes it would be a useful service for the Census Bureau to provide this data displayed in ways that make sense to numbers of users whose needs can be identified. At present there is no objective basis for making a determination of this kind, and we would be interested in any relevant experience.

7. Finally, there is a problem which is frequently talked about but which, to my knowledge, has had very little objective work done on it--namely, how one determines the value of information. In an information-producing agency there is a natural tendency on the part of statisticians to assume that the cost of gathering information is a small fraction of what its usefulness must be to those who receive it. However, we do not have--and we're not aware of anyone else who has--any criteria which are operational guides for determining the value of information or even for ranking various suggested information programs in terms of which have the best claims for support. Conceptually, the problem is relatively easy. You determine

the expected values of all decisions that might be affected by the information both with and without the information, and the difference between these expected values is the value of the information. As has been pointed out, this is conceptually straightforward but it has not yet been applied, to our knowledge, in any cases beyond the trivial.

This listing naturally includes mistakes of both kinds, with some projects that are quite narrow and specialized, along with others so broad it's hard to tell even where to tackle them. We hope that at least a few fell into the ken of those here.

We do not now have money set aside for commercial contracts on the projects mentioned here, but if a worthwhile proposal were received, we could get reasonable amounts of money. One group at the Census Bureau, the Center for Measurement Research, has money for contracts in the measurement research field which could probably be made available for such projects as fundamental ways of determining the value of information.

On a reimbursable basis, we can and do provide the service of planning and conducting surveys, and publishing the results. For some agencies we provide, on a reimbursable basis, time on computers and other facilities of a rather specialized character. We provide consultation to Government agencies and certain international organizations in the areas of statistical methodology and sampling at cost.

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Donald G. Haag
Post Office Department
Washington, D.C. 20260

Operations Research is a relatively new concept within the Post Office Department. When a systematic approach of this type is undertaken a vast group of conflicts arise. We accept the basic idea that a system is the totality of the experience, the people, the equipment and materials, and so forth, that they use.

In terms of Post Office systems, when we attempt to treat all of the elements--things like Human Factors maintainability, reliability, sociological impact, economic impact--we find that the magnitude of the numbers involved and the implications of the variations of these numbers is substantial on both the national and regional basis. For example, when we deal with the concept of the movement of 80 billion pieces of mail annually, and involve 33 thousand different geographical locations, we find the magnitude of the numbers to be manipulated can quickly overwhelm even our third generation computer hardware.

We feel that while it is possible to solve relatively large approach problems, some of the Post Office problems must be reduced before even the high speed computer simulations and mathematic manipulations all using acceptable operations research techniques will permit us the expedient of considering large numbers of variables and will permit us to consider different alternatives. We are equally aware of the fact that methodology and scientific processes cannot replace the judgments of individuals at a management and policy making level. We, therefore, believe that tha anlayst's ingenuity in setting down a problem and at arriving at alternative solutions must be augmented by the judgment of the policy making and operational management personnel.

We found the need for operations research has grown within the Post Office faster than in industry due generally from the fact that no systematic approach or scientific analysis has been done for a long period of time in the postal system.

The Post Office has experienced major increases in certain phases of mail processing and we have had significant changes in the accuracy requirements of the processing functions. These have brought about increases in cost with both capital equipment and at labor intensive work stations. We have experienced some major changes in the composition of the mail and there have been changes in the time to transport mail between locations. Major increases continue in a projected trend upward in the volumes of mail that are to be handled.

We find as we look at problems that we often discover multiple constraints some of which are funding, manpower, facilities, equipment, and so forth. When you start combining the alternatives, the constraints, and defining variables you quickly find that the classical approach to the problem does not necessarily fit the situation as it is constituted in the postal system.

We are guided by three basic principles of operations research: we want to deal with significant problems; we want to develop methodologies that are reproducible in nature, objective and approach; and most important we want to provide the technical alternatives to the decision making element of the Post Office.

I spoke about the large size of the Post Office. In order to make it more flexible we divided the mail handling system into four discrete functional areas. First, the collection and acceptance function which covers the total area of collecting mail into the postal system. This includes from the time individuals drop mail into the local collection box and large mailers who transport it sometimes directly to the train stations. Second the processing area which covers all handling and processing of mail within the walls of the Post Office. Third, the transportation function which handles the linking of the processing plants. Last, the delivery function which covers the total area of final delivery of the mail piece to the patron.

To give you an idea of the magnitude of the typical costs involved in the mail handling system, I thought it would be appropriate if I gave you some cost figures. The cost for domestic mail handling for Fiscal Year 1967 (all direct labor costs including direct supervision) accounted for about $2.5 billion of the operating budget. The city delivery services ran about $1.4 billion, and the transportation generally ran about $1.3 billion. So you can see that we are talking about a system with operating costs in excess of $5 billion annually.

During the past year that we have had intensified use of operations research we applied ourselves to the following areas: We have undertaken and completed a technical mail system survey which included field sampling of pertinent characteristics of the functional areas. We started a documentation of our engineering and development historical costs. We have started a data bank which includes some letter mail characteristics and an interesting aside here might be that it's easy to oversimplify Post Office problems. We said, "What are the letter mail address characteristics that are significant in optical character reading?" and you might generally guess that there are five or 10. Well, there aren't. We stopped at 87 and reduced it to 47 that are measurable. This is the complexity of the things we are talking about.

We have some equipment operating characteristics. We have a series of cost information bibliographies and some simulation models. We have developed simulation models for the total processing function within the Post Office on the basis of cost, time and service. We have developed some mathematical models for a subsystem definition. We have developed some projected service requirements. We have developed an engineering set of goals and objectives into the year 1980. We have supported these efforts with an R&D cost model and standard computer model for analysis and statistical evaluation.

From these efforts we have evolved the following: we have the initial functional specifications for new letter mail processing subsystems. They are very rough at this point. We have validated a series of operational sequences. We have a detailed evaluation of some of the existing postal subsystems so we know what through put rates and costs are. We have undergone a major study of bulk mail handling and containerization to see whether this is an area where we can make significant savings. We have developed in the course of this work some information on the origination and destination of parcel post type mail and we have developed various statistical techniques that are tailor-made to our particular problems.

In the immediate future we look forward to operations research in the following areas: cost analysis in its broadest perspective, determination of detailed letter mail characteristics, expansion and refinement of our data bank, benefit effectiveness, methodology development, and what we mean here is we have done some preliminary work on the runout cost projections on state of the art estimation, things of this type. We will be working in the area of letter mail processing and parcel post systems research in order to determine what new types of systems we can evolve. We will be working in the area of coming up with some systems definition of evolutionary conceptual

systems, without today's constraints.

Perhaps the thing that we should look at here is the movement of the information as opposed to the material. There will be aggregation studies to determine flow characteristics of the mail. There will be transportation utilization research. We want to get into a major total system simulation. It is a significant problem when you try to link up 33 thousand nodes in a macro-model. It's similar to the communication problem with the exception that you have got a material interface every time you make a connection and the material interface is not the same. It may be a parcel or it may be a letter. It's an extremely challenging area.

In data development we have quite an extensive program in trying to determine what kind of test deck we can use for optical character reading, what are the real characteristics of the mail. We have gotten some 19 cities and we have taken some work that was done in the past and we put it on the computer that tells us how many inches from the edge the address starts, what type of font, things like this.

We have a number of lesser efforts that are being conducted in other areas. We feel that we have made significant progress in the applications of operations research to the problems of the postal system. We have established for ourselves the criteria that in operations research all of our work should be reproducible by any professional and that the final and most difficult step of each operations research program is the most important to us and the only step that justifies the undertaking of the program. And the step I am talking about is the implementation, or at least the implementation plan.

There are two groups within the Post Office that are involved in operations research. I am with the Bureau of Research and Engineering in the Research Directorate. There is another brand new bureau called the Bureau of Marketing, Systems Analysis and Planning under the head of Mr. Ronnie Lee. It is my understanding that they will be involved in things of economic nature, rate structure implications, things like that.

I hope then that perhaps today I gave you an appreciation in a few short minutes of the magnitude of the job that the operations research discipline itself faces in the Post Office, and I hope I have interested you in some degree in a successful solution to these problems. As least we are in there trying.

Joint Meeting of Government
Operations Research Users and Producers

Ira Dye
Office of Economics and Systems Analysis
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Operations research in the Department of Transportation has grown rapidly because, for one reason, we're new. The Department is just two years old this spring. Our objectives are to bring about economic efficiency in transportation, to promote the optimal use of environmental resources in transportation, to increase transportation safety, and to support other national interests with transportation, as appropriate.

In the Office of the Secretary there is my office, the Office of Economics and Systems Analysis, and the Office of Planning and Program Review which deals with the planning, programming, budgeting process and is directed by Allen Skaggs. We are a staff function of the Secretary; the Secretary's line authority goes directly to the operating administrations. They are often called modal adminstrations because, by and large, their direct concern is a single transportation mode: Federal Aviation Administration, Federal Rail Administration, Federal Highway Administration, the Coast Guard, and the Urban Mass Transportation Administration. There is no one office in the Department of Transportation that is responsible for OR in the Department. Although we have informal linkages among ourselves to keep track of what is being done, no one particular OR office has coordinative responsibility over another. So, to ensure making yourselves and your capabilities known throughout the Department, you really have to cover all the administrations. There is great diversity among the administrations' OR activities. The FAA, for example, has a large staff doing in-house work. The Federal Rail Administration in its general rail part performs little analytical work, but has a most ambitious and sophisticated systems analysis effort in progress in its Office of High Speed Ground Transportation, the Northeast Corridor Project. There is also great diversity in the application of OR within the Department. It is applied to PPBS short-and long-range planning, often considerably beyond Department programs, technical analysis and design of new hardware systems, and policy issue studies.

Although the Department of Transportation has a number of contracts with universities and non-profit organizations, the only grant program is that of the Urban Mass Transportation Administration. Its purpose is to promote graduate study and research in urban transportation planning. Generally speaking, our research topics are developed within the Department. Although unsolicited proposals are encouraged, we would prefer for you to come in and discuss the idea with us at an early stage rather than to receive a fully developed unsolicited proposal. We could then explore the areas of common interest and perhaps arrive at a mutually agreeable approach. There is an eight-page handout which goes into some of these details and gives the names and telephone extensions of the specific people to contact.

The rest of our program will be devoted to short talks by representatives of our major OR components. Our approach will be to give you specific examples of projects that either are in progress or completed. In this way we hope to let you see the kind of work we do. All of us here talk for the Office of the Secretary.

In the Office of the Secretary our budget for outside OR type work has been in the $2-3 million per year area. About 10 to 15 per cent goes into computer services, that is time-sharing data processing, programming services, use of proprietary software packages, and the like. Most of the rest of the money goes into contracts awarded us as a result of competitive bidding. Normally, these contracts are for developing methodologies or studying special issues.

An example is a recent study of the transportation problems of the handicapped. It developed methodologies and programs for local areas to determine the extent of the problem and how to alleviate it. Another example of contract research is our study entitled "Intercity Transportation Effectiveness." The purpose of the study is to develop a method to approximate a mix of vehicles, routes, schedules, and terminal facilities that would satisfy intercity common carrier passenger and cargo demand at a minimum social and economic cost. We wanted a method to account for alternative sets of characteristics on both existing and future vehicles and to differentiate between alternative sets of terminal facilities in a given network. We needed forecasts of future passenger and cargo demand and their associated impacts on vehicle, terminal and network requirements. The methodology was to be usable both in an ideal mode in which total social costs, that is, user times and costs plus operator costs, are minimized and in a realistic mode in which the operator attempts to maximize his own profits.

Although applicable for all intercity transportation modes, the first focus of the project is on the air mode. The focus on the air mode is obvious --analysis leading to action in air passenger transportation is the most urgent. We expect our intercity transportation research to help formulate Government policy and recommendations concerning user charges and fares. It should help answer such questions as: What kind of fare structure ought the CAB to consider? What should we be saying in our discussions with CAB on fare structures? How will demands be reduced by certain fare increases? Should increased fare requests be granted, what does this do to demand? By how much would revenues increase per a given fare increase? What happens when enforced limits on number of flight operations are put into effect at certain airports? What will be the delays if these safety ceilings are rigidly adhered to at LaGuardia or National? What delays can be expected anywhere--LA, O'Hare--as the traffic growth increases? As to new terminal decisions: Is a new airport needed? Where should it be located? How would a fourth airport in the New York area affect airline operations? How should the Federal Aid Airport Program be carried out to best serve the public? What about V/STOL? What new terminal capabilities or configurations would best do this? How about SST capabilities?

It can also deal with merger and intercarrier agreements, the impact of future growth, and air passenger and cargo demand. Such questions as: What if the growth continues on at one rate for passenger and at a higher rate for cargo? What are the consequences of this for the satisfaction of future air demand? We expect the contractor to deliver by the end of the year a modularized methodology or set of models within an executive routine which examines demand, selects routes, assigns traffic, and provides a timetable and guidance on fleet reduction.

Also, it would consider technological advance. In this project we have worked very closely with the contractor with practically daily contact. We intend, as with other contracts of this nature, to apply the methodology developed to practical problems by continuing contract research. We already have a stack of problems we can hardly see over dealing with this particular methodology. We are looking forward to adapting it to the maritime, rail and/or bus modes to assist us in those areas.

In terms of output over the past two years, about one-third has come from contract research and two-thirds from in-house work. A considerable amount of our in-house effort goes into developing or working with the modal agencies on Bureau of the Budget issue studies. Much of the remainder goes into fast response items where analytical assistance is needed for a developing policy issue. Data is gathered and analyzed and alternative solutions to the problem provided in timeframes varying from a week to three or four months. It is at these times that we turn for outside support to contractors with whom we have software and computer contracts. Extra programming help, data processing, and the like are imperative to meet the short deadlines. An interesting example was an assignment a few months ago to do an independent economic analysis of the SST project. It required a

maximum effort for about three months. Completed, our analysis has been forwarded to become an input to the Administration's decision-making process.

Joint Meeting of Government
Operations Research Users and Producers

Walter Felton
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The Federal Aviation Administration utilizes operations research on a very large scale in managing the National Airspace System. Five management processes are informed, nourished, stimulated, and challenged to some extent by operations analysis. First, the Research and Development Process; second, the Planning Process; third, the Flight Standards Process; fourth, Systems Operations and Maintenance; and finally, the FAA Management Process.

Because of the size and complexity of the National Airspace System, operations research functions are distributed throughout the United States. They are assigned to the operating organizations, to the experimental facilities and to the headquarters staff.

At least 250 personnel are performing operations research functions of some type. Not all of these personnel are classified in the 1515 series--research have other job classifications, such as engineers, economists, mathematicians and statisticians, psychologists, management analysts and air traffic control specialists.

In contrast to the large staff resources engaged in operations research, the contractual resources of an operations research type have averaged less than 20 man-years per year for the past 10 years. With the exception of several large contracts directed to nonroutine measurements of system operation on a large scale, operations research contracts have served either to reinforce the staff during workload peaks or to supplement the incomplete skills of the staff.

Figure 1 indicates the working groups and the problem areas. Ira Dye's chart introduced the working groups--my chart indicates where the major groups of operations research functions are located. The largest groups are in the Office of Plans, in the Systems Research and Development Service and in the National Aviation Facilities Experimental Center (NAFEC). Perhaps over 150 of the operations research types are in those three organizations. At least another hundred are in the operating services, the management services and the Aeronautical Center. Problem areas are listed on the left side of Figure 1. I will not identify the techniques that are used or the techniques that we are looking for. FAA is not technique oriented--it is problem oriented. The primary job is to solve problems and the secondary job is to find the skills to solve those problems.

FAA's primary interest is safety. While a high order of safety is achieved, FAA is never satisfied with the accident rate. Air transportation should be safer than it is.

The second item of primary concern is reliability. FAA management conducts a daily review of safety and reliability. At half past one each Monday through Friday, the managers of FAA sit around a table at headquarters where they engage in telephone communication with regional offices, area offices, and facility offices with regard to the accidents, incidents, and major component outages that occurred on the preceding day or days. Every item is reviewed in detail. In fact, the daily list is reviewed in detail from half-past six in the morning until shortly before the telephone conference. This daily conference is one proof of the importance given to safety and reliability.

Figure 2 is the first example of our operations research work. This is not the Apollo Control Center at Houston. This is an Air Traffic Control (ATC) Simulator located at Atlantic City, New Jersey. It is one of our two ATC simulation facilities. The combined resources of the two simulators enable us to put 120 simulated aircraft onto the displays of our simulated control facilities at one time. Each of these positions in an airplane; the women are called petticoat pilots.

Figure 3 shows an augmentation of this facility in the form of the SST flight simulator at Langley. It is easier to move the SST flight data from Langley to Atlantic City than to move the simulator from Atlantic City to Langley. This hook-up has been used several times in investigating the traffic handling of SST type aircraft in an environment of jets and propeller aircraft.

Figure 4 is an example of a study we did two years ago on the expected delays of our eight busy airports and the major choices we faced with regard to increasing the capacity of these airports. The study determined the effectiveness of various improvements, including how much time each method would buy. Here is the situation at one of the eight airports. Los Angeles airport has three parallel runways, but they can't be used simultaneously in IFR weather. Our study estimated that by 1972 the average delay at Los Angeles during peak periods of two hour duration will begin to be unacceptable on an annual basis. That's three years from now, if we do nothing. If traffic is distributed evenly throughout the 24 hours, we would buy just one year. If the safe separation is reduced from three to 2 1/2 miles and if automatic sequencing methods are used, we can delay by three years getting into the unacceptable zone of traffic delay. The cost of doing so is not as great as you might think--this happens to have a very favorable cost-benefit ration. Because putting an ILS on the next paralled runway will buy us another year, we have a choice. Shall we reduce the separation and introduce computers for automatic sequencing or shall we put an ILS on that dual runway. The cost-benefit ratio is not quite as effective for the ILS but it buys us another year. Another choice is to pour some concrete and put in that fourth runway. That will buy us another three years and it's quite cost effective. The final choice in the study was to look for another location and put in a new airport. The forecast traffic can be handled for at least another ten years without getting into severe delays at either the present or the new airport.

Figure 5 is the result of a satellite application study. If a satellite is used to determine the location of aircraft crossing the ocean, how often should the satellite measure aircraft position? This chart takes into account the navigation error of the airplane and the tendency of an airplane to drift off its course because of blunders. Blunder analysis is much more important for this situation than the analysis of random errors. Separate tables for subsonic and supersonic aircraft specify how often aircraft position should be sampled to enable a blundering aircraft to navigate within prescribed limits.

In closing I want to repeat two points. First, FAA has a large in-house capability. Second, FAA needs help because we are constantly searching for new ways of applying analysis techniques to our problems. For example, we are currently looking for new ways of measuring system capacity. Every time we go to the Bureau of the Budget to buy some equipment we are asked to answer difficult questions such as: What will this procurement do for our transportation? Will it save lives? Will is save money? Will it save time?

OPERATIONS RESEARCH IN FAA

PROBLEM AREAS

- TRAFFIC DEMAND
- HUMAN FACTORS
- ENVIRONMENTAL FACTORS
- SAFETY
- RELIABILITY
- COSTS
- CAPACITY

WORKING GROUPS

- OFFICE OF PLANS
- OPERATING SERVICES
- RESEARCH AND DEVELOPMENT
- MANAGEMENT SERVICES
- NAFEC
- AERONAUTICAL CENTER

Figure 1.

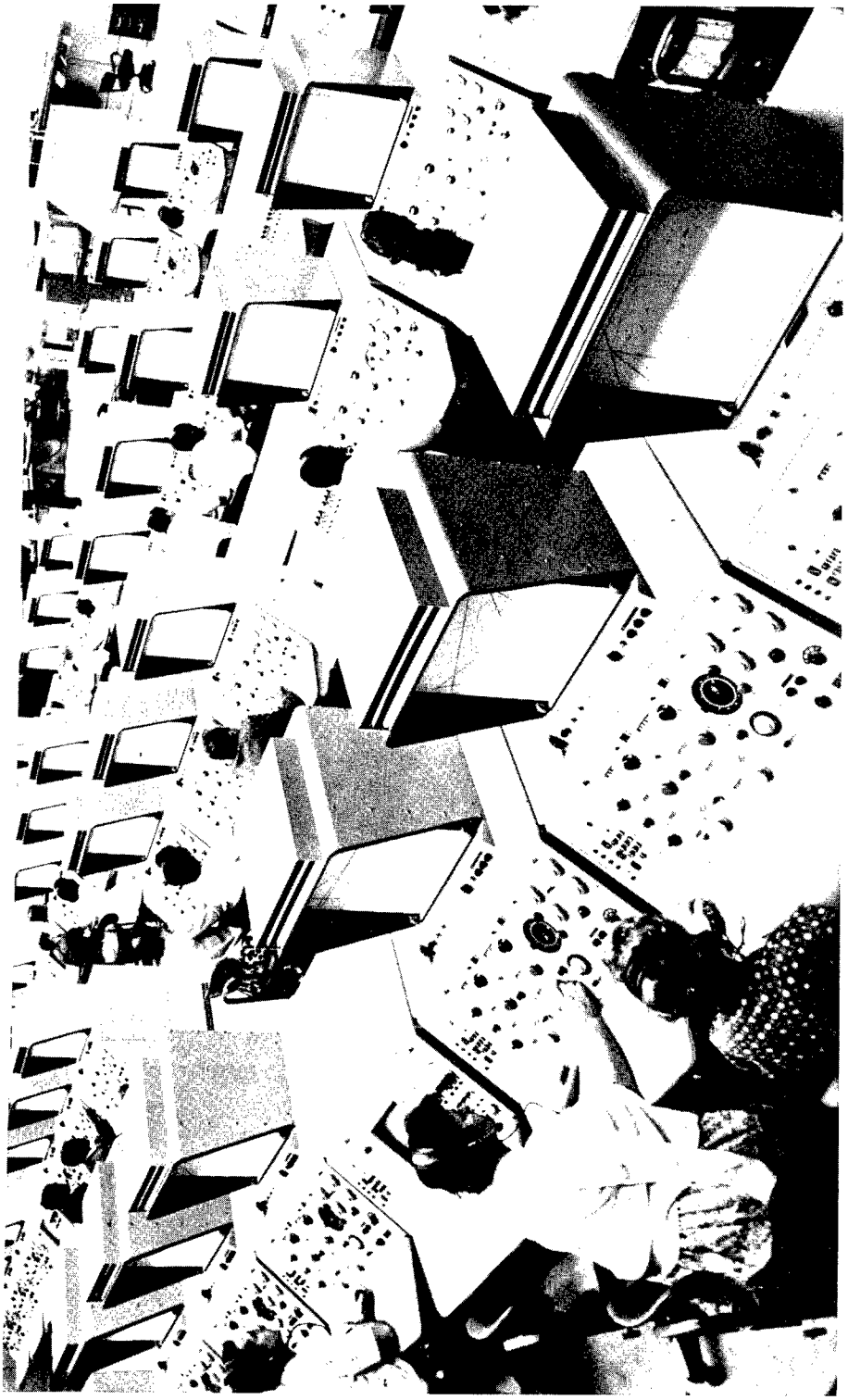


Figure 2.

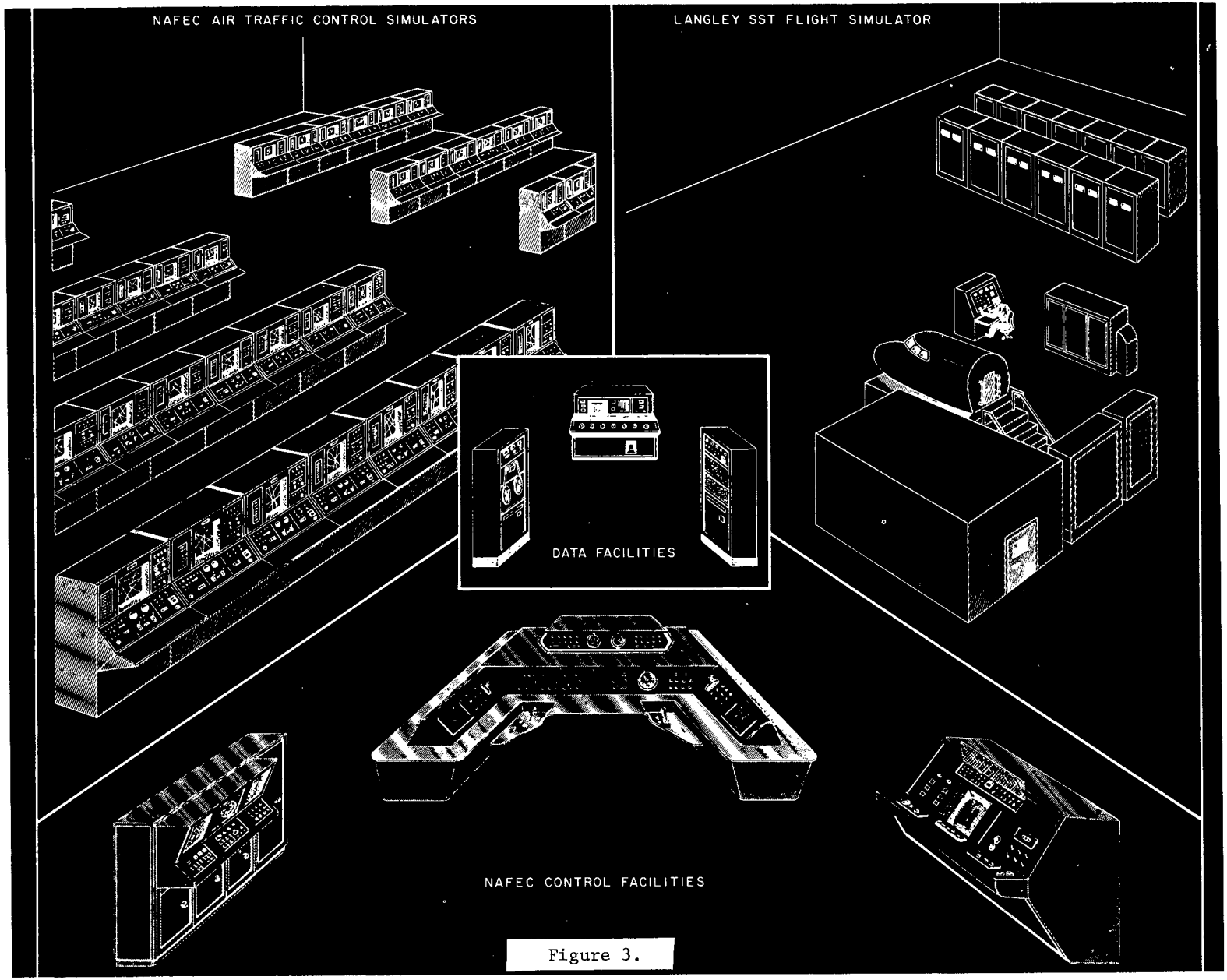

NAFEC AIR TRAFFIC CONTROL SIMULATORS
LANGLEY SST FLIGHT SIMULATOR
DATA FACILITIES
NAFEC CONTROL FACILITIES

Figure 3.

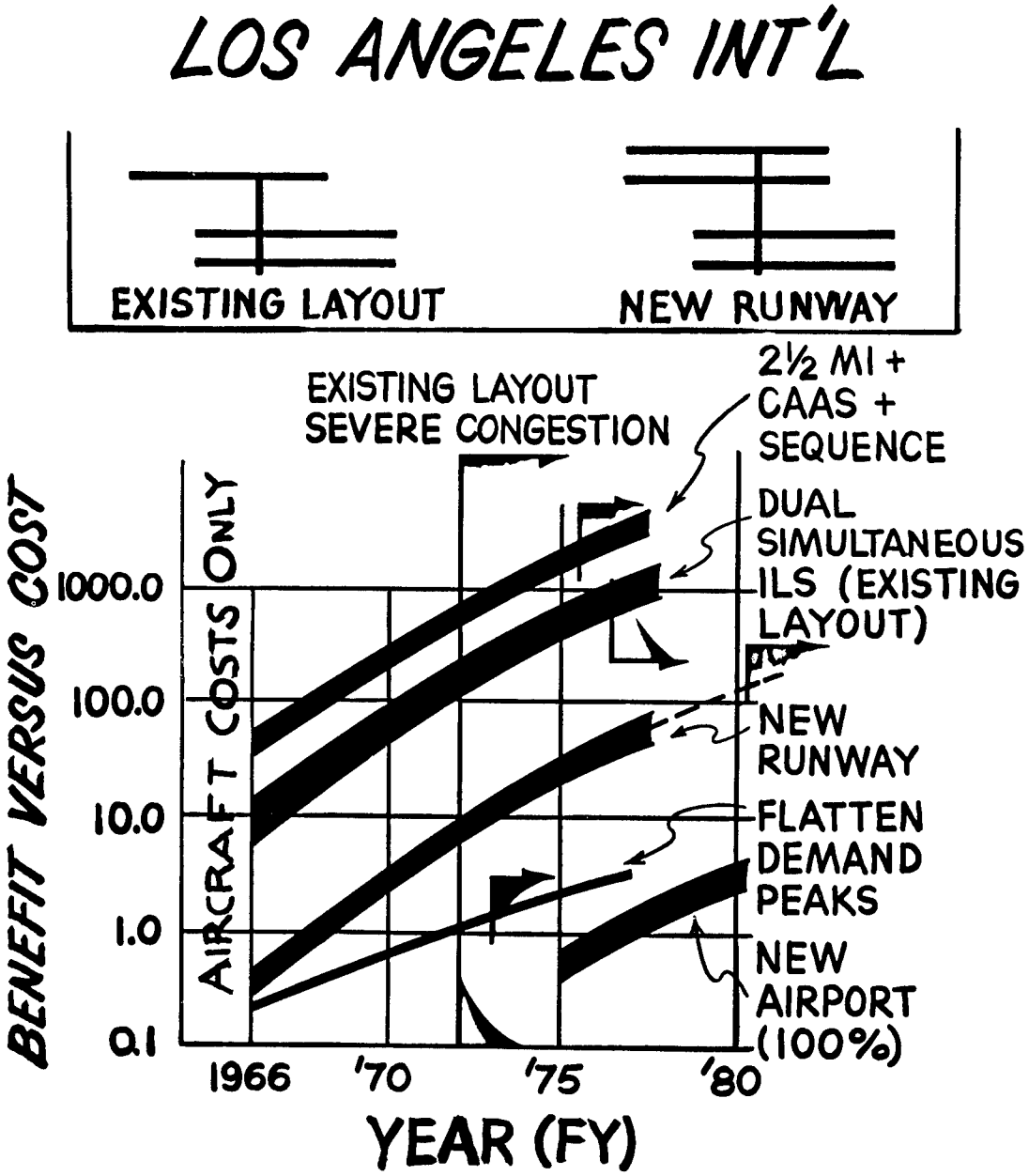
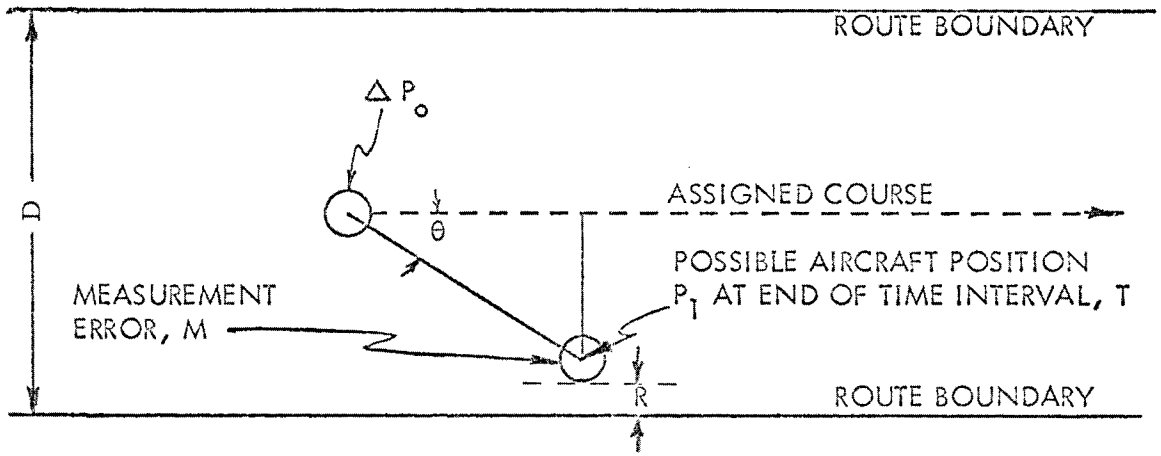

LOS ANGELES INT'L
EXISTING LAYOUT
NEW RUNWAY
EXISTING LAYOUT
SEVERE CONGESTION
2½ MI +
CAAS +
SEQUENCE
DUAL
SIMULTANEOUS
ILS (EXISTING
LAYOUT)
NEW
RUNWAY
FLATTEN
DEMAND
PEAKS
NEW
AIRPORT
(100%)
BENEFIT VERSUS COST
AIRCRAFT COSTS ONLY
1000.0
100.0
10.0
1.0
0.1
1966
'70
'75
'80
YEAR (FY)

Figure 4.



VALUES OF T

ALLOWABLE TIME BETWEEN FIXES (MINUTES)

MEASUREMENT ERROR, M (2σ)	SUBSONIC AIRCRAFT V = 600 KNOTS, R = 2 NM D = 60 NM	45 NM	30 NM	SUPERSONIC AIRCRAFT V = 1750 KNOTS, R = 4 NM D = 60 NM	45 NM	30 NM
1 NM	28.9	18.1	7.2	9.0	5.2	1.4
4 NM	24.6	13.7	2.8	7.5	3.7	-
10 NM	15.7	5.07	-	4.5	.75	-
16 NM	7.2	-	-	1.5	-	-

1σ VALUE FOR ΔP_o = 7 NM

$\theta = 4^\circ$

PARAMETERS INVOLVED IN AN INTERMITTENT ATC SURVEILLANCE PROCESS

Figure 5.

Joint Meeting of Government
Operations Research Users and Producers

Edward Weiner
Federal Highway Administration
Department of Transportation
Washington, D.C. 20590

The Federal Highway Administration has developed an integrated and balanced program of research and development in the field of highway transportation. The program is directed at developing techniques and solutions for a wide range of problems pertinent to highway transportation.

The Federal Highway Administration is composed of three bureaus:

Bureau of Public Roads,
National Highway Safety Bureau, and
Bureau of Motor Carrier Safety.

The first two of these bureaus conduct in-house and contract research aimed at developing solutions to immediate problems, and theoretical analyses of fundamental systems.

There are five major areas of research which would have operations research implications. First is the analyses of the underlying requirements of highway transport. Projects under this research area deal with analyses of the functions of transportation, of transport efficiency, and of the users of transportation systems.

Second is the study of complex traffic movements. These projects involve analyses of stream and network flow problems. The third research area is the development of reliable methods for forecasting transportation demand particularly urban transportation demand. The fourth area of research concerns the development of techniques for increased capacity, control and safety in traffic movement. A fifth area is a comprehensive analysis of highway safety. Research in this area is directed at studies in the three components of the highway safety problem: the driver, the vehicles, and the highway itself.

One of the problem areas which has high priority in the research program concerns urban transportation. Urban transportation is a multifaceted problem involving transportation systems, environmental aspects, elements or urban activity patterns, and institutional structures.

Congress recognized the need to deal with urban transportation problems in passing the 1962 Federal-Aid Highway Act. The Act states, "It is declared to be in the national interest to encourage and promote the development of transportation systems embracing various modes of transport in a manner that will serve the states and local communities efficiently and effectively." This Act further stipulated that highway projects may not be approved for Federal-aid in areas of 50,000 population or greater unless "such projects are based on a continuing comprehensive transportation planning process carried on cooperatively by states and local communities."

Currently, there are 233 urban areas to which this Act applies. All of these areas are actively engaged in planning programs, which had an annual expenditure of $23 million in 1968.

The urban transportation planning process varies from area to area in terms of organizational structure, funding, scope of work, specific methodology, and level of sophistication. In general, each area proceeds through seven major phases These include:

1. Inventories of population, economic and land use activity, transportation, and other pertinent items.

2. Analysis of existing conditions and the development of simulation models.

3. Definition of goals and objectives.

4. Forecast of future population, economic and land use activity, and travel.

5. Development, analysis, and evaluation of alternative transportation systems and land use plans.

6. Selection of a transportation and land use plan.

7. Implementation.

The major objective of these urban studies, which has operations research implications, is that they must develop an optimum transportation and land use plan which can carry the forecasted travel demand while meeting the goals and objectives of the urban area. The Federal Highway Administration's interest in these urban studies, which bears on operations research, is to develop and improve procedures to forecast urban activity and travel, and to test, evaluate and select alternative transportation systems.

The travel forecasting process, which is one portion of the transportation planning process, is currently composed of five basic steps:

1. Land use
2. Trip generation
3. Trip distribution
4. Modal split
5. Traffic assignment

In the land use step, all travel generating activity is allocated within the urban area. Operations research techniques have been used in land use models to determine the optimum allocation of residential activity to minimize the total development cost, subject to constraints such as soil suitability, availability of sewers and transportation, and desirable density standards.

In trip generation, the number of trips produced from each section of an urban area is determined. The trip distribution procedure determines where these trips go. In modal split, the proportion using each mode of travel is determined, and traffic assignment determines the specific route that the trips will take.

These procedures must be calibrated for each urban area undertaking a transportation study. Once developed, they are used to test and evaluate transportation proposals by simulating travel movements over these proposals. The procedure for developing viable transportation systems is one of successive approximations: develop the transportation proposals, test the proposals, evaluate them, and then refine the proposals and test them again.

In each test of the transportation proposals, it is necessary to recycle through one or several of the forecasting steps, depending on how different the transportation alternates are in terms of the level of service provided.

This travel forecasting approach to the development of optimum transportation systems have evolved over the last 15 years. It is now reasonably accurate and sensitive to the important aspects of urban transportation. However, we are seeking to further improve this process. One missing link in the process is a generally

acceptable procedure for developing an optimum transportation system. The present approach is more art than science. It requires that all the design be performed by the analyst. It would be desirable to have a procedure which would develop an optimum system for a range of given conditions.

A second area of research concerns the evaluation procedures used to measure the effectiveness of transportation systems. Current procedures cannot rigorously consider all aspects of transportation system evaluation. Many of the more subtle impacts of transportation must be evaluated on a rather gross qualitative basis.

A third research area involves the forecasting process as a whole. As it stands, it is time consuming, expensive, and to some extent, a cumbersome approach to testing transportation systems. It is not computationally efficient. We have designated a general research area called "third generation travel models," with one of the objectives being to upgrade the entire forecasting process so that it is more in tune with the needs of the urban transportation process, and is more efficient to use from the analyst and user standpoint.

In summary, urban transportation analysis is an ever widening area of research. Some of the current techniques are products of operations research methodology. In the future, it will probably be more so. There is a need to improve urban transportation analytical techniques, and those having a knowledge of operations research and of urban transportation requirements can make significant contributions toward solving one of our pressing urban problems. The Federal Highway Administration welcomes the opportunity to work with groups involved in operations research in both our operational and research programs.

Joint Meeting of Government
Operations Research Users and Producers

Myron Miller
Department of Transportation
Washington, D.C. 20591

In the next ten minutes I plan to present a very brief overview of the Northeast Corridor Transportation Project. This is a project that is in its fifth year and up to this point has cost about $9 million. The project is a comprehensive regional transportation study and, although it is being done by the Office of High Speed Ground Transportation in the Federal Railroad Administration, involves considerations of all modes of transport in the Boston to Washington megalopolis.

At the start of this project there existed neither the data nor the OR tools to attack this very complex task. The task itself is to determine the intercity facility requirements of the Northeast Corridor through 1980.

An illustration of the degree to which the Northeast Corridor (roughly Washington to Boston) has become a megalopolis is that it contains approximately 1 1/2 percent of the land area of the United States and yet contains about 20 percent of its population.

I think as travelers we all know that acute transportation problems within and between several of the major metropolitan centers are already present in the corridor region. Travel between cities and the more distant areas within the region is of uneven quality, first of all, by any single mode and poorly integrated among the modes. Critical delays exist in and around major city transport facilities as for example the New York-Washington air crisis last summer. Unless something is done these things are certain to become more acute during the next decade. In fact, preliminary estimates of passenger demand by the Northeast Corridor Transportation Project indicate that it will be necessary to double the present intercity transport capacity of Northeast Corridor over the next 15 to 20 years. The question will be: More of the same or are there better solutions? A significant proportion of the $10 to $15 billion of investment required to meet this increase should be planned and programmed within the next few years.

In brief, what's been our approach? To aid in the identification and analysis of future requirements for the corridor region, the project has developed a comprehensive and systematic procedure for examining a range of regional transportation system alternatives. The major emphasis to date has been on passenger movements. This procedure makes extensive use of the mathematical computer simulation models which had to be developed to analyze a broad spectrum of transportation planning options, including costs and service characteristics, a wide range of potential impacts of travel demand, and the flows of traffic through the complex networks of the region.

What do we expect will result from all of this effort? The ultimate result of the project will be a set of alternative investments offering different possibilities for solving the Northeast Corridor Transportation problem. Each of the alternatives will be different from the others in one or more major respects, for example, capital requirements, service capability, impact on land use, etc.

The project results will give the Congress the opportunity to decide which transportation developments to emphasize, and to select the alternative transportation combination which contributes best. In that sense the corridor project will distill the options which the decision makers have - in other words we will attempt to make them more meaningful and intelligible. We will measure and forecast the consequences of each option in benefit-cost terms. It will not reduce the range and scope of the options presented to the decision makers.

Furthermore, the model structure and simulation will make it possible for decision makers to ask the question "What If?" and get timely answers.

What then is the status of this complex project. I think it's correct to say that we have made substantial progress. Technological projections from the High Speed Ground Transportation Program have been extremely useful. The data collected from the demonstration projects - the high speed trains, etc. - are beginning to get fed in and will certainly be useful in demand model improvements. We now have a simulation of the Northeast Corridor Transportation System programmed and running in the computers. This includes all modes with their costs and revenues in conjunction with the simulation with the demand models which predict total transportation in the corridor and its split between the modes.

This spring and summer we will put through the simulation model system four possible ways in which the corridor passenger transportation system can be changed between now and 1975. We will consider, for example, improvements at two levels of investment and performance for the high speed rail, and then we'll consider vertical takeoff and landing aircraft, and tracked air cushion vehicles. In the simulation of these four new systems we'll provide improved passenger service to nine major metropolitan areas in the Northeast Corridor and this simulation will take into account the interaction of the new systems with the existing modes as they will have evolved by 1975.

Now, I'm the first to acknowledge that this is only a modest beginning. For the first time, however, we have an analytical system in which the simultaneous competitive interplay among a number of transportation modes can be explicitly considered in estimating total modal demands and costs. We can approximate the interactions which lead to an equilibrium in the transportation sector. Thus, for example, the effects which the introduction of a tracked air cushion vehicle systems would have on all modes in the corridor and the impact of changes in demand on costs of all modes can be simulated based on the supply functions for each mode and on a joint multimodal demand function.

Well, it sounds like everything's rosy. Does this then mean that the project has no problems? Well, certainly the answer is that there are many little problems. These include: lack of enough traffic flow data degrades the calibration models; the fineness of the area subdivisions degrades the simulation process. But I think one can compare the development of the model system to the development of the circuits and components needed to build a television set. We are now getting the picture on the screen; are getting a feel for the linearity of the picture; and are evaluating the message that is being conveyed by the picture. This is very much like, for example, the use of the cathode ray oscilloscope as a powerful tool in analyzing problems. You change the circuit and you can use it as a visual diagnostic device to tell you what's actually happening. So, yes, there's much to be done, but I think we've developed a powerful tool and we're now busily engaged in using it.

Probably the most critical and difficult problem area is the development of more effective demand models. This problem is not purely a theoretical problem. Demand models must be based on traffic data. Additionally, the demand model development also tells you what data you wish you would have collected, and so on. The process is iterative.

One of the areas that we have not engaged in as extensively as we would like at this point is in the development of a freight demand model and freight simulation. This becomes important not only for its own sake. There is a high degree of interaction between freight and passenger transportation. Limitations of funding have delayed this work on freight data collection and analysis.

A quick summary of what I've been saying is that the Northeast Corridor Project is the first major attempt to develop a comprehensive procedure to help guide the allocation of regional multimodal transportation investments by the federal government. The basic methodology developed by the project and the designs for data collection will be useful to planners throughout the nation, particularly as a contribution to furthering the state of the art in transportation systems analysis and planning. Improvements in this newly developed capability is a continuing need of the Department and, I feel, of the nation. It is most important that major public investments in transportation, particularly in densely settled areas such as the Northeast Corridor region, should not be undertaken without consideration of the alternatives available and the future impacts of such decisions. The Northeast Corridor model system enables the Department to simulate alternative transportation investments and policies to determine their relative attractiveness in advance of major public expenditures. Approximately 150 or more reports have already resulted from the work of the Office of High Speed Ground Transportation, some of them relating to the Northeast Corridor analysis.

I would like to suggest that those contractors who have taken advantage of the availability of these reports to become knowledgeable - and these are available through the Department of Commerce Clearinghouse - have become some of our most successful contractors. We have many complex problems. We have a small staff, and a small budget, so that is one of our problems (maybe the biggest one.) We work very hard trying to make sure that all of our work is documented and becomes available. We look forward to talking to those who've taken the time and trouble to dig into some of our problems and have come in with ideas. We welcome good unsolicited proposals. We welcome good ideas, and we go out on RFP to get the contractors to solve problems as we identify them.

Joint Meeting of Government
Operations Research Users and Producers

R. J. Matthews
Department of Transportation
Washington, D.C. 20591

Figure 1 gives you a very quick picture of the Coast Guard. We have 12 districts. We are spread all over the world. What we don't show is our activities over in the Mediterranean. We have approximately 45 thousand military and civilian employees. We have approximately 350 vessels, 300 aircraft, and some 1300 shore stations. All of them are arranged in these 12 districts under two areas, except some of our large activities such as the Coast Guard Academy and Aircraft Repair and Supply Base.

As shown in Figure 2, at Coast Guard Headquarters we have a relatively flat organization. I can say that because there are no admirals around today. Most of our centralized analytical effort is conducted up off of the Chief of Staff, as you can see: Plans Evaluation, Programs, and Budget. However, each of our office levels does have something of an analytical staff most of it is of the military type, officers who attended postgraduate training, etc.

In the past, except for certain very specialized areas, Ops Analysis, Ops Research, whatever you want to call it, has been very limited in the Coast Guard, at least by that name. Of course, we did a lot in search technology, drift patterns, wind patterns for going after our customers out on the high seas, but nobody really thought of that in terms of operations research. This is continuing and we are now getting into a lot of software areas, basically at the insistence of the Bureau of the Budget. Bureau of the Budget Circular 66-3 with its PPBS system gave us our greatest impetus into this area. It was shortly after 66-3 was published that we lost our first battle which, you know, was pretty fast to lose. We argued for a centralized analytical staff, and lost, so our Plans Evaluation Division consists of only 11 professionals. We have the tremendous talents of one economist, one mathematician, four program analysts, and five military officers to assist. But we don't let that bother us. We use contracts to the greatest extent possible.

I think our first efforts in the Coast Guard, because of our slow beginning, had to do with such things as developing mission performance standards and benefit measures, and if you still want to get some reaction at Coast Guard Headquarters, mention benefit measures. It causes immediate silence and blank stares all over the place. But we're educating them and they're coming around.

The next year after 66-3 came out was one of painful education, as I've mentioned; to use a worn out phrase, somewhat of an agonizing reappraisal. Although that is quite interesting it's not germane to what we're discussing today, and I'll move on.

An indicated in Figure 3 we took an inventory of what we thought might be some of the interesting problems in the Coast Guard and they are interesting. They cover all the way from the SAR (Search and Rescue) Mission, which is the one most people in the United States and internationally recognize the Coast Guard for, and they go all the way down to a mission area that perhaps some federal agencies wish the Coast Guard wasn't involved in, Marine Data Transmission and Marine Sciences. But quite an impressive list of activities.

Figure 4 shows some of the activities that we've been able to get into. We've added a couple. We've had problems of hardware, as you can see, of an aviation plan, and we've had a lot of software problems. We have done some work in every one of these areas, not the least of which was done by a very interesting device known as Administative General Quarters. About two years ago the Commandant decided we had a helluva lot of areas that we had to study and there was only one way to do it.

Each office at Coast Guard Headquarters was directed to cough up 10 percent of its professional staff for a period of 90 days. Reluctantly they did. We accomplished 46 studies in that period of 90 days, approximately 20 of which were extremely valuable and we have implemented many of them.

I'd like to show you several efforts that we worked on, to give you a closer idea. As shown in Figure 5, in the area of Merchant Marine safety--you heard MarAd earlier--we're looking at it from the side of procedures used by the ships, by the Merchant Seamen, and one of our biggest problems was how effective was our program. We've been doing it for years but were we really doing anything for the money we were putting out. And we could never figure how to work it up, so finally we've come up with this one. We think in a very gross, or macro, sense this can be a very effective, if you will, measure of effectiveness, namely, that deaths prevented divided by deaths prevented plus deaths occurring. One of our problems is data. We have data to work this one out, and we worked backwards in time, and it seems to be quite a useful one. We're going to work on the micro aspects of this in the months and years to come.

I thought I'd show you what this actually calculated out last year. As shown in Figure 6 consider that 88 percent effectiveness wasn't very bad. One more minute and I'll go through the other ones quickly.

We've a very interesting study going on involving several contracts to many firms in the National Data Buoy Systems Study. This is the one we hope will sell. We'll need a lot of backing from the Bureau of the Budget, of course, for the amount of money involved. It could involve as much as $10 billion over the next 15 years. But these are the steps involved and we hope that perhaps maybe if we can do this again next year we can report some very detailed results of it.

As seen in Figure 7, our most interesting study to date and one that strikes at the very core of the Coast Guard is the Search and Rescue function. It's a very complicated study. Ed Cushen and his staff have provided some very outstanding assistance to our analysts in the Office of Operations working on this one, and we are about to achieve what we consider a real breakthrough. The first time in the history of the Search and Rescue effort in the Coast Guard, and I think I can really end this by saying that for years the Coast Guard considered one of the very prime factors in search and rescue was a thing called response time. The faster you got to the scene of an accident, the more likely you were to save the people who were in trouble, and this could be described by those who know these things as a kind of a negative exponential function, and, lo and behold, the analysis has shown so far that this isn't the case at all. We're really coming to find out that perhaps how fast you get there has little effect on the total number of lives you save. As a matter of fact, of the roughly 1400 lives lost last year in Maritime accidents, we found less than two percent would have been saved even if we had arrived there within five minutes.

This is the type of thing that we're finally finding out. It's going to mean some revolutionary changes in the Search and Rescue posture of the Coast Guard as well as the organization and the location of our facilities.

We anticipate next year that we will be having available some $2-to-$5-million depending upon the budget process in the area of both hardware and software systems analysis. The handout that you'll get after this symposium will have the areas that we'll be working in as well as the contact points to be made concerning those, and we have no objection to unsolicited proposals.

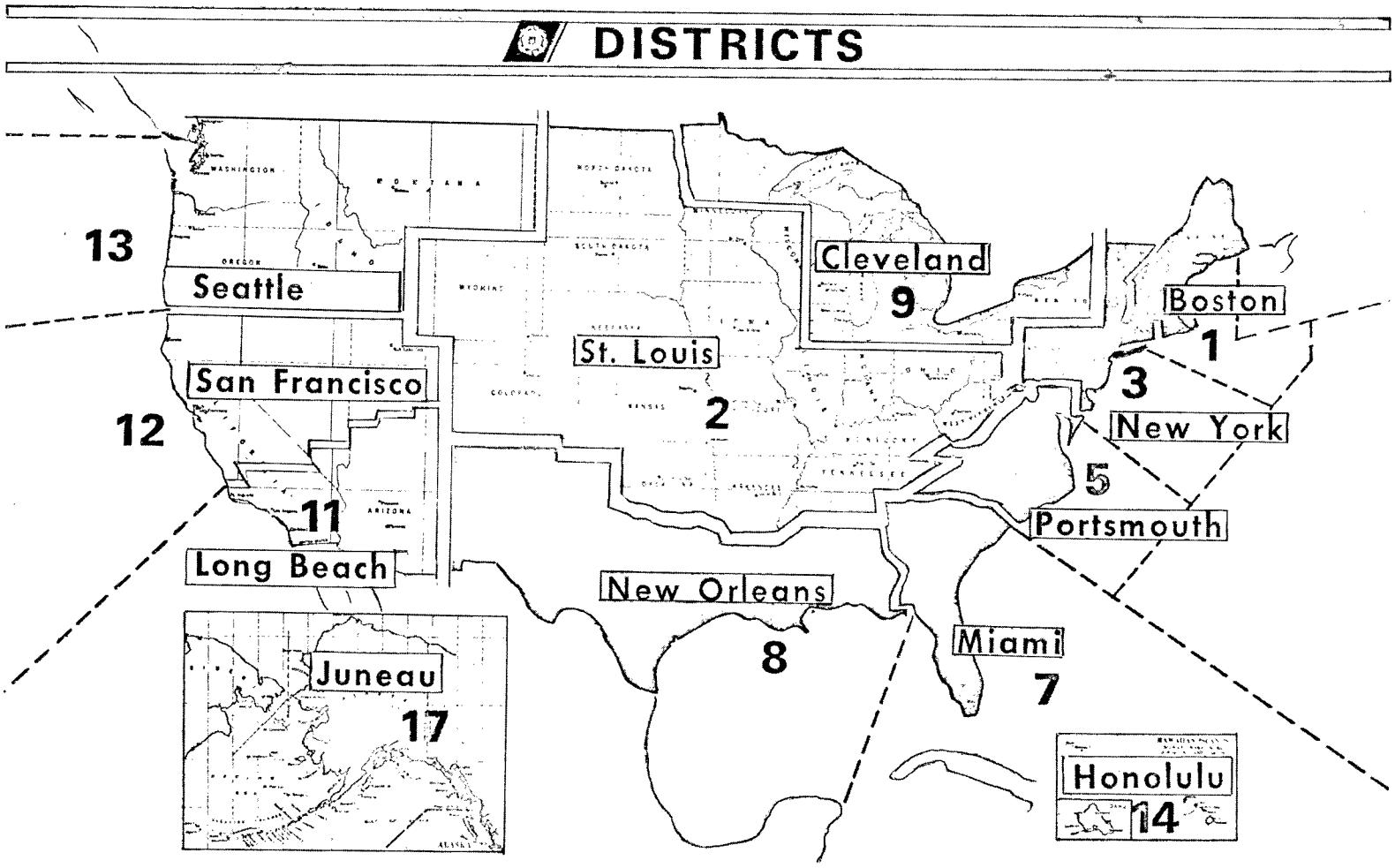

DISTRICTS
13
Seattle
12
San Francisco
11
Long Beach
Juneau
17
St. Louis
2
Cleveland
9
Boston
1
3
New York
5
Portsmouth
New Orleans
8
Miami
7
Honolulu
14

Figure 1.

DEPARTMENT OF TRANSPORTATION

U.S. COAST GUARD ORGANIZATION

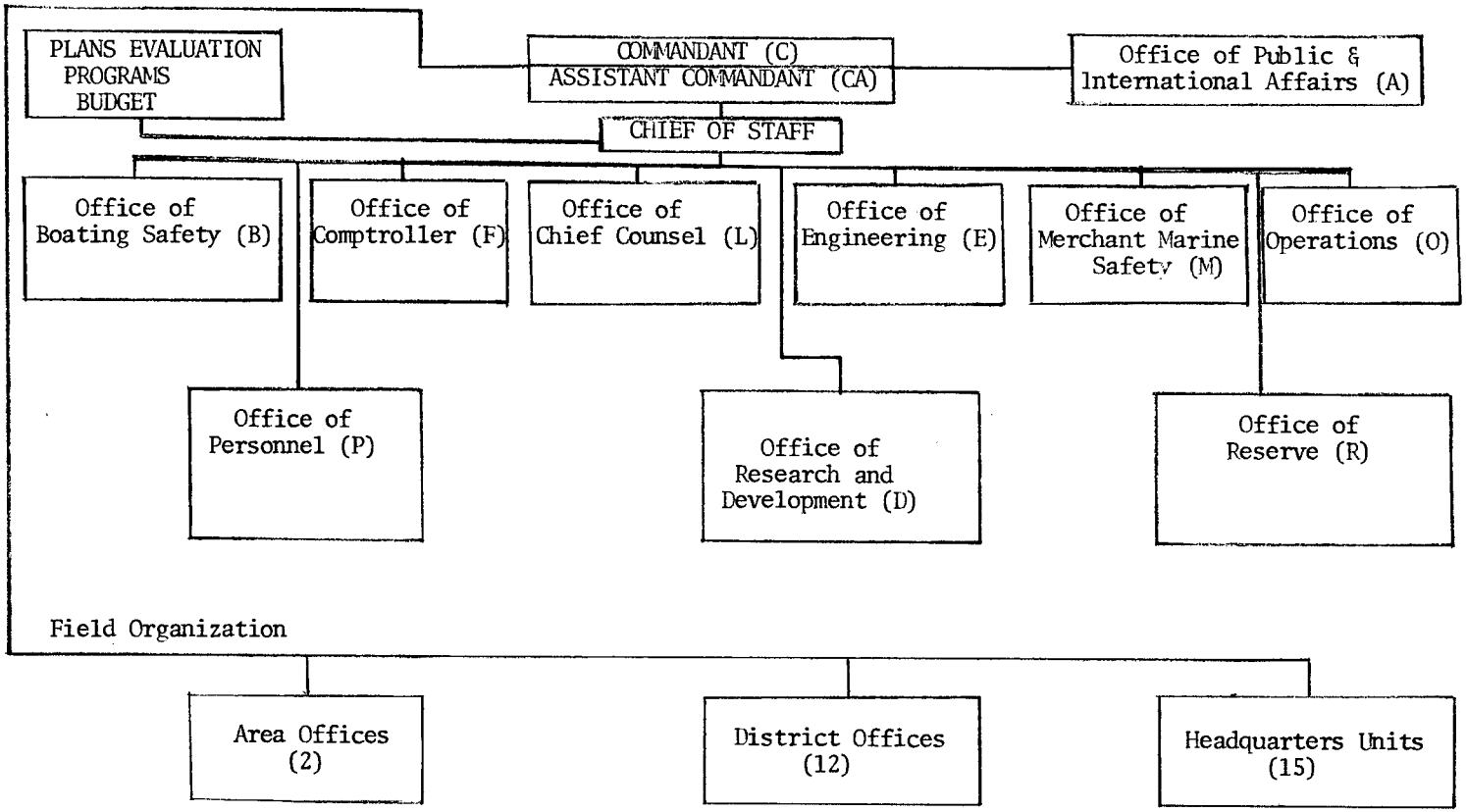


Figure 2

CANDIDATE STUDIES

SAR CRITERIA

POLAR

DOT SAFETY

FISHING VESSEL REGULATION

POLLUTION

SUBMERSIBLE SAFETY

CONTAINERIZATION

CONSHELF SAFETY

DECADE OF EXPLORATION

NATIONAL NAVIGATION PLAN

PORT SAFETY

AIDS TO NAVIGATION SYSTEM

CG ROLE IN COUNTER-INSURGENCY

HEC ANALYSIS

PORT & WATERWAYS DEVELOPMENT

ELECTRONIC LONG-RANGE AIDS

MARINE DATA TRANSMISSION

Figure 3

EFFORTS

•AVIATION	•CUTTERS	•SHORE UNITS
•ROLES AND MISSIONS		
AVIATION PLAN		SUPPLY AND INVENTORY
BUOY TENDER UTILIZATION		DOMESTIC ICEBREAKING
OCEAN STATION PROGRAM		OFFSHORE LAW ENFORCEMENT
MOBILIZATION REQUIREMENTS		HOUSING
SAR PLAN REVISION		ANTI-WATER POLLUTION
POLAR REQUIREMENTS (AGQ)		NATIONAL PLAN FOR NAVIGATION
NATIONAL DATA BUOY SYSTEM		DOT SAFETY ISSUE
UNDERSEA SAFETY		SAR CRITERIA AND FORCE ANALYSIS
CONTINENTAL SHELF SAFETY		MERCHANT VESSEL INSPECTION
POSITION FOR 6TH NAOS CONFERENCE		RESERVE TRAINING ALTERNATIVES
		POLAR TRANSPORTATION REQUIREMENT

Figure 4

EFFECTIVENESS

$$E = \frac{\text{DEATHS PREVENTED}}{\text{DEATHS PREVENTED + DEATHS OCCURRING}}$$

Figure 5

PROGRAM EFFECTIVENESS

$$E = \frac{1024}{1024 + 131} = 88\%$$

Figure 6

NATIONAL DATA BUOY SYSTEMS STUDY

PHASE

1 REQUIREMENTS

2 STATE OF THE ART

3 COST EFFECTIVENESS ANALYSIS

4 COURSE OF ACTION

5 COST BENEFIT ESSAY

Figure 7

Joint Meeting of Government
Operations Research Users and Producers

David M. Glancy
Urban Mass Transit Administration
Department of Transportation
Washington, D.C. 20591

Being the last member of a panel has several virtues. First, of course, you can avoid the difficult task of presenting concisely and coherently the many applications of Operations Research because of the excellent job the previous panel members have done. Also, it gives you the opportunity to attempt to identify the similarities and dissimilarities of agency approaches.

It seems fitting that the youngest element of the Department of Transportation should follow the oldest. The Urban Mass Transportation Administration, which comes out as UMTA in the Washington acronym game, is also the smallest administration. UMTA was established in DOT on July 1, 1968, having been transferred by Executive Order from the Department of Housing and Urban Development. Currently, UMTA has a staff of approximately 50 people and an annual budget of $175 million.

The functions and responsibilities of UMTA are exceedingly broad. As set forth in the Urban Mass Transportation Act of 1964, the agency is to deal with all aspects of urban mass transportation. This, of course, means that in many aspects of transportation within urban areas there are often other agencies, both in DOT and other Federal Departments, with some responsibilities. Based on its legislative background, UMTA provides a somewhat different perspective to these areas. The other administrations, which make up DOT, were all established under the interstate commerce provisions of the Constitution; UMTA, however, was established under the general welfare provisions, giving UMTA a transportation user orientation.

Because of the broad scope of the Administration, the problem areas it faces are the same or similar to those faced by the other administrations within DOT. The technical problems and applications of Operations Research faced by the Office of the Secretary, the FAA, the Office of High Speed Ground Transportation, and the Federal Highway Administration, which UMTA shares, have been so well described there is no need for me to bore you with a repetition of them.

We work with all of the other agencies. Right now we have projects on rail and tunneling technology underway with the Federal Rail Administration. We have projects involving urban performance models and airport access with the Office of the Secretary. We have some projects involving traffic control and the Urban planning process going on with the Federal Highway Administration. We coordinate, I think, very well.

Since our Administration got tagged in the introduction as the only one with grant program to universities I should explain a little bit about it. Actually, there are two programs. One is our basic research, development and demonstration program, in which grants are given to public bodies and to non-profit organizations. The form of the grant contract is very much like a regular procurement contract in that it calls for an end-product. In this program, we do like unsolicited proposals from universities and non-profits. We prefer that they come in informally first, so we can discuss them and see how they fit our program and, in a term we use, perfect the proposals.

UMTA also has a University Research and Training Program, and it's a little different. It is a program in which universities compete for grants. The purpose of this section of the law, which was established in 1966 but only implemented this fiscal year, is for the establishment of centers of higher education dealing with all aspects of urban transportation. On this program, I would like to make a point. Every other section of our law deals with urban mass transportation. The University Research and Training deals with all aspects of urban transportation--all

forms, including private auto. It's not just for planning. It can be planning, design, research on hardware, etc. In the past year, 14 grants have been given to universities for academic 69-70. These have averaged somewhere around $100-thousand each.

The emphasis of this program is on training and that research which complements the training. The applications, received for this program, are then evaluated as a group and grants awarded annually.

An example of applications that fits with some of the talk we heard earlier about PPBS is some work that we did when we were still in the Department of Housing and Urban development. In 1966 there was also an amendment which required the Urban Transportation Administration to develop a comprehensive plan for all aspects of urban transportation research and development, soft and hard. In May of 1968, the report, Tomorrow's Transportation, New Systems for the Urban Future, was published. This was a first attempt at a comprehensive look at the problem. We're following in from this and one very small element that was about three or four levels down from what Mr. Carlson was talking about, I can describe. It's an interagency agreement with the Navy and one of their captives, the Applied Physics Lab of Johns Hopkins University, for concept evaluation.

In this work, since there are all kinds of new concepts, the first step is categorizing them by operating regime; such as short distance, high volume, some network type of systems, and out on the other end, something that gets very close to the High Speed Ground concepts in fast transit links like Larry Edwards' gravity vacuum tube.

Following this, what Johns Hopkins is doing is taking approximately a dozen systems which are what you would call medium distance network (medium distance within the urban context, that is) and developing the base line description of these systems. Many of the concepts are written up only in Sunday supplement style, which is not very good for analysis.

Next, they are estimating the research development and status, where these are in process. Then they are estimating the various costs involved to full development. Also estimation of the time required and the probability of success of development. In this process the critical development problems are identified. Finally is the evaluation of the ability of the concept to perform as claimed.

The purpose of doing this is to determine which concept or concepts should be funded or supported in its development by the Urban Mass Transportation Administration. It is possible that all 12 concepts might have the same critical problems, in which case instead of supporting one UMTA might support work on the critical problems.

The second step, which is not going on at APL but is going on in-house in a number of different ways, is the development of requirements for this category of system. These two steps are similar to the work being done for the Office of High Speed Ground Transportation by TRW Systems.

I think with what I have said and what you have heard from Ira Dye, Myron Miller, and Dick Matthews you have an idea of the various ways in which OR is used in DOT and where your assistance is needed.

Questions and Answers

Question from Floor: My name is Moder. I'm with the Research Analysis Corporation. I have a few comments and questions, and I don't want to make them sound as if I'm trying to be obnoxious. First, Mr. Matthews, in talking about the speed of the SAR operations, something like this had already been done in the medical profession with the use of ambulances. Had you people got that information and used it? The speed in getting a patient to the hospital was not a critical element in his survivability or death. (Refer to page 46)

Mr. Matthews: Yes, we had that information available. The other factor, of course, was not just the fact that a person is injured in a Maritime accident, but the fact that his presence in that environment is inimical to his health. In other words, he's not necessarily injured, he's just in the water, but you've got to get him out to save him. But, yes, we had that information.

Mr. Moder: And then one for Mr. Dye. I believe Dr. Lynn of DoD reported in one of the JEC hearings that they had made a study of the SST. I think cost-effect figured in this and its usefulness, particularly over land, and I think he did come to a conclusion that we'd probably have to use it at sub-sonic speeds over land. Had this been incorporated in your studies? (Refer to page 30)

Mr. Dye: Yes. There have been, of course, a whole host of studies done on various aspects of the SST, and our study (and I can't go into the details on it) we used a boom restricted market, boom restricted meaning that it could not operate over populated land areas.

Mr. Moder: And then my last question would be: Do we need that speed? Because I have read where there is a physical and psychological effect of speed so that if you bring a passenger over in faster time he loses effectiveness for a much longer time.

Mr. Dye: This factor of it was analyzed but both am I not at liberty to discuss the results of the analysis but I don't feel that it's relevant to the discussion here this morning in any event.

Question from Floor: To the gentleman who just finished speaking, in all of these analyses that you do and that the rest of us are doing, there are certain consequences, both benefits and penalties. I'm very much interested in how you fellows coordinate with other federal agencies to get the same quantification of these benefits and penalties. (Refer to page 30)

Mr. Dye: I'll take that. The Bureau of the Budget takes that responsibility. In other words, they're responsible for establishing criteria for judging federal programs, and there's a certain amount of that within Departments. At detail levels within Departments, the Department Program Analysis people are responsible for developing and applying criteria to either rank or specifically put numbers on program effectiveness.

Mr. Glancy: Ira, I think there's another answer that applies both to FHWA and UMTA in another way. This is the fact that neither the Urban Mass Transportation Administration nor the Highway Administration do the planning for local areas. We do not make the decision of this implementation or that implementation. We provide the funds and techniques of analysis, both of us do this, and it is the local decision through the planning process which involves not only the Federal Highway, the Urban Mass Transportation, but the Federal Aviation, HUD, and in lots of cases HEW, and the whole local environment. We're not trying to plan for someone. They're planning for themselves. In hardware, like the High Speed Ground, we're providing alternatives, but not building these alternatives or forcing these alternatives down somebody else's throat. So that it's really a decentralized process. It certainly can stand a great deal of improvement and there's a lot of work going on trying to improve it.

Dr. Cushen: When I was discussing our own Technical Analysis Division I said we're not interested in developing methods per se. There are some areas where a public service does need to be performed, for instance, the identification and measurement of performance criteria, and in my opinion this is one of the areas where method development is very badly needed. Once you have selected the criteria it implies an allocation of resources among different functions. This instantly runs afoul of the question of institutional prerogatives and the sovereignty of the agencies that you are talking about, their immortality. To that end, therefore, we have in fact invested really the bulky part of our research money into developing methods relevant to this particular topic. The person to get in touch with is Howard Morgan, an Economist, and his telephone number is 921-2416. Now this particular effort is at sub-critical mass. We are attempting to develop something in such a way that you could treat different components of a utility vector separately. For instance, we were talking about the effectiveness of the National Bureau of Standards. It might very well be that the projection of effectiveness of NBS science research on an economic axis does not fairly reflect the value of the services performed. We think this is something that does require basic research. This is something that we do have.

Joint Meeting of Government
Operations Research Users and Producers

Professor Norman N. Barish
New York University, Bronx, New York 10453

Our research program, under grant or contract support, has been almost exclusively with organizational units having research missions; such as National Science Foundation, Office of Naval Research, Army Research Office, Air Force Office of Scientific Research, Public Health Service and so on. We have found that some of the applied research requirements of many operational, mission-oriented organizations do not fit in with the academic requirements of a university.

A sample of some of the contracts and grant research which we have been doing in recent years is listed in the one-page handout which was submitted for distribution.

We are interested primarily in long-term relationships which fit in well with our research interests and our instructional activities. We are not too interested in consulting-type research relationships.

A general concept of the topical areas which are of greatest to us can be obtained by my presenting a sampling of our course offerings, and then I will say something about the background of our faculty.

In the general area of stochastic and deterministic methodology, we are interested in things like sampling, mathematical programming (linear, non-linear and dynamic), renewal processes, Markov chains and applications, regression and analysis of variance, industrial experimentation, nonparametric statistics, sequential statistical methods, games and statistical decision theory, optimum-seeking methods, queuing, correlation and multivariate models and so on.

In the general area of industrial economics, we do work in economic analysis, forecasting, economic planning models and so on.

In the general area of computer sciences and data processing systems, we cover computer methodology, systems analysis and design, design and construction of compilers and programming systems, artificial intelligence, systems simulation, computer languages, computer systems and so on.

Another area is reliability and quality control, life testing, and maintainability. In the operational methods area we are interested in things like safety engineering, inventory models, production planning and scheduling models, traffic flow theory.

We have a rather strong program in the behavioral processes and theory of organization, human factors and engineering design, physiological measures and human performance information processing in man. I believe that this gives you a general idea of the scope of our academic interests.

We are a multidisciplinary department. Not only do our faculty have educational backgrounds in psychology, economics, mathematics, probability and statistics, physics, as well as engineering, but many of our people have applied their skills in areas which are quite different from their formal educational backgrounds. Thus, one of our computer scientists took his formal academic training in physics and many specialists in probability statistics and stochastic processes also have degrees in engineering.

I think that I have fulfilled the purpose of my presentation here in terms of outlining the general areas in which we work and our general areas of interest. I am confident that some of the problems which have been presented here are suitable for contract research in our type of department, but that in many cases the applied research requirements would not fit in with the joint operating requirements of the

government organization and an academic department. We are frequently more interested in doing research on fundamental problems, where we will do some of the things which the invitation to this meeting indicated was not the primary focus of this meeting (for example, determine a more efficient algorithm for solving an integer programming problem).

Joint Meeting of Government
Operations Research Users and Producers

Dr. Charles Bartfeld
The American University, Washington, D. C. 20016

I think the problems of American University as far as research is concerned are very close to problems of New York University. In brief, American University, located here in Washington, is a medium size university, 4,000 to 5,000 full time undergraduates, about 3,500 mostly part-time graduate students on campus and about 7,000 part-time off campus students both in and around Washington.

Now, different from other universities, many of our students and most of our part-time students are more mature, experienced students of very high quality with highly individualized backgrounds and experience and educational requirements. Many are people who already have achieved a high degree of success in one career and are preparing for a second career in university teaching, consulting, management, and so on. Others are interested in continuing their education in order to assume higher management positions within their organizations. Holding other jobs, they are generally not available for doing graduate research except the research required for doctoral dissertations; many of those students come with fairly clear plans already formulated. One of the advantages of American University is that it has relatively small teaching units which means we can give individualized attention to students and try to help them achieve their goals.

American University does not have an engineering school but we do have, we think, a good trade-off. We established the first School of Business Administration in the Washington area and this is clearly reflected in the basic philosophy related to Operations Research and Management Science. A major difference is that we at AU address ourselves to the problems of OR mainly from the point of view of the user/consumer. Although we clearly recognize the importance of the technical and mathematical aspects of operations research, our major emphasis is on preparing students for positions of executive responsibility and leadership. This means that our graduate must be able to utilize the tools of management science and operations research while at the same time understanding that management means getting things done through people. He must understand the behavioral foundations of executive actions and be able to deal effectively with people and communicate effectively - this clearly includes communication with technical and professional people. The graduate must understand his role as a manager and himself as an individual in relation to others.

This approach, which includes specific technical and mathematical upgrading in addition to other MBA related areas, differs substantially from the currently more popular emphasis on mathematical methods, but it permits us to bridge the communication gap that exists between the mathematically or technically trained person and the manager. So, we are fundamentally interested more in emphasizing the basic underlying concepts and less their technical aspects. This means that we recognize that in education, as in other areas of life, we can't really optimize; however, we certainly can talk about improvements. To put it in simple terms, we emphasize the "why" and the "what" to the detriment of the "how-to-do-it in 15 easy lessons" cookbook approach.

Now, what then is American University's program that is particular to operations research and management science? As can be expected from a university worth its salt, our administrative structure might look a little bit complex to the uninitiated, but c'est la vie.

In the area of operations research/management science, we have two degree granting institutions, the School of Business Administration and the School of Government and Public Administration. We have one certificate granting institution, the College of Continuing Education, and last, but not least, the administrative vehicle for teaching the related courses, the Center for Technology and Administration.

The area of concern to this conference is called "Technology of Management" at American University, and it includes five major comprehensive fields. Two additional specialized minor areas are of no conern to us here, namely data processing for teachers and sources of scientific information which are specialized areas of study for scientists on the doctoral level.

Figure 1 shows the School of Business Administration as the degree granting institution and CTA, the Center of Technology and Administration. The five comprehensive fields in Technology of Management that we deal with are: Computer Systems, Operations Research, Management Information Systems, R&D Management, and Scientific and Technological Information Systems. All courses are presently taught by CTA.

We have a BS in Business Administration with a major in Computer Systems. We grant an M.B.A, where, in addition to Management, one comprehensive field is in one of the areas in Technology of Management. Now, I do not include, when I talk about technology of management, the normal standard courses that we give in our management programs that include Quantitative Methods, Economic Analysis, Forecasting, PPBS, and so on.

On the Ph.D. level we offer two degrees. One is the Ph.D. in Business Administration, which, in addition to Management and Mangerial Economics, has one comprehensive field in any one of the areas of Technology of Management and one other comprehensive field out of a list of about 25. We then have a specialized degree -- Ph.D. in Business Administration: Technology of Management--and here, in addition to Management and Managerial Economics, we have two comprehensive fields in the Technology of Management. Now this is as detailed as I can be in the few minutes allotted to me. Generally, course sequences are individually tailored to the specific needs and requirements of the students, because, as I explained before, many of our students have rather varied backgrounds. Inquiries about the program should be addressed to Dean Nathan A. Baily at the School of Business Administration.

The School of Business Administration, in conjunction with the Center for Technology and Administration, has an additional unique program. This is the Executive Certificate Program, designed for those students who have reached their present executive position without having gone to college or without having really completed more than about 30 hours of college work. We recognize that these students should not be required to start with a regular and we have a special program for this purpose. As you can see in our prerequisites for this program, we have two inequalities--less than 30 college credits and over 35 years of age--plus executive experience. In addition to 12 hours of prerequisites, we require five courses in one field in the Technology of Management. Inquiries may be addressed to Dean Baily.

Figure 2 shows the School of Government and Public Administration, which is the second institution which grants degrees in conjunction with the Center for Technology and Administration. As you can see here, we offer an MA in Public Administration: Technology of Management; the difference is the number of comprehensive areas in the Technology of Management field. Futhermore, there exists a Ph.D. in Public Administration: Technology of Management, which is similar in structure to the Ph.D.

program in the School of Business Administration. Inquiries here should be directed to Dean Earl DeLong of the School of Government and Public Administration.

The College of Continuing Education gives a Graduate Certificate for those students having a bachelor's degree in one of the areas of Technology of Management plus a few other courses. For information, contact Dean Herbert Striner.

Figure 3 is a recap of sources of information.

As those of you who live in the Washington area probably know, we have a new President, President George Williams, and we are revamping our research facilities, in line with other contemplated changes. We have research capabilities both within the full-time faculty and in the part-time faculty that is available to us and we would be interested in receiving inquiries.

School of Business Administration & CTA

B. S. in Business Administration. Major: Computer Systems

MBA

1 Comprehensive Field in Technology of Management

Management

Technology of Management

Ph.D. in Business Administration

1 Comprehensive Field in Technology of Management

Management

Management Economics

1 other comprehensive field

Computer Systems

O.R.

Management Information System

R. & D. Management

Ph.D. in Business Administration: Technology of Management

2 Comprehensive Fields in Technology of Management

Management

Management Economics

Scientific & Technological Information Systems

Executive Certificate Program

1 Field in Technology of Management

Prerequisites: < 30 college credits

> 35 years

executive experience

Inquiries:

Dean N. A. Baily, SBA

Figure 1

School of Government and Public Relations & CTA

MA in Public Administrative: Technology of Management

1 Comprehensive Field in Technology of Management

1 other comprehensive field

MPA: Technology of Management

2 Comprehensive Fields in Technology of Management

Ph.D. in Public Administration

1 Comprehensive Field in Technology of Mangement

3 other comprehensive fields

Ph.D. in Public Administration: Technology of Management

2 Comprehensive Fields in Technology of Management

2 other comprehensive fields

Technology

of Management

Computer Systems

O. R.

Management Information Systems

R. & D. Management

Scientific & Technological Information Systems

Inquiries: Dean Earl H. DeLong - SGPA

College of Continuing Education & CTA

Graduate Certificate in

Computer Systems
or O.R.
or Management Information Systems
or R. & D. Management
or Scientific & Technological Information Systems

Prerequistes: Bachelor's Degree

Inquiries: Dean Herbert Striner - CCE

Figure 2

Degree Programs Executive Certificate	SBA	Dean N.A. Baily Extension 441
Degree Programs -	SGPA	Dean Earl Delong Extension 651
Certificate Programs -	CCE	Dr. Herbert Striner Extension 333
O.R. Training Programs (off campus & outside Washington area)		Dr. Richard Powers Director, CTA Extension 614
Research		Dean Stephen Horn Dean of Graduate Studies & Director of Research Extension 328

Figure 3

Joint Meeting of Government
Operations Research Users and Producers

Dr. Gerald L. Thompson
Carnegie-Mellon University, Pittsburgh, Pennsylvania

I'd like to begin by saying that I am on the faculty of the Graduate School of Industrial Administration at Carnegie-Mellon University. Let me briefly describe our educational program and then I'll go on to our research program.

In the Graduate School of Industrial Administration we have a two-year master's program that admits approximately 50 students per year. Hence, we have roughly 100 such students on campus at all times. We also have a Ph.D. program which grants degrees in Economics, Industrial Administration and Operations Research, and there are approximately 60 students in residence in that program. Finally, we run a nine-week executive program every spring that is attended by executives from industry and government.

The Management Sciences Research Group includes some of the faculty of the Graduate School of Industrial Administration at CMU. At the present time the group includes Professor Balas who works in integer programming theory and applications; Professor Cooper, who works on mathematical programming models, theory and applications; Professor Donald Gaver, who works in applied probability and statistics; Professor Robert Kaplan, who works in the areas of dynamic programming and probabilistic programming; Professor David Rutenberg, who works in the international business area; and myself. My interests lie in the areas of mathematical programming, mathematical control theory, and combinatorial problems.

Our group has always had strong interests in applications, and a large part of our work has been inspired by real life problems. In such cases we try to formulate a mathematical model of an applied situation and, when possible, find an algorithmic, or lacking that, a heuristic solution for the model.

In order to give specific examples of such approaches let me briefly review some of the work of the project over the past 15 to 20 years.

In the1950's(before I was a member of the project) there was the work done by A. Charnes (now at the University of Texas) and W. Cooper on applying linear programming to oil refinery problems, which culminated in the development of chance constrained programming. The latter is now a standard area of research in the literature. Another important contribution in the 50's was the linear decision rule for forecasting and smoothing workloads which was developed by C. Holt, F. Modigliani, J. Muth, and H. Simon.

To mention some more recent work done in the 1960's, I might mention the Manpower smoothing programs developed by F. Levy, J. Wiest and myself in the early 60's. This was followed by J. Wiest's thesis on the resource constrained critical path problem. Still another development was the decision critical path method developed by W. Crowston and myself, which was further extended by Crowston in his thesis. Still a later development was the work by E. Balas who applied the concept of a disjunctive graph to solve algorithmically the CPM problem with resource constraints.

I would like to briefly discuss a current project. This is the model developed by A. Charnes, W. Cooper, R. Niehaus, and others for operating with the Civilian Manpower Management Program of the U. S. Navy.

There are approximately 500,000 civilian employees of the Navy. The problem of monitoring their progress through the various levels of positions that they can hold, plus the fact that some of them move from one job category to another within the Navy, or even to cease employment with the Navy completely, together with the fact that there are always limited budget resources but very large demands for hiring new people, make the management of this large group of people an immense problem.

Professors Charnes and Cooper, together with Niehaus of the Navy, developed a goal (linear) programming model with an imbedded Markov chain for managing the Civilian manpower problem of the Navy. The imbedded Markov chain has coeffieients that indicate the relative probability of a person changing from one civilian Naval employment category to another, or of leaving Naval employment altogether. Thus the imbedded Markov chain predicts future employment patterns. The goal programming part of the model was a way of reconciling the incompatible constraints of the desires of the Navy for having a large number of civilian employees, and the limited budget provided by the Congress for paying such employees. What the goal programming model does is to come as close as possible to feasibility, that is to reconcile these incompatible constraints.

I went into the Navy civilian employment application in some detail in order to emphasize that our group is interested in considering applied problems and developing from them mathematical models and solution techniques. Frequently such models have entirely different applications than those for which they were originally developed.

Our group is also interested in algorithmic developments. For example, I noticed in one of the handouts to the meeting that there was interest in a code and I will make it available to anyone wanting it. I also observed that there was some interest in location problems. Various people at CMU have worked on such problems. We have also worked on network models of various kinds.

Still another capability at CMU that I might mention is the School of Public Affairs that has just been organized, and which has Professor William Cooper as its Dean. This department is organizing a strong operations research group which will be particularly interested in application to urban problems.

I would like to close by discussing in a little more detail our program for executives. This program brings together about 50 executives from all over the United States and from some foreign countries. Their average age is 42, and the positions of these men are typically middle management in industry or gorernment. I have experimented with the use of a time-shared computer as a technique for teaching them various operations research techniques such as linear programming, CPM, and PERT, forecasting, decision problems, etc. The executives learn how to run programs in each of these areas to solve problems of the kind they might encounter in their work. They do not learn the technical details of how these programs solve the problems, they just learn how to call the computer, how to get data into the computer, and how to interpret the computer's answers. In other words they learn the managerial not the technical aspects of operations research. To my mind this has worked out very well as an educational device.

I might close this talk by suggesting that the same idea might be used to develop short courses for training groups of government employees in the use of specific OR techniques.

Joint Meeting of Go ernment
Operations Research Users and Producers

Dr. Arnold Reisman
Case Western Reserve University, Cleveland, Ohio

As many of you no doubt know, the Case Institute of Technology was the cradle for academic work in operations research. We are still quite in the business of both doing operations research and teaching it. We now have about 80 full-time graduate students, some 85% of whom are fully supported by the department's research grants and contracts.

Our research has investigated many areas. I will stress the applied areas here today, although by no means are we a unimodal department. One of the major areas of concentration in the department is research on the management of research and development supported by a Themis Grant. Although the grant is situated in the Department of Operations Research, there are several other units cooperating. Namely, the History of Science and Technology Group, Science and Public Policy Group, and the Departments of Organization and Administration and Economics.

We are also quite interested in applications of operations research in education. In this area we have done work in the field of curriculum design, national dynamic manpower planning studies, the management of the operations of institutions of higher learning, and also we are now concerned with the management of university endowment funds.

We are also quite interested and have been for some time in the applications of operations research to the health care field. The department has performed studies in the area of prepaid dental plans, and we are now working in the field of the optimal design of clinics in general and dental clinics in particular. We are working in this with a group of dentists in Cleveland and also with the Cuyahoga County Community College. Basically we are concerned with what amounts to a job-shop design optimally operated.

We are also concerned in the design of a curriculum and orderly expansion of educational facilities for the training of a new breed of paraprofessional in the dental field, a person who will be able to do everything a dentist does except cut hard and soft tissue and/or perform diagnoses. We are doing quite a bit work with the CWRU medical school, a school, I might say, of some note. We are working with the Arthritis Clinic which is one of the models for early treatment of arthritis. We are working with a county hospital, the Highland View Hospital, on a center for early and comprehensive treatment of spinal cord injuries.

We are also quite involved in applying operations research to a voluntary Federation of 22 social agencies, ranging all the way from an old age home through a major hospital. We tend to take a team approach to many of these studies, that is, we involve not only operations research faculty and students, but faculty and students from related areas. In the case of the Social Agency Study, we are involving people from the School of Applied and Social Sciences as well as the Federation professionals, who will implement these studies.

In addition to many of these mission-oriented studies, we are also doing work in the extension of the methodology of operations research. Work has been and is continuing in the extensions of queueing theory, inventory theory, various aspects of mathematical programming, reliability theory, and so on. We have, in the past, and will continue in the future to provide short courses for the industrial, commercial and government community.

Like all other campuses, we are somewhat concerned, or at least our students are soemwhat concerned, with the thrust of research on university campuses. Many of our students are interested in urban problems, including education. We have 15 Ph.D. candidates who are either writing their dissertations or about to start writing in the area of OR applications in education.

Joint Meeting of Government
Operations Research Users and Producers

Dr. Gustave Rath
Northwestern University, Evanston, Illinois

In Northwestern the operations research and systems analysis interests reside in the Department of Industrial Engineering and Management Science, supported by the School of Management, the Department of Civil Engineering and other departments.

I'm going to present my own biased view of the world. I'm concerned with design and implementation so I'm going to be emphasizing that, and not discussing very intensively the more theoretical research going on. We have an operations research theoretical capability, information science and simulation. In our department we have an organization theory in behavioral science activity which is concerned with research on research.

I'm going to talk mainly about projects. I would say that recently work in crime and law enforcement has been of a great deal of interest to us. We have worked on the President's Commission on Violence and our report is going to be released soon. This is work in conjunction with A. M. Bottoms of the Chicago Police Department. We have been doing work in simulation of and prediction of crime, command and control, as well as management information centers in major police departments. Also, we have carried out some cost benefit studies on such things as should you use dogs or people or mixtures of dogs and people for patrol.

One of my students is finishing a dissertation in the Chicago Police Department where he has developed a PPB system with a resource allocation simulation model to help do allocations.

We have a sizable group, including two surgeons, in health services research. One of the surgeons is getting a Ph.D. with me in industrial engineering, and so we do some work in hospitals. Here we are interested in simulating and predicting hospital operations. We have been working very intensively in clinical pathology looking at equipment replacement decisions as well as some of the intensive care unit and surgical applications.

In the area of education, we have developed and implemented a PPB system in Skokie District 68 which has been operating two years, and we have been doing many systems analysis and cost benefits studies with them in such interesting problems as, "Is instrumental music something which is of benefit?" The cost is very high and you benefit few people. It turns out that you might better give grants to the students to have piano lessons at home instead of having lessons at school, or have all private lessons externally supported. It's cheaper to do it that way. I have one student who is currently trying to build a model of a university department.

In the area of welfare, we are working with the American Welfare Association in redesigning the Welfare System in four counties in Pennsylvania and in Maine. This involves setting up a management control system and separating the payment system from the welfare system.

I have another student who is working with a number of religious orders, and he is in the process of consolidating four seminaries. He's interested in problem formulation and developing some general planning models which would be applicable to many institutions.

We have had other people interested in railroads. Bill Allman did a railroad simulation here at the Bureau for his doctoral dissertation. We've found that working with the National Bureau of Standards, having our students here, has been a wonderful opportunity for them to be with major programs, get good experience, and do a good dissertation.

On the more frivolous side of life we have been engaged in systems theater and art and technology. So you can apply computer science and systems concepts in a wide number of fields.

In terms of our theoretical work, we have been doing some work in close concert with the Civil Engineering Department and the Transportation Center in lane changing models. We also have some students interested in location problems, the location of branch stores as well as the location of housing. We have a reasonably large project involving the study of project solection and how it should be done. This is the R&D portfolio problem. This is in close contact with our research on research activities.

In the more theoretical areas, we have work going on in duality theory and non-linear programming. We have work in sequential optimization and in many areas of Markov processes. The people involved here are Adi Ben-Israel, Jim Falk, Gordy Wright, Erhan Cinlar and Art Hurter. In the handout which you ultimately will get is a list of faculty and a more detailed description of some of the research activities.

Lastly, probably one of the things that I am very interested in pursuing and getting support for is to allow more student projects to be done in concert with institutions. Currently we field about 120 students and put them in applied projects. The assignment is, "Here's a phone number and the name of somebody, go do some good," and we have put them in government agencies, companies, and other places so if there are agencies either close to Chicago or willing to have us work with them or who want to pay transportation for them, we can make a deal.

Joint Meeting of Government
Operations Research Users and Producers

Professor S. Russell Stearns
Dartmouth University, Hanover, New Hampshire

I want to bring to you the points of interest we have at Dartmouth, and at the Thayer School of Engineering, and also to talk some about our capabilities and then finally some about our needs.

I am on the faculty at the School of Engineering but I do want to expand this concept very quickly because at Dartmouth for one thing the School of Engineering is interdisciplinary within itself. We do not have branches of engineering as such; we just have what would be known as disciplines, and students work on an almost individual basis, with advisers, along the lines of their own particular interests.

Secondly, we work very closely with the College of Liberal Arts; in fact, we are a Department of Engineering Sciences in the College of Liberal Arts. We also work very closely with both the Business School at Dartmouth and the Mathematics Department. This is important, I think, to us all here because the trend today in the discussion we are carrying on is in the interdisciplinary approach to these matters of consequence in our society. We emphasize at the Engineering School the basic fundamentals through the Engineering Science Program of the first few years. In the graduate years we emphasize, on the one hand, a program in basic science or research which leads to a Master of Science Degree and a Ph.D. A second stem in the graduate years, in parallel with the research stem, is the Thayer School Professional Engineering Program which is based on the application of Professional Engineering. This second stem starts with a Bachelor of Engineering Degree after five years, then a Master of Engineering Degree and a Doctor of Engineering Degree. So I do want to emphasize the dual opportunity at Dartmouth both in the basic research side and in the applied professional engineering side. The entrance into the 5-year or the fifth year Bachelor of Engineering Program is normally from the 4-year liberal arts study in engineering science noted previously, and there is an A.B. Degree at the end of the fourth year. So, you should recall that after five years the student has two degrees, an A.B. Degree representing his liberal arts background and the Bachelor of Engineering Degree representing his professional engineering training, mainly in the fifth year.

In terms of capabilities the faculty of the Arts and Social Sciences is very important to us. They are quantitatively inclined as well as qualitatively inclined, and they work with the computer almost as much as the men in the Science and Engineering Departments. In the sciences we work very closely, of course, with the physical sciences and with the mathematics department. It is here that one of the major strengths of Dartmouth lies, in the Kiewit Computer Center which is an outgrowth of the interest and tremendous capability of Dr. Kemeny. We have at Dartmouth, in the Kiewit Center, a GE 635 computer system, a time-share computer system. I do want to say just a couple words about it. It is probably as far advanced as any in the world. It has 200 possible simultaneous input stations, and a turn-around measured in seconds and minutes depending on the problem. Each individual has his own private input to this computer; therefore, he really has a multi-million dollar computer at his own disposal. You work through a teletype system to the computer on a conversational mode, or you can introduce work through batch processing. The beauty is that one has a one-to-one relationship with a large computer. It has had already up to 118 simultaneous users, to give you an idea of its capacity. Another great benefit from the Computer Center and from Dr. Kemeny and his associates has been the creation of a language many of you are familiar with called "BASIC". This computer language developed at Dartmouth is now the official GE language; BASIC can be learned in 10 minutes to the extent that a person can start computing, and can be learned in two hours so that he can do some programming. Some of the most active programmers we have discovered at the Kiewit Computer Center in Hanover, in recent years, have been the undergraduates in the grade school. You see children of the ages 8, 9, and 10 in the Kiewit Computer Center running the computer and programming. In the high school, students are doing college grade work. In the undergraduate college, students are doing graduate level work. All students have

an opportunity at Dartmouth to work with the computer and it is estimated that 90% of the student body have had some activity with the computer and most of them are able to do some programming. Computer programming in "BASIC" is introduced in the freshman year through regular course work and not through special courses.

Now in regard to the actual capabilities of the Engineering School in terms of the subject before us today, I wish to emphasize that students deal with real world problems. We welcome problems from any source. We have problem support from industry and from governmental agencies. We work mainly on a one or two student basis together with a faculty adviser. The 5-year engineering student is required to complete a project for the B.E. Degree which is rather extensive. I will give you some examples of B.E. projects and then describe the project work of the Masters Degree candidate and the Doctoral candidate who also work on the same type of problem. The projects are more practical, you will notice, in the professional engineering stem rather than purely theoretical. Theoretical problems are presented to students more in the research stem which I am not talking about today. I will concentrate on the professional stem.

There are problems both in terms of hardware and software; I think our interests today are more in terms of the software, perhaps, than in the terms of the hardware, if I read the literature correctly. Nonetheless I would like to indicate a couple of projects involving hardware which were being reported this week at Dartmouth by bachelor candidates. One was the development of an analog digital conversion apparatus for a time-shared computer which would enable one to control processes from the analog through the digital and back to the analog, either on an automatic or on a manual input basis. There is a time-sharing, audio-visual input device developed by a student. There has been an acoustical telephone hook-up device developed by a student, and this spring a B.E. candidate has developed a graphical display program which would enable a man, through time-sharing, to introduce data on an individual basis. The user can work on his problem and design through computer graphics in time-sharing. The graphical representation on the tube, including drawings on PERT charts can be corrected or modified with an electric pen. This is different a little bit from the computer graphics in existence today in that a general program has been designed and not a program developed for a specific purpose such as the circuit design programs. One student has developed a graphical display of a PERT or a CPM diagram plan. He has carried this through to the extent that he can display on the tube the complete PERT program or he can move a window around on his program and display any subpart of this PERT program. He can call for the critical path, and he can look through a window on the graphical display and see what the bottlenecks are, and where the slack exists. The projects and the problems that I am emphasizing lead quite generally into computer applications and this, of course, is because of the tremendous asset available to us.

The software solutions to problems emphasize simulation, I think, possibly more than some of the other methods, especially in regard to urban problems. Let me just give you a few of these particular student projects for masters, doctoral, and bachelor of engineering degrees. We do have sponsorship through NSF, which was mentioned a moment ago, and under this particular project there are two main avenues of exploration. One is assistance to community decision makers. We have a school bus project developing here, and secondly, we have a fire station location project. The second area is the development of data and methods of measuring a community or region, and for forecasting future conditions such as population. We also have a complete computerization program developing for the library which will rpovide, if it is successful, input to the library for the users to call for information from the library, or for library management to put bibliographical or Library of Congress information into the library.

I would like to note a few other projects by title, very quickly. I did mention that a school bus routing system is being studied at the moment. A housing program for the State of New Jersey to assist contractors in deciding how to develop their work schedule and their starts in housing. A command and control system for the police in New York City to give better information to the nerve center of the police station. An access to airport project has been developed now to give a minimum cost, maximum value system for various types of modes between the central city and the airport. One student completed an analysis of a sea level canal for Panama in which he operated ships of various sizes

through the canal, both two-way, taking tidal currents into effect. A street and highway maintenance and improvement program whereby local communities could decide which street should be maintained this year or improved as opposed to some others. Management techniques have been designed, and a simulation of the economy of a town of 10,000 is under development. Finally, a simulation of a nuclear reactor plant on the Connecticut River was written and the results used for testimony to the State of Vermont.

To conclude, we have capability both in terms of interested faculty and in terms of students at these various levels from the fifth year B.E. on through the doctoral degree. We do rely heavily on problems proposed by agencies, industries, and contractors to support this program. The program is open-ended in general; we do not give students cookbook problems. We will welcome any interrogation or questions in regard to what we might do for you and we'd like to know what you can do for us.

Joint Meeting of Government
Operations Research Users and Producers

Dr. James Boughton
Duke University, Durham, North Carolina

Let me begin by saying that I'm going to speak this afternoon about a particular research group which operates within the Department of Economics at Duke University and which has capabilities in operations research. This group is known as the Econometric System Simulation Program, or ESSP. It was founded in 1966 under a grant from the National Science Foundation for the purpose of coordinating research on the development of simulation models of socio-economic systems. Since the time of its founding it has been directed by Dr. Thomas Naylor.

Since 1966, ESSP has been expanded to the point where now more than 20 professional and semi-professional persons work regularly in the group. These people have skills primarily in econometrics. We also have mathematicians, statisticians, people with skills in operations research and in most areas of the social sciences. We have ties, not only with the Department of Economics at Duke but also with the newly founded School of Business Administration, and with the Mathematics Department at Duke. Many other departments have been involved at one time or another with projects undertaken by ESSP. We also have ties with the near-by University of North Carolina.

We try to be a broadly interdisciplinary group. We emphasize cooperation between faculty and graduate students in developing and implementing projects and we also try to emphasize cooperation among people with differing scientific backgrounds in keeping with our interdisciplinary orientation. So far the group has produced 37 working papers, most of which have been published in professional journals. Lists of these papers are available upon request.

As part of the preparation of these working papers, we have developed over the years a number of operational simulation models. Among them are models of the textile, tobacco, banking, and world coffee industries, to give you some idea of the breadth of the work we do. We have also developed urban models, inventory control systems and queueing systems. Many of the techniques we have developed and used, and many of the models we have used, are described in the various books and articles published by our staff members. Perhaps the most widely known is a book entitled Computer Simulation Techniques written by Professor Naylor in conjunction with Professors Balintfy, Burdick, and Chu.

As far as facilities are concerned, we make extensive use of an IBM 360/75, a 360/30 and a remote terminal in our own offices with time sharing capabilities on the Model 75. We have a package of regression programs which includes all the well-known simultaneous estimation techniques and we have several versatile simulation programs and languages.

So that is basically what we are. We work within Duke University and our basic idea is to develop operational simulation models of widely varied types of socio-economic systems.

At the present time we are working on a number of large scale simulation projects, each of which, I might add, is in need of contract support. One example is that we are developing corporate simulation models. The idea here is to develop a general framework for corporate simulation m dels making use of the existing literature on specific models. This is a project which is just getting underway this summer, and for which we do need additional contract support.

Another project that we are working on deals with the effectiveness of family planning programs in underdeveloped countries. This is a very large scale, long-term project which has already received some enthusiastic contract support, and we would like to be able to place more people on it if possible. The major work on what project will be beginning this fall.

One crucial project is the development of a macroeconometric model as a framework for the use and the testing of industry and sector models. We found that the various macroeconometric models that have been developed are developed with different sorts of ideas in mind and haven't been particularly applicable to the projects that we are doing. We would like to develop a macroeconometric model that is specifically useful for this purpose.

This is a crucial step in the development of useful and constructive simulation models. We are going to begin work the summer on this macro model. We are in need of quite a bit of additional support to what we now have.

In addition to these specific projects that we are working on right now, we have a number of people who are working with us who have capabilities and interests in urban studies, regional models, theoretical studies in econometrics, computer simulation, gaming, and so forth, and of course we would more than welcome contract support in any of these areas.

Joint Meeting of Government
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Kenneth R. Bordner
The Franklin Institute, Philadelphia, Pennsylvania 19103

I noticed awhile ago, there was a battle over the origin of operations research. We have one thing going for us. We are the oldest research institution in the United States. The Franklin Institute was engaged in contract research in 1836 when it was awarded a government contract to investigate the causative factors of boilers exploding on steam ships. To show how operations research has changed, it was a 10 man-year program and cost $20,000. To show you how operations research has not changed, it was two years overdue.

The Franklin Institute's official title is The Franklin Institute of the State of Pennsylvania for the Promotion of Science, Mechanics and Arts, and has three primary divisions, the Institute Science Teaching Museum in Philadelphia; the Bartol Research Laboratories in Swarthmore, Pa., specializing in low energy physics; and the Franklin Institute Research Laboratory, also in Philadelphia, which does basic and applied research in five disciplines.

I don't know if you people have the same problem I have with operations research, but I have some small children who ask what their Daddy does and I really can't tell them. If I was a bus driver or something like that, it would be easier to explain, and for years they were disappointed that I wasn't a guard over at the Science Museum because that they could understand. Now that my older boy is beginning to understand life, he gave me something the other day which explains (and I think it's worth taking some of my time) his vision of operations research. He clipped this out of one of his Peanuts Cartoon Books. If you are familiar with it, there are two characters who are primary, Linus and Charlie Brown. Linus comes staggering up and says, "Well, it took me six weeks but I finally figured it out. All in all he gave her 22 turtle doves, 30 French hens, 36 calling birds, 40 gold rings, 42 geese a-laying, 42 swans a-swimming, 40 maids a-milking, 36 pipers piping, 30 ladies dancing, 22 lords a-leaping, 12 fiddlers fiddling, 12 partridges in pear trees." Charlie Brown looks at him and says, "Why did you do that?" And he says, "When I grow up I'm going into Operations Research." And Charlie says, "You should be very good at it."

We do only contract research; we are a self-supporting division of the Franklin Institute. We do some grant work, however, we do very little because there is no fee involved and this makes the Director very unhappy. We have approximately 300 degreed professionals in all disciplines. We have five primary departments. Operations Research is in the Systems Science Department along with Behavioral Sciences. Our major areas of interest started like most OR with the classical areas of command control information systems, experimental designs and the like, for the Department of Defense. But as time goes on we have branched into some of the following areas which I will briefly present.

The first is environmental resources and two primary programs are currently in effect now. We are a member of the so-called IDRES, which is the Institute for th Delaware Riverene and Esturine System in conjunction with the Academy of Natural Sciences of Philadelphia and Lehigh University to develop the Delaware River to attract Pennsylvanians away from the Jersey Coast. We have two primary areas that we are dealing with in this particular institute and one is the development of a computer model of the Delaware Estuary and Riverene System and the second is the development of recreational land use and investment potential for Delaware River usage.

In addition, several years ago we started a very small program in Philadelphia to measure the content of sulphur dioxide in the air in Philadelphia and this has since led to a contract with the city of Philadelphia for the development of an air pollution warning system.

Another area is criminal justice. We are currently working on the state criminal justice plans for the states of Pennsylvania, North Carolina, and, hopefully Florida. We have just completed a contract with the Philadelphia police department doing an operational evaluation of their entire force, and we are beginning some programs with the Philadelphia police department on police information system and also in the development of a closed circuit television system for their use.

We are doing work in health systems. We have completed a program for the Department of Transportaton for the development of emergency medical care demonstration projects in the United States. During this period we developed the criteria for emergency medical care systems. We are getting into some work on the development of state statistical health centers, hopefully soon, in Nebraska and in line with our medical work we are affiliated with the Jefferson Medical College and Hospital in Philadelphia.

We do work in transportation. Again we have developed the Pennsylvania Master Plan for transportation which was an integral part of development of the Pennsylvania Department of Transportation, and we have developed a series of computer models for overtaking and passing on two-lane rural highways for the Bureau of Public Roads, which essentially models the total traffic environment on two-lane rural roads. We will begin a program on development of human factors involved in skid resistant coefficients in arts and driving skills. We are also involved in the economic design of highway lighting for the Highway Research Board.

Other economic studies of some interest - we were involved with the economic evaluation of the Continential United States Autovon and Autodin Systems (that's Automatic Voice Network and Automatic Digital Network Systems) for the Office, in those days, of Emergency Planning. We have developed a cost effectiveness resource allocation model for the State Department to determine whether Foreign Aid would be more beneficial to a certain country by sending 400 tons of carrots or 300 dancing maidens, or the like, and they can weigh these back and forth.

We also do industrial consulting in the area of management information systems and investment. We have recently gotten into the area of personnel research. The utilization of resource allocation models and the like have found to be applicable in the area of career motivation studies and we just recently completed a program for the Department of the Army on the Motivation of Junior Army Officers, and are developing programs for the same types of motivation studies for nurses and airline stewardessess.

We have done work in communications on simulation or message processing and developed the so-called MACS or Modern Army Communication System.

We work in educational research. We have had programs to evaluate Pennsylvania Title III Programs, under the Elementary and Secondary Education Act. We are working on the evaluation of the Philadelphia Title I Program and we currently operate a child study center in our research building which is part of the Get-Set Program. It's interesting to note that the financing for the child study center came from a so-called Benner Fund which was donated by a philantropist in the city of Philadelphia, half of it went to the Franklin Institute for the betterment of mankind and the other half went to the lion house at the zoo.

We have dabbled in football play prediction studies and even discussed the possibility of a management information system for Playboy, Inc. However, they told us they always pay with cash, so there's no problem. Again briefly we have mathematicians, statisticians, sociologists, economists, engineers, one meteorologist, and one lawyer.

Joint Meeting of Government
Operations Research Users and Producers

Dr. H. E. Smith
George Washington University, Washington, D. C.

We are a member of the faculty of the School of Engineering at George Washington University and we are in the Engineering Administration Program, Engineering Administration and Operations Research.

I want to speak first about our educational programs and then on our research interests and activities, all rather briefly.

The Engineering Administration Program began at George Washington some 16 years ago and was aimed then at providing information, knowledge of management, proficiency in the exerci e of management action f rmulas for those who are engineers and scientists. It's developed over these years since we only admit people who hold degrees in physical science, mathematics or engineering. It is exclusively a graduate program. We have developed an operations research program leading ultimately to the Master of Science Degree and Doctor of Science Degree we offer only Masters and Doctors degrees, therefore. The program has had two thrusts from the beginning. They have been the following: First, an analytical and problem solving orientation, and second, a quantitative orientation. The late Glen Camp was the individual who started operations research at George Washington in our school.

We also engage in a program of continuing education which the School operates. We participate in it. It does involve statistics, mathematical methods for operations research, mathematical methods for systems analysis, and operations research, as well as some discrete management areas. We have upon occasion in the past conducted special courses for commercial activities, industrial activities, and government activities in the field of operations research.

Now to come to our research interests. We have been engaged for some time in application of engineering and operations research to the medical area. This not only includes the electronic instrumentation control devices and so on, but the analytical approaches to the treatment and the physical rehabilitation of patients. This is an ongoing activity. It is expanding sometimes beyond our expectations.

We also engage in a program of policy studies in science and technology, which the University operates under an institutional grant from NASA. This has been a program that has been ongoing for some years. The School of Engineering and its faculty provide the technical input. For example, we are now toying with a problem which might be stated as follows: the optimal design of truck carriers and their effect on highway design, safety and noise.

We have had a variety of these activities going on and in order to give it some structure as distinguished from the educational programs, which programs have been going on for some time, we have organized an Institute of Management Science and Engineering to take over these research interests and research activities, and to operate them with our faculty and with research associates, research professors and so forth.

Also, at the University for almost sixteen years, the University has given sponsorship to the Logistics Research Project which as carried on essentially for the United States Navy. Both the Navy and the University desired to restructure this activity, to reorganize it, to broaden its outlook. Therefore, it will be incorporated within the Instutute which will give us additional capabilities, for example, in inventory, in mathematical programming and in heuristic programming.

The Institute therefore is designed to undertake and does undertake activity in Management Science and Systems Analysis. We do conduct seminars. We have just finished one in Systems Analysis. So we have these ongoing activities, we have these capabilities should you desire to inquire into them further. We are a local University and we will be happy to maintain a dialogue.

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Professor Lynwood A. Johnson
Georgia Institute of Technology, Atlanta, Georgia

First, I would like to tell you a little bit about how Georgia Tech views operations research and how we treat it, and then I would like to discuss some of the projects that we are involved in, that are related to the development or application of operations research methodology.

Georgia Tech is a unit of the University System of Georgia, and it is in Atlanta. It is a specialized institution having degree programs only in science, engineering, management, and architecture. It has about 500 faculty and 8000 students, of which about 1500 are graduate students. An unusual feature for the student body of a state institution, I suppose, is that about 50 percent of the students are from states other than Georgia.

The operations research responsibility lies principally within the School of Industrial and Systems Engineering. That is, the academic programs and the majority of the research that can be labeled operations research are in this school. However, there are also operations research interests and capabilities in the Schools of Information Science, Applied Mathematics, Industrial Management, and Civil Engineering. In many instances the operations research projects are carried out by individuals from several schools.

I represent the School of Industrial and Systems Engineering, which has about 700 students. About 125 of these are graduate students, with approximately 30 pursuing the Ph.D. Virtually all students seeking the Ph.D. are majoring in operations research. We have about 31 full-time faculty at the rank of assistant professor or higher, plus several instructors and lecturers, which bring the total faculty to about 40. There are 25 Ph.D.'s, with about 17 of these having majors in either operations research or fields closely related to operations research.

I will not dwell on the academic programs other than to say that the undergraduate programs in Industrial Engineering are oriented toward operations research in that the student is given a good introduction to operations research methodology and that systems design courses require him to make use of this theory.

Also, we administer an interdisciplinary Systems Engineering Program, which tries to cut across all of the engineering fields. It is not degree-granting, but it is an elective option for all undergraduates.

In the graduate program, the emphasis again is on operations research. We offer the usual graduate level courses which others have talked about, I think. We also offer courses in systems science and systems analysis. We are trying to build a strong capability in that area.

All of our graduate students must write a thesis. By requiring everyone to do a research project, we are trying to stimulate research. We do encourage applied operations research in a variety of environments as a way of satisfying this graduate research requirement.

We have a number of people from the military services, who pursue graduate programs at Tech. Recently Georgia Tech was selected by the U. S. Army for concentrated use in meeting their educational objectives in operations research, and currently we have several officers under this graduate program, with a sizeable increase scheduled for next year.

Our research and projects fall into the usual two categories. We are either doing research on operations research methodology or else doing research on some problem that, hopefully, would be of interest to someone. Areas of methodological research include the following: optimization -- nonlinear and integer programming; network theory; statistical decision theory; forecasting; sequential decision processes; systematic sampling; inventory

theory; project management; organization analysis; methods for project selection; scheduling; and several other areas that would more or less run the range of operations research techniques and methods.

The applied research projects include some that are initiated by sponsors and others that are done only because of the interest of the student or the faculty. We are engaged in a large systems analysis project for 18 paper manufacturers. We are studying the long range effects of technological, social and economic changes on the harvesting and transportation of pulpwood.

We have a very active program in hospital and medical systems. A current project is the study and the design of systems for a new hospital at the Medical College of Georgia. This hospital will have to meet both educational and the usual hospital service objectives, and there are complex problems in designing the physical facilities, as well as the various soft systems. We are supplying the systems analysis capability for the hospital design.

We also have been concerned with supplies inventory policy, hospital staffing policies, forecasting of health care needs in the community, and problems of value measurement in medical and health care decisions. These are activities that have been carried out under grants and projects in the hospital and medical systems area.

In the area of water resource management, we have worked with people in the School of Civil Engineering in the use of operations research methodology in developing policies for the control of stream pollution. We have conducted research on the interactive effects of the various users of water resources -- recreation, industrial, drinking, etc.

Other projects include, systems analysis of solid waste disposal management policies, using industrial dynamics as a tool for systems analysis; network models of transportation systems; long-range investment policies for an airline, essentially the capacity acquisition problem of when to buy planes, and how many; capital budgeting systems for an aerospace firm; maintain-ability models to assist in establishing specifications for equipment; expansion policies for a multiplant manufacturer -- these plants are geographically dispersed, the market is changing, where do we put the capacity.

Then there are a number of other non-sponsored types of research which have related more or less to the industrial environment; problems in material management, in quality control, in forecasting, and in facilities design. Research has involved use of operations research methodologies to develop useful tools for solving these classes of problems.

A number of these have been written in military operations research, because of the presence of many officers pursuing their degree programs here.

Since we are not a university, we do have to draw from time to time on the skills of people in disciplines not represented at Georgia Tech. We may go to the University of Georgia or to the Medical College, or to the local industry or local hospitals, and we do have cooperative projects.

I suppose I could summarize our interest in operations research as (1) we would like to educate people who are competent to do significant operations research work, and (2) we would like to contribute to the development of operations research methodology. One way to accomplish these objectives, we think, is to apply operations research in the analysis of various systems problems -- either systems design or just systems analysis, if we are not doing the synthesis. We are interested in all environments: industrial, urban, hospital, military, etc. We seek projects so that we can utilize students, obviously. We want to support them. Projects have educational value and these students, in general, are interested in doing something that they can find meaningful. We would also like to give the faculty opportunities to develop their areas of specialization, and we would like to contribute to the solution of meaningful problems. I think our approach to operations research has more of an engineering orientation than, say, a mathematical one. Naturally, we are not interested in getting involved in the details of an implementation or doing the implementation ourselves -- we are not a consulting service; but we are concerned with looking at a problem and solving it.

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Dr. Daniel Spencer
Howard University, Washington, D. C.

I am in the position to speak only for the Department of Economics at Howard University. Obviously, the University has other Departments with whom, of course, we have close ties and these Departments have research capabilities, and I should be very happy to put anyone in touch with the right personnel in these other Departments. I might mention some of these Departments, such as Business Administration, or Government, or the School of Engineering, or Sociology, or our Small Business Guidance and Development Center, and some others.

But speaking for my own Department, I would like to say that we are interested in offering services and training as well as some research and consulting activities on the part of our faculty and associated with our graduate students.

We have had some training operations in the Department previously. We have been associated with the Carnegie Institution in Washington, done work for the Peace Corps, held summer training for foreign students in the United States funded by AID, and then on the research side we have had contracts with various government agencies including Office of Economic Opportunity, the Agency for International Development, and United States Air Force Office of Scientific Research.

Now, our interests - we are interested in a contract for training or anything in urban economics, or research contracts or consulting work in econometrics modeling, cost benefit analysis, systems analysis problems.

I would like to read the statement that we have made that we intend to circulate as a summary sheet, but I would first like to mention to the government agency representatives that we have the benefit of being reasonably handy here in town, and also we have quite a few graduates and alumni too, who can provide expertize in certain special fields. The statement of our Department is as follows:

The Department of Economics, Howard University, provides quantitative training opportunities in its formal curriculum as follows: The Department offers an undergraduate major in economics and graduate study toward an M.A. degree with emphasis on quantitative economics. We also offer Economic Theory Courses and other work for a year beyond the Master's level. Our courses regularly offered include:

Econometrics I	Linear Programming and Operations Research I
Econometrics II	Linear Programming and Operations Research II
Quantitative Economics I	Mathematical Economics
Quantitative Economics II	

Two years of Economic Statistics Courses

In addition we have an extensive Urban Economic Program, especially a new course we are offering entitled, "Urban Economics Modeling and Simulation" which will be offered by the distinguished Econometrician, Frank de Leeuw.

Also the Department is prepared to set up a special training program during summer sessions and in the regular session tailored to the special needs of government agencies. Of course, we would need some advanced planning to obtain clearances and necessary room space, but we have had experience in this and we can do it again.

The Department's faculty is also interested in offering its services for research projects or consulting opportunities, especially involving our capabilities in econometric model analysis, sampling, and resource allocation problems.

The faculty resources include a full-time econometrician, a mathematical statistician, an emeritus statistician, and a considerable number of part-time faculty who are working and teaching with us, as well as juniors teaching statistics and quantitative courses. We also have promising Graduate Students who are available for work on projects.

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Dr. Stephen D. Slingsby
Ohio State University, Columbus, Ohio

First of all, I'm not speaking for the facilities at Ohio State University in total. It's a 50-thousand student University; with approximately 43 thousand of those students located on the main campus in Columbus. There are numerous programs and institutions but I shall be speaking of only one in particular.

I am director of a Politicometrics Research Program which lies within the newly established College of Administrative Science. The latter combines the formerly separate entities of Business Administration, Public Administration, and Social Welfare. As the representatives from Carnegie-Mellon and Northwestern mentioned, there is an entirely new orientation in the study of public administration. This new perspective is a shift from the traditional description of process to the employment of deterministic and stochastic methods by which the processes can be analyzed and modeled. This same change is taking place at numerous other institutions including OSU and the University of Michigan.

In Politicometrics we have a strong methodological concern for the problems in inter-relating operations research and political behavior. The transferability of the former's methods to the arena of the latter will necessitate numerous modifications in design and possibly the development of totally new approaches.

Very basically, politicometrics is the science of measuring political behavior. Particular to that is a very broad operational goal. That is (and it is similar to the goal of political philosophers since Day 1) to facilitate social and political change while maintaining order. Politicometrics hopefully will facilitate change short of massive violence in our society. The occurence of the latter produces such strong counter forces that it has severe constrain on the direction and pace of social change. This process then recycles and has a snowballing effect. This results in greater and greater differences between those desirous of particular changes and those adverse to such.

It is these conflicts over Viet Nam, black militancy, draft resistance and their alignment with cleavages that necessitated, for instance, the Johnson step-down in 1968. Such a significant event - taking away the symbols of contention of LBJ and the Democratic party - was needed to affect sufficient harmony. An initial period of harmony exists simply as a result of the change (the spirit of giving the new man a chance) the honeymoon as we know it, in political office. Harmony of a longer range depends on the manipulation, by design or by accident, of the divisions in the society. In the pluralist language the politicometrician can aid in maintaining order by monitoring cleavages -- social, political, economic, ethnic, and religious -- and conflicts - issue and partisan - and preventing their alignments. Finally, in its most general form, politicometrics is concerned with model construction, for the administrator and the politician, to enable him to better monitor his environment.

One of the key attributes of politicometrics modeling is the assistance provided in the discrimination and interpretation of feedback -- that is, such models better enable the politician and administrator to determine the real needs from the articulated demands. This is a requisite function of representation as I see it, and can be interpreted as a mandate for initiating public policy that may be out of tune with current public sentiment. The much discussed persuasive powers of a national leader are relevant here. In times of crisis, the politicians and administrators, per their representative functions, need to rely on a more objective basis for this differentation than their "feel" for the situation. If they were not sensitive to the precipitation of the particular crisis, they hardly could have much trust in their sensitivity to determine the real cause or causes and means of alleviation.

There are two organizational entities I am speaking to and for, and that's the Politicometrics Research Program and the Politicometrics Corporation.

The Research Program is, as the title notes, concerned with basic research - the Politicometrics Corporation is concerned with applied research and implementation.

In addition to research, the Politicometrics Program purposes are:

(1) to provide definition for this emerging field of study and research,

(2) to serve as an organizational entity by which

(a) those currently conducting research of a politicometrics nature may use the organization as a focal point of communication, and

(b) those initiating such research can be facilitated in the exchange of ideas with those currently engaged in this type of research.

(3) As a vehicle to provide the opportunity for those in more quantitative areas of a particular field to interact with those of a more behavioral orientation. Also to allow those with a narrower scope of interest and not as fully oriented towards human activity systems (i.e., industrial engineering) to interact with those who more strictly concern themselves with defining behavior in such systems (i.e., political science and social psychology).

(4) Sponsoring a Symposium by which papers may be presented reporting on research efforts and results in the general area of politicometrics, and

(5) to communicate to those in government and industry, the prime users of such models, the extent and applicability of the research.

Significantly, the Program's purpose is to initiate and conduct basic research to develop methodologies appropriate for the measurement of political behavior as described in this presentation. This necessitates the development of new uses of 19th and 20th century mathematics and the possible development of new mathematical forms that will provide logics more consistent with the transformations in political behavior.

Graduate seminars are going to be offered in this subject with students from Industrial Engineering, Political Science, Mathematics, and Public Administration this fall and spring at Ohio State University.

Both the teaching and research in politicometrics can be divided in terms of scope and application. I'll1 outline four categories: micro and macro; basic and applied. Macro-politicometrics is the modeling of a political entity, a broad diversity of processes and structures and the gathering and employment of the information describing each. This is similar to the operational simulation models in econometrics, but here the orientation is towards operational simulation models of political systems.

Micro-politicometrics usually concerns s single program (although it may be a function of more than one department or agency of a governmental entity) of government. The purpose of modeling such a system is to determine measures of effectiveness. National crime prevention, local agency for the Development of Human Reseources, etc., are examples.

Essentially the macro-level is concerned with development models that will allow the simulation of political behavior in the nation, state, municipal, or community levels, and micro are designed to assist with the development of control and planning criteria for public administrators and politicians responsible for a particular functional area.

Basic and applied research. Basic research is essentially the innovation of methodologies and logics appropriate to the modeling of political behavior. A number of heuristic models of political systems were developed in the late 1950's and early 60's, such as the Almond and Coleman models and the Easton models. Generally the evolution has been from heuristic-purposes models to analytical-purpose models; not yet do we have operational-purpose models. This latter development is mostly a two-way street which necessitates the continued liaison of the people in front-line activity (those in administrative positions) and those in the academic sphere concerned with a theoretical orientation. Because of that, we are like some of the other institutions you have heard about today, actively engaged in the initiation and operation of programs for public administrators. Such programs include seminars in which there are both graduate students and public administrators to interact in the construction of operational models.

Joint Meeting of Government
Operations Research Users and Producers

Boyd Z. Palmer
University of Pennsylvania, Philadelphia, Pennsylvania

As you probably know, a large part of the Operations Research group that began at Case Institute of Technology moved from that University into the University of Pennsylvania and the nucleus of that group is still there. Professor Ackoff is one of those, and several others who ere ori inally at Case are still at Penn.

We have at Penn a Management Science Center that is primarily doing work for industry on a contract basis. We also have the Moore School of Electrical Engineering which is developing a Systems Engineering course in conjunction with Operations Research, and they are now trying to change the Ph.D. program so that a person can work on a project in Urban Systems and get a degree in Systems Engineering without being an electrical engineer. This has been a problem before.

Within the Wharton School of the University of Pennsylvania there is the Department of Operations Research and Statistics. I don't know how many students are there or what the thesis subjects are, although I know one thesis is dealing with library effectiveness, and a lot of the interest in social systems has centered on education, working with the city of Philadelphia. Another part of the Wharton School is the Fels Institute of Local and State Government, and as a part of that is a section called the Government Studies Center and inside of that is a Systems Division and that's where I am located.

We are a non-profit institute doing contract research. We now have several projects which we are working on, including designing a simulation model for the personal health care system in the Philadelphia Metropolitan Region. This will be used in conjunction with the long range planning procedures for the Philadelphia Department of Public Health. We are also serving as consultants to the city of Philadelphia in their effort to develop a Planning-Programming-Budgeting system. We have another large project in PPB, working with pilot school districts within the state of Pennsylvania. This is in the third year now of a three-year project. We have a PPB system already going in these pilot districts and we're trying to work out a way with the state of Pennsylvania to implement this in all school districts in the state. I think the prospects are good.

In connection with that, we are having a one-week workshop in the first week of August which will go through the procedures that have been worked out, including the computation of about 10 or 12 indicators which are being used by administrators to tell whether or not the programs are doing what they want them to.

We are working on developing a complete PPB structure for municipalities - not just for education but covering the whole service area. This has led to an intense interest in the use of systems analysis in cities.

We are very practically oriented; we want to get into something that can be used. Therefore, we have a time limit to our contracts and say we will deliver something by that time. Now this runs into problems when you get into research of the university type because a lot of research is open-ended and you simply cannot promise delivery by a certain time. So we try to get two parts going. One is, we contract for something we know we can deliver; at the same time we try to get interests stirred up among the students to go into a real research effort to show what we should have done if we had had the techniques and the data. This has, I think, real possibilities, but at the same time we are trying to serve as a bridge between the up-in-the-air type of research done by the universities in general and the actual applications such as within the city of Philadelphia where, when you try to present a different kind of an index, they start saying, "This is too sophisticated, we cannot use it because we haven't had it before."

We are also working on the design of a solid waste management system, designed around the Delaware Valley Region. We are working on a library resources and requirements study, again with the city of Philadelphia's school system.

A couple of other major interests are based on attempts to get technology designed and developed to be useable by cities. The technology that has been developed by the space program has generally not been applicable to cities, and so the idea is to try to find out from cities what they need in the way of new technology, develop financing mechanisms and foundation support to get people to design these things, and then develop and package them so they can be used.

We've tried to concentrate on the interdisciplinary approach. Our emphasis is to try to get a project using several of the resources of the university on that project. You keep a small core staff and then go out and bring in those pieces where they can be most useful. This is not easy because you still have vested interests within the university much as you do in government; but I think it is possible, and we are going to continue to pursue this approach. I think it is much cheaper to do it that way than to build up within one staff all possible capabilities. If you are large enough, this may be a better way, but Fels Institute is small and will be changing over later on. We're getting a new director who is much more interested in what he calls public policy analysis, analyzing policy more from the national point of view. He will be developing a joint Ph.D. program with the Department of Community Medicine, for example, within the hospital of the University of Pennsylvania, and with other areas.

I didn't realize I was the only representative of the University of Pennsylvania, and I feel that the resources that the University has are such that it should not be left out of the inventory that you are getting here.

Let me close with one of my own feelings about the use of operations research in government. Fels Institute had a symposium two years ago at which C. West Churchman gave a talk, and he said that he thought it was a fine idea to bring scientists into the political situation, primarily because it would educate scientists about politics. I feel the same way.

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Victor C. Searle
Department of Health, Education and Welfare
Consumer Protection and Environmental Health Service
Washington, D. C.

In common with many of the governmental acronyms, CPEHS is a relatively new and long title. Spelled out, it is Consumer Protection and Environmental Health Service of the Public Health Service.

This group was organized in July 1968 and represents a combination of the Food and Drug Administration, the National Air Pollution Control Administration, and the Environmental Control Administration, headed by an Office of the Administrator. I am from the Office of the Assistant Administrator for Research and Development.

Our mission is to provide leadership and direction to programs and activities designed to assure effective protection for every American against hazards to health in his environment, and in the products and services which enter his life. Of course, it is in this context that our interests and requirements in Operations Research fall.

I have mentioned the three component Administrations. Granting that we are not yet a year old, you will recognize that many things have not jelled, but we are incorporating various operations research techniques and tools into our R&D program management practices and will continue to do so. Management information analysis, storage and retrieval capabilities are a primary concern, both for scientific research and control program management. Our final information capability will be a highly integrated, computerized network, supplemented by the traditional publications and library information systems, and this system will be implemented contractually.

As we go farther, we anticipate the use of mathematical modeling for the analysis of the ecological impact of environmental stressors - and stressors are sort of a jargon that we have adopted as a general term. You think of pollutants, air pollutants, water pollutants, etc., but such other things which put stress on the human, such as noise, radiation, etc., we class under the generic term of stressors. As I say, we anticipate the use of mathematical modeling for analysis of the ecological impact of these environmental stressors, and utilization of the entire CPE resources to maintain or to gain desirable degrees of stressor control. This will be applied as our operations research tool becomes more refined.

Involved also is the Planning, Programming, Budgeting System with its desirable management features, and it is used by CPEHS to assess the total systems concept to the full scope of environmental health, human ecology, and consumer products. Our sub-systems in this area are designed to enable management to guide, direct, and manage our research and development program, and evaluate its performance.

Currently, we have two projects under way with operations research implications. The first is the research and development and program assistance system supported by a scientific, technical, intelligence and program information storage and retrieval system. The Project Officer on that is Dr. R. B. Medz. The second project is the development of a useful, within our area, research and development classification system. Mr. J. L. S. Hickey is the Project Officer on that. Both are on the same telephone number, which is 301 962-7361. As I mentioned before, we are relatively new and thus these are the only projects that are in immediate prospect.

There are some operations research projects within the constituent Administrations. I do not have any details about them, but I know that air pollution in particular has had some ongoing. Let's face it, we have not at this point been able to pull them together -- this is one of the purposes of our system, to locate the others and see how they can be tied together. We do find, for instance, a considerable overlap in the information storage and retrieval, and we are hoping then to define the scopes of the several activities and

make them mutually supporting rather than duplicating. A good example is the matter of occupational health and effective air pollutants. You talk in terms of inside, outside, and each group sees the need for material in the other area, but if each is solid in its own area and can support the other, we feel we can get a great deal more efficiency.

To answer your questions, yes, we are interested in contracts; we anticipate contractual implementation. As a matter of fact there is a request for proposal out with the proposals due in a short time for the initial implementation, or the initial study of this proposed system of integrating our information activities and starting the development of these environmental stressor matrixes. I think there were some 72 people who, based on the Commerce Business Daily, came for request for proposals. That's the first point, and it would be anticipated with the limited staff we have, and you know as well as I do the limitations on hiring more people in the government, that this will tend to continue.

The second point was grants vs. contracts. To the best of my knowledge, and this is a subject which is under very considerable discussion throughout the Public Health Service, grants, so far as least, are all handled through the separate Administrations. They also award contracts. As of now, the Office in which I find myself, the Office of Research and Development at the CPEHS Headquarters, has only been concerned, or has only utilized contracts.

The third point is that unsolicited proposals, certainly, are always welcome and considered. They do not necessarily result in a sole source procurement but they certainly would be welcome.

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Dr. William Dorfman
Department of Health, Education, and Welfare
National Center for Educational Statistics
Washington, D. C.

I'm speaking here rather informally on some areas of interest to the National Center for Educational Statistics. I shall not discuss the program evaluation efforts of the Office of Education, except to say that these are the responsibility of the Assistant Secretary for Planning and Evaluation in HEW, the Office of Education's Office of Program Planning and Evaluation, and the various planning and evaluation staffs of the Bureaus which administer grants-in-aid.

The mission of the National Center for Educational Statistics is to describe the condition and progress of American education. It publishes 40 or 50 annual reports on various sectors of education in addition to a number of special reports and technical notes. For the most part our output has been descriptive in nature, but there has been a substantial analytical effort. For example, I can mention projections of pupils, teachers and expenditures, research on cost/benefit methodology for evaluating compensatory programs for the disadvantaged, and the development of a computerized pupil-teacher flow model. Some of our most extensive statistical analysis has searched data from the Equality of Educational Opportunity Survey (that's the "Coleman Study") to determine the extent to which educational achievement is a function of characteristics of pupil, teacher, school and community. Acting in a leadership capacity, the National Center for Educational Statistics held a symposium on Operations Analysis of Education in November 1967, where 1100 participants listened to 41 papers. The Proceedings appeared a few weeks ago as a special issue of the Journal of Socio-Economic Planning Sciences.

Now the Center is in transition, and is no longer using the concept, Operations Analysis, to characterize some of its analytical efforts. However, we are considering work in some areas that would be exciting to some of you. We are interested in improving the accuracy of our projections series. We are interested in the design of social indicators for education. We are interested in the value of information as a function of the importance of the decision maker and the significance of the decision. We are interested in measuring the quality education and determining the value added by the educational process. In particular, our attention is concentrated on developing two new projects.

First of all, we wish to identify output measures for various sectors of the American educational system, i.e., elementary, secondary, higher education, vocational, adult, etc. These output measures may vary depending on whether they are aggregated at the school, school district, or national program level. At the national level, the National Assessment Program of Educational Progress is being financed by the Office of Education and should yield indicators of system outputs. The National Assessment Program requires extensive testing and is limited in scope. The question arises, can we determine outputs indirectly without actually testing students? As you know, the final output of education consists of changes in the pictures in the heads of students or changes in their behavior, which can only be measured imperfectly at great expense. This problem also exists for the physical scientists who do not measure directly temperature, gravity or the strength of a magnetic field, but take pointer readings which are correlated with the magnitude of the phenomenon of interest. Certainly the institutional measure of performance in education now used such as cost per student and pupil teacher ratio are essentially measures of input and not of output. Similarly the numbers of graduates going on to college or graduate school may only reflect the quality of the students who entered the system rather than the performance of the system. There is a strong need to fill this gap in our knowledge.

A second area of concern to us is the feasibility of developing measures of rele ance of education for the current and future life styles of students. One of the first tasks is to define relevance, since it is being used in so many different ways. In general, we need to know how well curriculum and instructional materials are adapted to the life

experiences of students. One of the problems in such a study is the possibility that subject matter which is relevant to present life styles may not be relevant to future life styles. For example, country boys who are trained in agricultural vocational programs may not find this training quite so useful on moving to the city.

Now there is no certainty that we will fund these projects, which are at an early stage of problem definition. But I am certain that there will be incresed analysis in depth at NCES, some of which may be appropriately labeled operations research.

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Dr. W. Jay Merrill
Department of Justice, Washington, D. C.

I am with the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration.

It might be interesting to have a few words on the history of this organization. The Omnibus Crime Control and Safe Streets Act of 1968 created the LEAA (Law Enforcement Assistance Administration) and this was basically a follow-on to the OLEA (Office of Law Enforcement Assistance), which sprang from the Presidential Crime Commission of several years back. The OLEA has, over the past few years, granted considerable sums of money, at least from the point of view of non-defense agencies, to universities, non-profit organizations, city governments, state governments, local police agencies, and so forth, in order to try to get the full effort against crime control underway. In the latter part of 1968 this effort was formalized in the Law Enforcement Assistance Administration.

The LEAA has two major sub-groups, one of which is OLEP (Office of Law Enforcement Programs) which gives grants to states on the basis of their comprehensive state plans to fight crime. To receive this money the states need only to send in a plan. I mention this particularly now bec use very often these state and local governments need a good deal of technical assistance in the areas of operations research, general scientific and engineering support for their plans; and will probably need this for several years into the future. Obviously some states, the bigger ones like California for example, have submitted voluminous state plans and have had the aerospace and "think tank" industries working on it with them. So that might not be a very fruitful route. Many of the other states, and perhaps expecially ones that aren't as advanced economically as California and New York, would be very interested to hear from you. We do have a little booklet at the office which is at 633 Indiana Avenue, NW, Washington, D. C. 20530, which gives the State Planning Director who is the contact for each state in the OLEP program. The booklet is available on request.

The Institute as a whole is charged with the research and development activities in the fight on crime, and these are very broadly gauged. We are interested in looking at the criminal as a person and so we have psychologists and juvenile delinquency experts on the staff. We are interested in the social milieu in which crime develops and operates so we also have sociologists. We are interested in the economic aspects of crime. There is a good deal of feeling in the Institute that much crime is really a rational economic game which the criminal is playing with society, and therefore by looking into this aspect of it we will have a weapon which we can use on our side of this rational game.

The Centers which make up the National Institute are the Prevention and Rehabilitation Center. This is primarily concerned with the individual criminal and with the corrections activities -- the prisons, detention homes, probation activity, and parole.

The Operations and Management Center is concerned with operations research and systems analysis techniques which have a bearing on the general effort against crime. This, of course, would include PPB, management information and control systems, simulation models, mathematical models, and operations research techniques which might be adapted from other sources such as business and the military to aid police activities and overall strategies. So we have the broad approach of the scientific and management systems attack on the crime problem.

We have another Center which is the Law and Justice Center where we hope to go into the question of what our laws are all about, what should they be, and what role can they play in setting up the social and legal environment which can have an impact on the fight on crime.

The vocabulary of this area is probably new to many individuals who have been working in OR elsewhere, so it might be helpful to indicate what we mean by a few of the words

that are widely used in this area. Law enforcement usually refers to the police activity. It doesn't refer only to the local force; it can also be sheriffs, state troopers, and investigators. The Criminal Justice agencies refer to the courts, prosecutor offices, the prisons, and other corrections' institutions. So, when we talk about a criminal justice system or modeling a criminal justice system, we are starting from the actual arrest and following the individuals from the arest point through the court system (bail, the trial, conviction or release) and into the corrections activities.

The way that we have been operating up to this point, as far as grants and contracts are concerned, has been to follow the lead of OLEA in which grants were given. We are still doing that to a large extent because we do not yet have a planned program, nor the personnel to write requests for proposals for contract activity. We hope to remedy this situation in early FY 1970.

We are very much interested in talking to individuals and groups with ideas which they think would behelpful to our program. It would be advisable, I think, to come and talk to us before going to the trouble of putting a proposal together, unsolicited or otherwise, and sending it in. If we could have from those of you who are interested just a brief statement of your idea, we can get together and see how it fits in with the other activities being considered for our program, and perhaps we can reach an agreement to submit a formal grant application or, as will be done in the future, put out a request for proposal. It will probably be unusual to get a sole source contract, although if you are the unique purveyor of something which we need, that, too, will be possible.

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Dr. Vernon C. McKee
Department of Agriculture, Washington, D. C.

I do not have adequate information to speak authoritatively about the Department of Agriculture's total needs and activities in the Operations Research field. Many agencies in the Department are using Operations Research techniques, and I will mention some of the agencies and ongoing activities.

I am with the Planning, Evaluation and Programming Staff, Office of the Secretary. This staff makes analyses and evaluations of program effectiveness and accomplishments and provides information for major decision-making to the Secretary, relating to the long-range planning of the Department's programs and objectives. The program decisions made by the Secretary are then transformed into 5-year program financial plans that provide the basis for the Department's budget request. The use of operations research, systems analysis, and related techniques is an integral part of our staff functions. These activities are essential elements of the Planning-Programming-Budgeting System previously discussed by Jack Carlson, Bureau of the Budget.

The types of program evaluations and evaluations and analyses range from short-term (one month or less) on specific issues to long-term, in depth studies on broad program issues. An example of the short-term type of analysis is one we made in October 1968 on the loan programs for rural housing and water and waste disposal systems for rural communities. The Bureau of the Budget wanted us to make an evaluation of our proposed program level in terms of the impact on U. S. economy. They wanted answers (within one to two weeks) to questions such as what would be the requirement for materials labor and capital; what would be the effect on prices and GNP.

Time did not allow for collection and development of data necessary for an input-output analysis. We had to use the "best available" at the time. We used the construction activity from the 82 sector, 1958 input-output study, adjusting the estimated coefficients for price changes from 1958 to 1966. The Council of Economic Advisors provided us with estimates for multiplier effects. We did have access to a computer in our office, and we were able to come out with a study in two weeks showing the dollar requirements of our proposed programs for each of the 82 sectors. This study might not meet academic requirements for a master's thesis or a doctoral dissertation, but it did provide some useful information to the Bureau of the Budget for decision-making. The most significant impact was the housing program, including the housing program of the Department of Housing and Urban Development, on the lumber sector. The final demand for lumber as projected for the housing program would cause a significant increase in the price of lumber. This in turn had implications for increasing the timber supply on national Forests manages by the Forest Service.

An example of a long-term study that we are working on right now is simulation models to provide more and better information for policy decisions on the farm commodity programs, starting with the wheat program. Each time the Department has to make program decisions for the coming year, the policy makers ask several questions relating to setting the allotment acreage another million acres higher or a million acres lower. What would this mean in terms of farm income? What would this mean in terms of production? What would it mean in terms of wheat export? What would it mean in terms of cost for the Commodity Credit Corporation operations? They want to know this for many different alternatives. Answers to these questions require numerous calculations, some simple arithmetic and accounting calculations and some complex functional relationships. The time required to do this with a desk calculator prevents looking at very many alternatives. This is a logical process for a simulation model, which will permit us to consider many alternatives and evaluate them in greater detail.

Now I do want to mention briefly a few projects currently underway in other agencies of the Department. The Economic Research Service is conducting a joint study with the

Office of Business Economics of interregional analysis and projections for the river basin planning activities. This program involves the use of linear programming, input-output and other methods of systems analysis in making projections of economic activity and needs for water resource development. Also in the Economic Research Service is a project to develop a national model of agricultural production. This project started about five years ago and they now have an operational model which they plan to update every year and make new analyses. This is an optimizing model using linear programming techniques.

The Forest Service has a staff group at Berkeley, California, working on a management model for the National Forest System. They are developing optimizing models using linear programming techniques, and testing three or four basic models. They are experimenting with them now to find the best feasible model to assist in managing the National Forests.

In summary, the Planning, Evaluation and Programming Staff does not have funds to make grants or contracts for research activities. We do work cooperatively with the other agencies of the Department in setting up study plans which may be done in-house or contracted. Inquiries can be directed to me or Boyd Alexander of the Planning, Evaluation and Programming Staff in the Office of the Secretary.

The action agencies of the Department would be more receptive to inquiries from other agencies and private firms for assistance in operations research and systems analysis. For those interested in activities for the other agencies, inquiries can be directed to the Administrator of that particular agency in Washington.

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Dr. W. E. Cushen
Technical Analysis Division
National Bureau of Standards
Washington, D. C. 20234

Now I have the pleasant responsibility of speaking for those government agencies who have not been represented here from the podium. In this regard, I come without portfolio, for I cannot speak officially on behalf of these which are based on the experiences TAD has had in communicating with and conducting projects for various agencies. I can offer my estimate of the potential market opportunities which these agencies offer the producers of operations research and systems analysis.

I think it is true of all the civilian agencies of government--those from who you have heard, as well as those not represented here--that if you, the producers of operations research, do good applicable work, your efforts will be rewarded by renewed contracts, continuing funding, and a faith in your ability to produce similar standards of quality in future ventures. What I am saying is that if you do a good job for a particular agency, you won't have much difficulty in obtaining support from that agency, even in future days of budget drought.

When you approach the spectrum of Federal agencies who might be interested in the kinds of work that you can offer, you should make a clear distinction in your minds between operating agencies with public programs and those agencies who are in the grant-giving business--for you will encounter very different desires and attitudes in each of these agency types. An operating agency, such as the Department of Commerce or the Department of the Interior, will exhibit attitudes and desires which differ greatly from those you will find in the National Science Foundation, the Office of Education, the Office of Naval Research, and other grant-giving agencies.

We have discovered that in your communications efforts with operating agencies, you will be fortunate indeed if you can attract more than a half hour of the time and attention of (as Jack Carlson says) any decision maker of consequence. On the very few occasions that we have been privileged to be exposed to that type of executive, we have ound such men remarkably knowledgeable as to the types of outputs that can be expected from the operations research profession. They know the difference between what they need and what they are likely to get. Decision makers in the upper, policy-making echelons of the operating agencies are concerned, not so much with the theory as with the relevance of results that operations research studies produce. Once the decision maker is satisfied that operations research and systems analysis do, in fact, yield results which are relevant to the decisions he has to make, then he will "have a soft spot in his heart," he will find the time--and have a great deal of inclination--to listen to those producers who have made that initial "good impression." As I said before, your productivity--your dedication to producing good, applicable results--will be rewarded.

You may encounter some difficulty in obtaining an audience with many Federal officials because of an apprehension that many bureaucrats feel--either consciously or subconsciously--when they hear such terms as "PPB," "OR," or "systems analysis." These men do not need to hear an enumeration of the capabilities of PPB, systems analysis, operations research. They realize the capabilities of these techniques. In fact, they may understand "all too well," in the sense that the results of your work may intrinsically hold forth dangerous implications. All too often, they have seen the subconsciously--be wary of the "services" you have to offer. Do not forget that you are working in a very political environment!

Now that I've alerted you to some of the perils and prejudices you may encounter when you first knock on agency doors, let's turn to the more promising side of the coin. Many of the agencies who have not been officially represented at our conference do need the services of the operations research and systems analysis professions, and they know it. They are quite willing to pay--and pay well--for the kinds of expertise you can bring to the solution of many critical problems. Very quickly, then, let me "fill you in" on the needs and desires of several government agencies.

First, let me give a brief estimate of the market potential you can expect to find in the Department of Housing and Urban Development. HUD's main thrust, from an OR point of view, appears to be in the Model Cities Program. There is much debate within the Department right now concerning the best way to evaluate and integrate the programs of the various cities involved, and, at some future time, our profession may be called upon to help in this evaluation effort. HUD is presently contemplating an RFP (Request for Proposal)--which will come out sooner or later--dealing with the large scale development of management information systems for cities.

Also, in this regard, the International City Management Association (ICMA, 1140 Connecticut Avenue, N. W., Washington, D. C.) is considering the establishment of a Technology Assessment Program for Cities. The ICMA plans to buy bits and pieces of applicable OR studies and then to redistribute this information to the member cities at a nominal cost.

If your capabilities are in the realm of solving urban problems, you should also go directly to the cities themselves. Many cities have received grants from HUD--in conjunction with the Model Cities Program. So, they have the funding capabilities to invest in operations research and systems analysis. And, city government officials are not unfamiliar with the services you have to offer. They do understand "nuts and bolts" projects, such as a fire station locator, and they are interested in attracting those of you who can do work relevant to their particular problems. The Model Cities "business" is likely to present an expanding future market for the producers of operations research and systems analysis.

In the realm of foreign policy, the Agency for International Development (AID) is probably your best potential source of assistance. If your capabilities and interests lie in this sphere, you should obtain copies of House Appropriations Subcommittee Hearings on the agency budget, to find out what the agency can and cannot buy. This is a good approach to understanding the financial situation of any agency in which you might be interested. In AID, for example, you may find that the "interest of the moment" centers on a particular country, like Nicaragua. The problem there might look something like this: There are x number of dollars which AID can contribute to improving the educational system in Nicaragua. Where should the money be spent in order to obtain the maximum return on dollars invested--i.e., should it be spent on text books, in faculties, in elementary schools, on adult education, on the university...?

The General Accounting Office and the Library of Congress are the foci for the legislative interest in operations research and systems analysis. They have just begun to make these techniques available to the Legislative Branch, but you can bet that GAO and the Library will be "where the action is" in a few years. Bob Chartrand is probably the appropriate person in the Library of Congress to whom you should address inquiries, and Keith Marvin in GAO. Thus far, the thrust of their work has been in computer-assisted print-outs of the status of various bills in the legislative process, and the evaluation of poverty programs.

Many congressmen have been working--on and below the surface--to make systematic analyses available to the Congress and to individual congressmen. Senator Gaylord Nelson has introduced a bill which would make $125 million available to the States for operations research studies. Keep an eye on the Legislative Branch, for,

as I said, this is where you'll find action--perhaps sooner than you think.

The National Institutes of Health (NIH) is an amalgam of grant-giving agencies, so, if you are interested in doing research in this subject area, NIH is a logical place for you to address inquiries. The problem which plagues administrators in NIH--as in almost all grant-giving agencies--is one of how best to allocate limited amounts of resources. Given that a large percent of their funding is easily allocated, where should the remaining small percent be spent--again, to maximize benefits. There have been in-house attempts to solve the problem. They have used linear and even dynamic programming techniques--but the coefficients have never seemed adequate for solving the problem. NIH needs your help, but they may be unable to believe that you can help them--because they have tried systems analysis, and been less than happy with the results.

The Social Security Administration has a fairly large OR group, some of which is distributed among their field operations. The Treasury Department carries out statistical research like discriminant analyses for the Internal Revenue Service and works on sampling procedures for the Customs Bureau.

The Department of the Interior is quite similar to the Department of Commerce, in that much of the work is carried on by line bureaus--e.g., the Bureau of Mines, the U. S. Geological Survey, Bureau of Sport and Commercial Fisheries, etc. You might find any one of these bureaus interested in obtaining your services. At the Secretarial level, the problem resembles that of any holding company: how to manage, coordinate, and integrate the work of all the individual components of the Department.

The National Science Foundation is another grant-giving agency. And, you who represent the universities may be interested in submitting proposals for funding of your research. In particular, you may be interested in questions of undergraduate science curriculum content, and in systems studies of an engineering nature.

NSF also has the in-house problem that we saw in the National Institutes of Health--i.e., how best to allocate limited amounts of resources. Administrators in NSF, however, have very little money--or time--available to devote to solving this type of problem.

The Department of Defense has not been represented here. We hope that they will be represented at our next conference, because Defense has made the bulk of the capital investment in operations research and systems analysis. It is quite conceivable that many of the approaches and techniques which DOD has used quite successfully for the last few years can be converted rather easily to serve the purposes of the Civilian agencies of government. There is no point in the civilian agencies' having to re-invent the wheel.

I must admit that, during the course of this Conference, I have been bothered by your frequent statements of "the industrial Problem." I question the seriousness of this problem as it has been stated. Certainly, on the part of the government agencies--those represented from the podium, those for whom I have been speaking unofficially, and those whom you have contacted on the floor--there is no intent to release proprietary information. As a matter of fact, this is punishable by law. So, when you talk to the agencies of government, you should not have to worry too much about any "risk" you may be taking in possibly "dumping" your competitive advantage.

Now, to the universities, when you approach the grant-giving agencies of government, please tell them what kinds of funding arrangements you can accept. Make your requests explicit. Must your funding be in the form of a grant? Are you interested in funding for graduate assistance, or are you looking for support for your faculties? Can you work in the summers?

Finally, if your interest in government is in terms of the job market we offer to professionals in operations research and systems analysis, let me show you Figure 1, which depicts the spread of GS ratings for O.R. analysts. GS ratings are given by a Board of professional OR people on the basis of education and experience. Notice that, since the beginning, the mean, median, and mode of the distribution has been a GS-14. The operations research analyst or systems analyst who enters government service as a GS-14 has a starting

salary now of $17,000 per year. The July pay raise will improve salary comparability.

On this note--a starting salary of eighteen and a half thousand dollars--I shall conclude my remarks.

GS RATINGS O.R.ANALYSTS

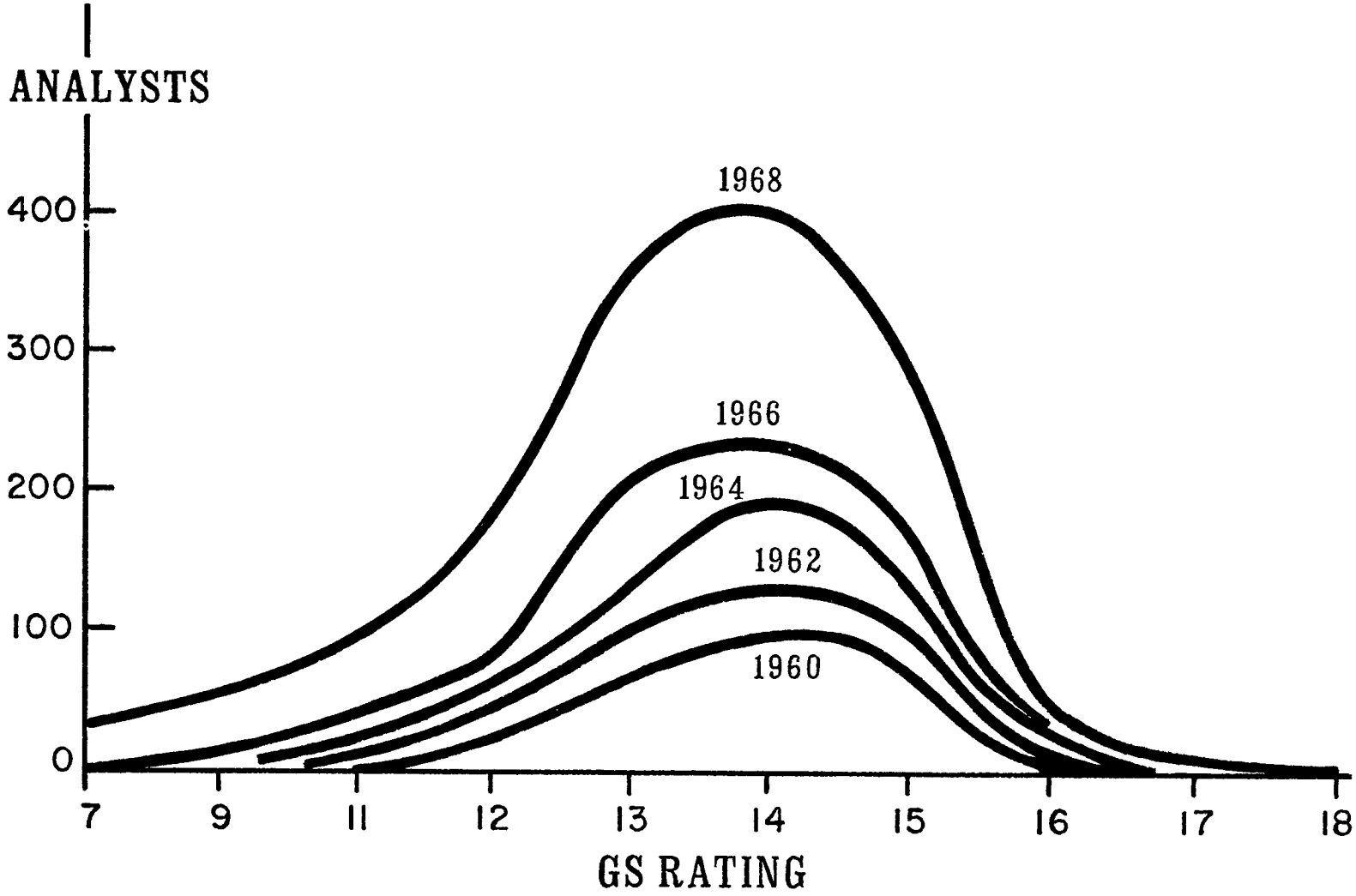

Figure 1.

Joint Meeting of Government
Operations Research Users and Producers

Dr. William G. Lesso
University of Texas, Austin, Texas

We, at the University of Texas, have operations research in two areas. Besides the Department of Mechanical Engineering, there is a sister group that exists in the College of Business Administration and between our two groups we feel that we have built up quite a bit of power in this area. In fact, prior to a couple of years ago, it was sort of like the Wastelands. Practically nothing in the area of operations research in that part of Texas. But since then we have had quite a few additions and we really have some super stars with us. Over in the Business School, we have Abe Charnes now and Fred Glover who is one of the leading experts in integer programming. We feel very fortunate because we have a mutual aid pact between us. We send our students over there for their courses and they send students over to us for ours. Within our own department, we number six or seven now. We are growing too and we are facing a population explosion as far as students go. Among our faculty we have Chuck Beightler who just won the Lancaster Prize with Doug Wilde for his book on Foundations of Optimization.

We in the Mechanical Engineering Department are one of five programs. We call ours Operations Research and Engineering Management. We are an out-growth of what was a more traditional industrial engineering effort and have since taken on more of the luster of operations research. We still do give degrees in Industrial Engineering and we even still teach courses more closely aligned with them.

We have a fairly large number of projects going on currently. I have left some of the sheets which you later will get in the proceedings out there and you will recognize it because it has our burnt-orange banner on it. We like to do things up big down there.

I would like to give you an idea of the research projects we do have going on right now and I am going to mainly stress the ones that I think are of interest to the government agencies. Oil is the big thing down in Texas and in conjunction with our Petroleum Engineering Department we have been doing some work in this area. One of our recent studies which we are going to publish very shortly, examines the economics of the crude prices increases as they affect the after tax earnings of oil companies. We found some very interesting results, and some almost peculiar things that happen because of depletion allowance. Also currently we are just finishing up a research effort involving the optimal number, size and location of off-shore drilling platforms. This is somewhat of a more commercial venture. We are doing this for a number of the oil companies but I think there are implications in here which are perhaps of interest. (We don't know quite how to put in a constraint to reflect the Santa Barbara Channel problem, though.)

Another one of our very recent programs which we have just finished is a project which was actually done by an Army Major going to school at the University. He had just come from the Electronic Command at Fort Monmouth and he did as part of his work a cost of ownership model on the next generation of teletype equipment. We have had an effort going in the area of cost effectiveness and related topics and this is our latest venture along these lines. We are mainly concerned with the economic time to replace equipment, repair it, when we should send it into overhaul and trying to project what the total life cycle costs were, to feed into a regular cost effectiveness model. This was really a sidelight to one of our more major stream of efforts involving studies in availability. I'm an old mechanical engineer and I became concerned with reliability when I worked for General Electric. Now we've since expanded our thoughts saying that it isn't just reliability we are concerned with but the trade-offs between reliability and maintainability. We've done some work in this area and have published some reports. Our most recent maintainability study has been concerned with deciding the optimal number of repairmen, operators in spare units for any sort of a system. Take for instance the operation of a taxi cab fleet within a city or a squadron or any composite unit of that type. We are preparing a paper that we will be presenting next week at the ORSA Conference in Denver.

There's another area which is of increasing importance and interest to our group. In Texas, we either have too little or too much water. Now when it rains they're really gully washers. In the Austin area we happen to be very fortunate to have a string of seven lakes which stretch for some 100 miles. In Texas in general, everyone is interested in water resources and we are now doing a fair amount of work in this area with our water resources board and with our friends from Texas A&M. They also have a large effort in this same area.

There is another study which has been dormant for a while but now is picking up again. We are looking at the design of economic systems for underdeveloped countries. It's surprising where operations research can be applied even in the Mechanical Engineering Department. We have a student from Iran who is very much concerned about the economic development of his country. He is a Ph.D. student and has been working on this for his dissertation research. He was elected the student president last year so we lost him for a year, and that's one of the reasons the program was a bit dormant.

There is one other area I'd like to mention in closing. We are working with our sister organization, the University of Texas Medical School in San Antonio, Department of Psychiatry, and we are looking at cost effectiveness studies for mental health services. We have been doing some systems simulation on their operation but eventually we would like to address ourselves with the question, "How do you measure the effectiveness of a particular type of mental health service?" We think we have some ideas but we don't know how valid they are.

Another effort that we have is a graduate study program in the applications of industrial engineering techniques to the design and operations of hospital facilities. This is a program we have been carrying on locally with our hospitals and we hope to expand this effort since in Texas alone, we have over 700 hospitals. We feel there is a lot that can be done to improve not only the initial design but also the efficiency of operation of the entire system.

These I think typify the sort of things which we do within our department and in conjunction with our colleagues in the Business School. We also work in concert with the other departments within the College of Engineering namely petroleum and civil engineering (mainly in the area of highway studies). We have done some work there although we have mainly been concerned with traffic at the local level.

I hope this gives you an idea of the sort of things which we have done. By the way, in answer to a question yesterday, we do put on short courses, usually in Texas, and we do structure them for specific needs. We are going to put one on this summer for public utilities.

We are constantly looking for good projects for our students. Many of the items which I have mentioned are written up in reports. I certainly invite your comments or questions about them and if there is one that is published we will be very glad to supply you with a copy of the report.

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Operations Research Users and Producers

Dr. John S. Ramberg
University of Iowa, Iowa City, Iowa

I represent the Department of Industrial and Management Engineering at Iowa. The summary sheet which we submitted is also in cooperation with the Department of Statistics and Economics. Some other groups which were not mentioned in that section are the Department of Bio-Statistics which we work with in medical school and Computer Science, another area that we are involved in.

I would like first to talk a little about some of the projects that we are carrying on now and have carried on, and then at the end get into some of the curriculum content of the school. Again I should mention that we have a complete sketch of the faculties in these areas in the summary sheet and also a sketch of the research interests. I just want to take a few that I think are somewhat more applied and talk about them.

The first is legislative districting by Monte Carlo simulation. This is a project that Professor Liittschwager has carried on there and has considerable experience in the area. We have done it now twice for the state of Iowa. The first time in the redistricting fashion. Now they reduced the size of the legislature there so that it is being carried out again. We found that this is the kind of thing that is not hard to sell to a group, because as soon as one party finds out the other party has access to such a thing, they realize quite quickly that they cannot afford to be without it. The nice parts of the project are that it allows them to play around with all sorts of redistricting types and with various types of constraints in the system. I will not go any further into how it operates. You can contact either me or Professor Liittschwager directly at Iowa for information on this system.

The second area we have been working on is the input-output analysis and simulation of hospital systems. I think I will just leave that one at that and go to some other ones.

A third area which I have particular interest in is the multiple decision approach to problems and prediction in classification. In the prediction problems area we are interested in the development of empirical models and then using multiple decision approaches to get information concerning the operating characteristics of these models. Now these are basically regression models and they are for the types of problems where one doesn't feel it's improtant enough to make up an OR model, but he may have many factors which he thinks are related to this model. We would just like some sort of approach to pull a model out of the air with this kind of thing.

The classification problem I could probably best define in the sense of an application that we are planning for this, and that is the area within the medical complex and the reason I mentioned the Bio-Statistics Department; that is, should we operate or should we not operate. This is the kind of diagnosis question people come up with. One example of this that we have been working on is the area of rheumatoid hands. Should you operate to improve the hand or not? And the classification problem that I have been working is really a methodology for selecting a set of variates for determining classification into "do operate" or "do not operate" or, in fact, into a multiple number of classes. This is really more of a statistical problem than an OR problem, and it is often called discriminate analysis. The particular emphasis I want to give to it is that we are looking at, given that you have a large number of variates that you might use to make this decision, how do you select from them?

A fourth project I should mention that has been carried out (and this will show the traditional sense of the Industrial Engineering Department) is the unit dose project at the hospital. I think it is obvious that if you have the pharmacy pass out the dosages in units for the patient with his name on it, you are going to have a large improvement in safety. One of the other effects that has been noted in the study which is important also is that it does not appear to cost any more to do it this way. That is, there is quite a savings in nurses' time and so on, and we have also, therefore gotten involved in nurse utilization and studies of this nature.

To give you a little bit of a perspective as to what our department is or what the OR group is like at Iowa, as I said, OR is not really a department with us but a grouping of a number of departments. Let me start with the Statistics Department. The Statistics Department at Iowa is a very theoretical group in its origins, originating from the Mathematics Department. The Industrial Management Engineering Department came originally out of the Mechanical Engineering Department and was a very traditional group. In the past few years each of the departments has moved toward each other to some extent. The Statistics Department has hired a number of applied statisticians; I think of one in particular, Fred Leone who joined us recently. The Industrial and Management Engineering Department has hired a number of people in the OR area so the two departments have come together a considerable amount during this time and in fact we have a number of people who have joint appointments in the two departments and also with economics and psychology.

The curriculum at Iowa is pretty much the standard curriculum in operations research. I won't go into all the course work. We do emphasize a great deal the statistical areas and probabilistic models. I would say probably our forte is the stochastic models and problems in statistics and all our students in Industrial Management Engineering take a considerable number of courses in the Statistics Department as well as in Economics.

We are interested in short courses and student projects. I think those were two of the things mentioned before.

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Dr. Rudolph P. Lamone
University of Maryland, College Park, Maryland

The Department of Business Administration at the University of Maryland offers both the MBA and Ph.D. in Business Administration with a concentration in area of Management Science.

The management science program for our doctoral students has a strong interdisciplinary emphasis. These doctoral students are required to have minors in the areas of organization theory - human behavior, finance, marketing - logistics. Furthermore, the management science concentration requires a supporting minor from one of the following areas: Applied or mathematical statistics, computer science or information-systems management mathematics, mathematical economics.

The over-all objective in the MBA program is to educate students for ultimate advancement to general management positions, rather than as technical specialists in a functional area. Consequently, MBA students with a concentration in management science may take only 12 of the 30 hours required for the degree in the area of operations research. With this background we feel that the student should be capable of translating the highly specialized and technical concepts and methods of operations research into the realm of experience and language of the decision makers.

Course work is currently available in the following areas: deterministic models, probabilistic models, simulation, optimization methods, econometrics, statistics, computer science, control theory, management information systems and applied mathematics. Furthermore, if a student wants to pursue work in an advanced or specialized area of operations research for which no course is offered, he may arrange with a faculty member for a specially scheduled tutorial course.

Presently, there are six faculty members within the Division of Quantitative Methods and four faculty members of the Department of Information Systems Management teaching in the management science graduate program. All have doctoral degrees in either economic statistics, mathematical statistics, operations research, management science, mathematics, or management information systems, the doctoral degrees being earned from the following universities: Johns Hopkins (3), North Carolina (2), North Carolina State (1), Michigan (1), Columbia (1), Indiana (1), Kentucky (1).

The primary research areas include mathematical programming, search procedures, transportation switching networks, network theory, decision theoretic models, dynamic programming, control theory, information processing, stochastic processes, management information systems, multivariate statistics, financial planning simulation-models, planning and control systems, and benefit-cost analysis.

Finally, I should point out that most of the faculty is actively involved in several government training programs in PPB and in the development of workshops emphasizing the application of management science in the public sector.

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Professor Alvin W. Drake
Massachusetts Institute of Technology, Cambridge, Massachusetts

I shall begin by scanning some MIT activities which may be of particular interest to the government administration and operations research community. Then I shall talk in a little more detail about what constitutes the MIT program in OR, particularly in the area of public systems.

For several years MIT has had a Center for Advanced Engineering Study and this is coming to be one of our main vehicles for working with people several years out of school -- both technical people and, more recently, public administrators interested in systems analysis. The Center for Advanced Engineering Studies (CAES) has non-degree and degree programs in several areas, one of which I'll summarize. Such programs are generally tailored to meet the needs and background of the individual student.

Almost without exception, CAES programs are nine months or a full year. It's expensive and logistically difficult, as you know. But such programs make available the regular educational programs of MIT, as well as the special subjects offered by the Center. There is time for participant to acquire and evaluate ideas he didn't encounter before. In a fair number of cases, students have acquired an adequate view of a new field to allow major redirections of their careers.

One of the CAES programs on a nine-month basis is called "Systematic Policy Analysis" and it is primarily for public employees, both federal and local. It deals with economics, probabilistic modeling, inference, and the methods of modern systems management at whatever level is suitable for communication with students who are generally concerned with a planning and managerial point of view. It is not a particularly mathematical endeavor.

Three special programs exist at the MIT Sloan School. There is a one-year program for senior executives, a nine-week Sloan Fellows Program and, of particular interest here, a four week "Urban Executives Program." This program brings to MIT a wide variety of people, some form the Federal government, but mostly people with continuing responsibility in local government. A participant might be the head of a city water department, a city manager, his assistant, or a director of a metropolitan planning council. The program presents the present state of management and how it has been affected by technology, while providing MIT with an opportunity to try to learn enough about urban needs and problems to develop more focused special programs and to speculate on appropriate redirection of our regular educational program. Eventually we might attract to the field of "public administration" more of the exciting kinds of students who have for a long time been directed primarily towards science and engineering as shaped by the needs of our defense program.

During the last two years a large organization called the Urban Systems Laboratory (USL) has been formed within MIT. The formation of USL constitutes MIT's major effort to achieve critical mass in educational programs, student and faculty involvement, and continuing applied research projects in the urban area. One document has been prepared by USL which may be of particular interest to members of this audience. Available on request from USL, this is a directory of onginin urban related research at MIT. It's a fairly thick listing and we cannot sample it effectively here. Some entries reflect that, in today's climate, people who used to specify their research area as "windmill gears" now describe it as "urban windmill gears." But this USL directory of urban elated research at MIT does also include nearly all those MIT efforts which have direct application to the problems of the city and of public agencies.

Now I'd like to say something about the MIT Operations Research Center, which is the part of MIT I know best. The Center is a research and graduate educational interdepartmental activity with about eight or 10 primary faculty members and about 30 students. Our educational program isn't that different from many others described here today, although we may have somewhat fewer core subjects and they may be conducted at a relatively abstract level. We try to use considerable research seminar experience for achieving aspects of the educational program that seem less well adapted for formal direct classroom work.

Because it is particularly relevant to this meeting, and because it is the work I am closest to, I'd like to note some of our activities in the Public Systems area. "Operations Research for Public Systems" is the name of an annual one-week summer program to be offered for the fourth time this September. Here we bring together a considerable number of administrators, customers, salesmen, skeptics and educators to consider some of the problems of the interaction of their professions and to review studies that appear to have significant implications for the operation of particular public systems. The speakers will range from a scientist who is the head of the Local government Operational Research Unit in the United Kingdom to Professor Collins, the former ma or of Boston. Collins has made the transition from trying to figure out what he wanted to buy to, in his new capacity, figure out what it is that should be developed and how it might be developed and "sold."

Our Operations Research Center, in public systems, is mostly concerned with primary problem definition and the formulation and exploration of policy-oriented mdoels in relatively young problem areas. We do not have a continuing research staff. We are not in a position (USL is) in which we can go into contact research which requires committing more than the few graduate students and faculty members who are especially interested in a particular research program. The only types of problems we can undertake are those which allow a student to obtain the educational growing experience which is a vital part of the thesis or dissertation endeavor. Our research projects will often involve one faculty member and one or two students. I'll give a few examples.

One of our students took an interest in operational aspects of the criminal justice system (just before the formation of the President's Commission on Law Enforcement and the Administration of Justice). In SM thesis work at MIT he did detailed modeling of the many sequential operations which must occur whenever a citizen requires police assistance. Working with the Boston Police Department he was able to show how response time would be decreased more by the addition of one additional dispatcher than by the addition of ten more police cars. The additional dispatcher was provided. This student's doctoral dissertation, done in cooperation with the Project RAND effort in New York City, has suggested planning and control methods for the allocation of radio-dispatched patrol cars in the city. On a larger scale, in work with the Science Task Force of the "President's Crime Commission," he participated in the development of aggregate models of the entire criminal-justice system, following the flow of arrested individuals through police court, and corrections systems. As you may have seen in this month's O.R. Journal, these overall systems models are receiving quite a bit of attention.

In closing, I can only mention by problem area other efforts in public systems currently underway at the MIT Operations Research Center. One of our students, working with a Department of Transportation Task Force, is developing quantitative models suitable for the exploration of alternative national strategies for vehicular insurance. Another student has been trying to develop a methodology for the evaluation and improvement of emergency ambulance services. Finally, one student has done his graduate research on the operational problems related to regional blood-banking systems. The O.R. Center work I have described is supported by N.S.F. and by P.H.S.

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Professor Salah Elmaghraby
North Carolina State University, Raleigh, North Carolina

Operations Research at NC State has a very brief and, simultaneously, a rather long history. It has the very strange administrative structure of being a minor program. It's only a graduate program, and the minor means that the student has to major somewhere else. Usually the term or the English word "minor" has a connotation that it is an unimportant activity. Well, as it turns out it is not "minor". Since 1960, for a graduate "minor" program, I have counted 36 Ph.D. dissertations and about 59 Master's theses which were written in operations research. That's since 1960, and for a "minor" program, which is a mighty good product!

Just to give you the Southern flavor of all this, here is a Master's thesis, finished in 1968, in the Department of Biological and Agricultural Engineering, with the title "A Farm Machinery Replacement Study with Application to the Replacement of Self-Propelled Cotton Pickers".

The cooperating departments are several. They are the Biological Agricultural Engineering, Civil Engineering, Economics, Electrical Engineering, Engineering Mechanics, Experimental Statistics, Forest Management and Industrial Engineering.

At NC State we have the great advantage of having what I call "contributing" schools and departments and, on the other hand, the "user" schools and departments. The contributors are, of course, the Schools of Engineering, PSAM (Physical Sciences and Applied Mathematics), which includes Applied Statistics. The users are the School of Textiles, School of Forestry, School of Design and the School of Education.

I would also like to mention, because I have found that many of my learned colleagues in other universities are not aware of this fact, that North Carolina State University is a member (or one campus) of a four campus state-wide university which includes the North Carolina State University at Raleigh, the University of North Carolina at Chapel Hill, the campus at Charlotte and the campus at Greensboro. There are four campuses and if the Legislature gets its way I think there will be two more. I didn't know about that myself until I went to North Carolina. We are privileged also by having Duke University in the Research Triangle Tri-University Park. You heard yesterday the Professor from Duke University say they use the Computer 360 Model 75, which is really stationed in the Research Park, and it is owned by the three universities, and it is administered by a Board of Directors appointed by the three universities - that is North Carolina State, University of North Carolina at Chapel Hill and Duke.

Concerning the number of students in the Operations Research program, we have about 45 students who are 'minoring' in Operations Research, about 15 of whom are writing dissertations in Operations Research in the various Departments I cited above.

What kind of research is going on? I won't dwell on the courses at all. They run the same gamut of courses that you find everywhere else, but the research is in two parts; the theoretical part, of course, is as everywhere else a function of the people who are present on the campus at any one time and as of the moment the people on the campus are interested in mathematical programming, in particular dynamic programming, nonlinear programming, in particular the Kuhn-Tucker theory. Sometimes I think we are very fortunate that Professors Kuhn and Tucker came up with their theory so that many of us can find jobs to study their theory.

Then there is, of course, the theory of Networks and Inventory, Scheduling and Sequencing, Investment, Capital Budgeting, and in particular Control and Optimal Control. This is a very active area of research.

Permit me also to mention a very important facet of our program, namely, Operations Research is on both campuses, Chapel Hill and Raleigh. I believe there are representatives from the Chapel Hill campus here, and we have the great advantage of having very strong coordination and cooperation with very little duplication. For instance, the campus at Raleigh has an Engineering School but the campus at Chapel Hill has a Business School. The campus at Raleigh has Experimental Statistics but the campus at Chapel Hill has theoretical and Mathematical Statistics. That doesn't mean that all engineering and applications are done in raleigh and all theory is done in Chapel Hill, but that gives you an idea about the division, at least of interest.

Now in the applied field, we have in-university research, and this is as usual, diversified. We have a design project in the School of Engineering. We have a THEMIS contract in electrical engineering on signal coding and transmission. We have an Institute of Water Resources which is sponsoring research in underground water. All these are within the University.

Also, there is a lot of in-state research going on: for example, there are programs on vocational education which are actually federally funded, and these are related to Institute of Vocational Education which is housed on the campus. Then there are the urban problems. There is the Institute of Urban Affairs at Chapel Hill, and Raleigh is also thinking of establishing one. Then we have a project with the State Highway Commission. They have a budget of about $18 to $20 million a year, and they are very much interested in the management of their highway equipment, and I mean the total picture of management which includes the pruchasing and maintenance of machinery, the control of the inventory of spare parts, the distribution of repair shops, etc.

We also would like to get the Association of General Contractors, a trade association representing the construction industry, to work with us on some research in the construction field and I think we shall be successful in that respect.

I would not like to stop without mentioning one more project. Most of the work cited above is sponsored, either by grants from the National Science Foundation, NASA or others. For example, the design program has a grant from NASA at Langley to design as easy-to-fly aircraft. To those of you who have been talking about optimal control and related areas, allow me to mention that the object of this project, which is a three year project, is to design an airplane which is almost automatic, so that flying it would be like driving a car, which of course will take all the pleasure out of flying ariplanes, but that is the objective -- an easy-to-fly airplane. This is the kind of stuff we're doing in applied research.

However, I would like to mention one research which is not sponsored by any agency or by anybody. A group of us in operations research and other individuals in and outside the University, as concerned citizens, got together and, being worried about the problems of school integration, decided to use some of the operations research tools and techniques in the service of the community to study, first of all, the student assignment to schools and, second, where would the schools be placed in the first place. Let me emphasize that this is an "ad hoc" committee of concerned citizens from the University and from the local churches, and other local individuals. We think we have an excellent model and we have an excellent program, proven by collecting data and simulating a postulated assignment. I would like to mention that we could not implement our procedure. The implementation was stopped, not because of the negro militants, or the white liberals, or the blue-sky thinkers. It was because of the School Board. Our efforts are still continuing.

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Dr. James E. Shamblin
Oklahoma State University, Stillwater, Oklahoma

In Oklahoma State University, the basic core of operations research is centered in the Department of Industrial Engineering. We have about 160 bachelor candidates, and this year, 56 master candidates and 21 full-time Ph.D. candidates. The names of our courses are the same as anybody else's.

Particular interest of our staff within industrial engineering, this is in the OR context, is in the area of optimization, economic analysis, management systems, and sensitivity analysis. In class, we try to emphasize the role of engineering in OR, which is problem-solving. We feel that the engineering OR has the same relationship to mathematics and statistics as the mechanical engineer with respect to classical physics. He applies the facts of classical laws of motion and thermodynamics.

So we have tried to emphasize that the engineer in operations research should be able to interpret a physical or economic system so that it may be modeled, quantified mathematically and then this model may be manipulated to achieve the desired objective. When he is through with this, he has to reinterpret the mathematics so that it may be formulated and applied. In operations research at Oklahoma State University we try to emphasize the interpretation and use, and I'll underline the word use, of mathematics for problem solving.

Our larger operations research projects are usually handled by an operations research group. This was founded by Dr. Fabrycky, who is now at VPI in the early 1960's. At this time, we have 14 professors who are interested in and work in various aspects in this group. They represent the Schools of Industrial Engineering, Electrical Engineering, Chemical Engineering, Economics, Accounting, Statistics, Mathematics and Computer Science. We are in the process at this time of trying to coordinate the activities of this group with the new Center for System Science, which has been established at Oklahoma State University, primarily in the College of Engineering. This was founded through a grant from NSF for a center of excellence.

The first project in this system's group is a study of the transportation needs that will be caused by the establishment of a port in Tulsa, Oklahoma, which will be opened to sea-going barge traffic. It sounds a little unusual for Tulsa to be considered as a seaport, but they are really going to bring barges up the Arkansas River, and we plan and are beginning a systems analysis project of the effects of this on transportation needs all the way to western Oklahoma to get some of that wheat over here so that other people can eat it. At this time, the initial group on this study is composed of an IE, an EE, and an economist and two graduate students.

We have worked on quite a few different types of research projects and I'd like not to take up all your time typing to list some of these, but they range from pretty qualitative systems projects involving the economic analysis for energy conservation and generation to rather theoretical mathematical modeling procedures.

In addition to our research activities, we have participated rather extensively in extension programs through a Department of Extension of the College of Engineering and we have courses that run from one day to three weeks on campus that vary from management development courses to operations research or specialized applications to PERT and CPM.

We conduct special courses designed for the needs of the participants for off-campus companies and these range from industrial to government agencies such as American Airlines, the Sunray Division of Sun Oil Company, the FAA, and quite a few others. We have for the past 10 or 15 years been interested in, not only on-campus, but off-campus extension work.

We are interested in projects that are suitable for university participation and would appreciate the opportunity to talk with government agencies. We feel like we, in a university, could work successfully with them.

Joint Meeting of Government
Operations Research Users and Producers

Professor Norbert Hauser
Polytechnic Institute of Brooklyn, Brooklyn, New York

Our Department is a brand new one and I think I'd like to take a little bit of your time to tell you something about the origin of our department because it is relatively unique. It is really a result of a marriage between two groups. One group was an industrial engineering - operations research group residing, as many other such groups, within a mechanical engineering department. The other group consisted of restless electrical engineers who wanted to use their electrical background toward non-electrical engineering type of problems. The IE OR group gradually got away from traditional IE concepts and went toward the now classical OR area.

The curricula emphasized probability, statistics, computer software aspects, economic analysis, psychological aspects and so on. The EE-oriented group established an inter-disciplinary curriculum called system science which was joined by members of other departments; they emphasized concepts such as modeling, control theory, computer science hardware aspects, and so on.

Before long, the two groups realized that they had much more in common than they differed from each other; so effective this year, we got together and formed the Department of Operations Research and System Analysis. We really wanted to call it the Department of Operations Research and System Engineering but did not do so for two reasons. The electrical engineers did not like our taking over the term"system engineering" and secondly, systems analysis allows us to use an acronym ORSA; the other way would have been ORSE, so anyway we are now called the Department of Operations Research and System Analysis.

We have one combined undergraduate curriculum which really combines these two aspects: the control theory point of view, the modeling point of view of the electrical engineer, and the probability-statistics computer oriented point of view of the OR man. We do permit our undergraduate students to take a concentration in a subject area after he has the fundamentals out of the way. This concentration could be computer science, Stochastic systems, or it could be bio-systems or transportation, or anything a student can make up provided such ourses are available; but we do encourage our undergraduate students to concentrate in some area of application. On the Master's and Ph.D. level, we have separate programs in operations research and in system engineering.

So, in effect, we have the whole range from completely software to hardware orientation, instrumentation and so on, and we have this lively interchange between the hardware oriented people and the software oriented people and, of course, there is an enormous area in between. Our orientation is strictly toward actual problems - as opposed to theory. We can afford to do so because we have very strong theoretical groups in our mathematics department, which emphasizes numerical methods, stochastic systems, and in our electrical engineering department which has a very strong system theory group, also great strength in computer software, computer hardware and so on.

We can afford then to be applied because we can draw upon the theory which the other departments provide for us. A wise man once said that it is better to find an approximate solution to the exact problem than to come up with an exact solution to the approximate problem. Unfortunately, we are never able to achieve either one actually. What we invariably end up doing is to develop an approximate solution to the approximate model and this also is the emphasis of our apporach -- to what extent may we distort reality in order to fit a given model and at what point do we decide to discard the model and use some less sophisticated approach -- a very serious problem, as I am sure most of you realize.

So I want to point out that we are not strictly cook book type application, but we do look into theoretical models and we try to explore them: How much can you use them, how far can you use them and how much do you lose by introducing certain approximations.

It will come as no surprise to you if I tell you that our main area of interest, therefore, is simulation and very frequently we will construct a simulation model to check on an analytic model to see how robust this particular analytic model is. At no point do I wish to downgrade theoretical approaches; we would be lost without them and we will send our students, especially our doctoral students, to these departments to take solid theoretical courses. But our particular research, which I want to get into right now, is invariably problem oriented.

Let me tell you something about our research activities right now. Dr. Merrill previously talked about some grants the Justice Department has offered. We are one of the grantees. We have developed a simulation model of the New York City Police Department's communication system; the report should be ready within a month.

We have several projects going on with local hospitals, ranging from, again, the hardware aspects, where a group of our junior people actually developed an on-line computer system which is almost ready to go on the air for use of doctors and nurses to develop a patient information system. We now have a proposal in to continue this to develop some criteria of evaluation of such a system as well as to get into the problem of diagnosis, of associating symptoms and preliminary diagnoses with final diagnosis because eventually every patient will have a card or a file which lists preliminary diagnosis, results of several tests and final diagnosis. This as you can see, presents a beautiful problem.

In cooperation with our Division of Transportation, which is another group at Polytechnic, we have several grants from the Department of Transportation and HUD, too. Some of them we just received within the past two weeks, one to set up a multi-disciplinary team in transportation; one to study the weaving effect on highways near entrance or exit ramps; one to study the effects of transportation in poverty areas, the ability or lack of ability to get to and from a job. We also offer special courses to New York State Transportation personnel.

A thing of interest to you which is not strictly OR, but I think should be of interest, is our computer animation project. In cooperation with Dr. Ed Zajac of Bell Laboratories, a group of our students and faculty developed a FORTRAN package which we called Polygraphics; it enables a person who knows FORTRAN to develop a computer-generated movie. Let me just use a couple of words to describe what this is. In effect, by programming the computer to produce its output on a cathode ray tube, then have a camera associated with this take a picture of this particular output, then let the program change it slightly, advance the frame, take another picture, and so on, you can come up with an animated movie. In effect, you can have a moving graph, you can change whatever you wish to, and introduce a third dimension in a graph, a very complex one. This has two major applications, one for analysis of relatively complex dynamic systems and the other one is for presentation to laymen.

Quickly, what do we want? We would like to expose our students and junior faculty to problems of the real world. We would like to get our senior faculty, of course, involved too. We like grants, certainly. We would very much encourage summer employment, or one-day-a-week type of arrangements. Fellowships, of course. One to two year employment would be of interest to us, too. The only requirements we have are that the problems should be general enough to be of interest to other people in addition to the particular user, and certainly they should be publishable, not secret.

Joint Meeting of Government
Operations Research Users and Producers

Dr. J. Wilkinson
Rensselaer Polytechnic Institute

Rensselaer is traditionally a school emphasizing engineering and science. At present it has approximately 4500 students on the Troy campus, of which 1200 of these are in the Graduate School, and these are distributed organizationally into five Schools: Architecture, Science, Engineering, Management, and Humanities and Social Science with the majority being in the Schools of Engineering and Science. However, over the next decade I think we will probably be seeing a change in Rensselaer as it plans to change its mix of students with a controlled increase in enrollment providing greater emphasis on Graduate and upper division undergraduate courses.

We will also see the introduction of a broader range of subjects in the undergraduate areas, making Rensselaer closer to that of a technological university, while at the graduate level we will undoubtedly see consolidation in a fewer number of graduate areas. This is in keeping with the concept of "spires of excellence" -- a new phrase in New York State. I anticipate that Operations Research and Statistics will fare reasonably well in this new distribution of emphasis.

At Rensselaer activity in operations research is observable in several quarters. However, as far as curricula are concerned most of the activity is found in two programs, one general in nature and the other specialized in nature. Both of these programs lead potentially to the Master's and PhD degrees.

The general program is one leading to a degree in Management with emphasis in Operations Research and Statistics. In this, students study subjects in several areas such as marketing, organization and policy, operating systems, finance, etc., with a heavier concentration in the area of operations research and statistics. In the case of the PhD program the studnet would do a dissertation in the operations research area requiring at least 30 semester hours of credit.

The specialized program comes under the sponsorship of a committee comprised mainly of faculty from the School of Management and the Department of Mathematics. In this program the major emphasis is operations research and statistics with the distribution of material between these two subjects being pretty much a flexible option for the student. The student must choose a minor in some other area that he can justify. Many logical areas for this are, another subject in management,economics, psychology, electrical, chemical, bio-medical, bio-environmental engineering, transportation and computer science and there are probably some others. These constitute most that we have had request for so far. In fact, I think it is safe to say, that one of our strong assets is in the great flexibility for the student to put together a strong major comgining operations research, statistics, and computer science with a minor in an applied field in management, science or engineering. Also the broad continuum that is spanned by the general program in management to some of the far out options in the specialized program provide much desired versatility.

Many of the other degree programs in science and engineering encourage students to take courses in operations research and statistics, but the main ones at present to take a minor in the subject have come from transportation, computer science, and managerial economics. Also a new program in urban and environmental studies, which is in an embryo state at the moment, is under the direction of a faculty member from the Operations Research Group, and it is anticipated that quantitative methods applied to urban problems will be emphasized.

Rensselaer by virtue of its position as a technological university does not cover as broad a range of disciplines as a full fledged university. Hence cooperation is desirable and encouraged with other area colleges. The two that we are mainly involved with in this kind of cooperation at the moment are Union College and the State University of New York at Albany.

So much for curricula. Let me discuss our research interests of the faculty and students and I am going to classify them into two categories, one the basic research in the academic disciplines associated with operations research, and the other, project-oriented research in systems analysis and the application of operations research techniques to problems in engineering, management and science.

In category one, the area of basic research, our faculty are primarily concerned in some of the following areas: linear and non-linear programming with emphasis on geometric, quadratic, and quadratic-like programming problems, matrix game theory, search methods of resolving mixed-integer programming problems for general problems and special classes of problems such as set covering problems, application of geometric programming to conjugate function theory and to computational methods and general problems in operational programming. The faculty primarily involved in these areas are Professors Lemke, Ecker, and Rao.

A second category in which I am primarily involved myself, involves an interaction of statistics with mathematical programming namely, the planning for data collection with specific reference to response surface models and to the evaluation of robustness according to various criteria of goodness. Also, Professors Chew, Carter, Godin, Nelson, Tuason and Wallace are active in such general areas as:

Reliability methods and hazard plotting, simulation methodology for discrete and continuous systems, game theory, dicrete search techniques, decision theory and sequential analysis, and applied probability.

In the applied area I will just identify projects by titles. We are very much involved and hope to become more involved with Lake George Ecosystem analysis in conjunction with the Environmental Engineering Department and the Lake George Research Group at Rensselaer. This work is associated with the International Biological Program involving Oak Ridge National Laboratory, the University of Wisconsin, the University of Georgia, and the University of North Carolina and is currently being funded by the National Science Foundation, the Office of Water Resources Research and the New York State Science and Technology Foundation. Other projects involve (i) simulation models relating demand for ancilliary services to other input variables of the Albany Medical Center, (ii) conceptual design and system analysis of multi-modal transportation, (iii) planning for mineral resources, (iv) development and implementation of computerized projection models to aid in planning for higher education, etc.

Although Rensselaer has embarked on degree programs labeled Operations Research and Statistics relatively recently, it is not a newcomer to the field. Former graduates with such training graduated from Rensselaer with degree labels of mathematics, management or engineering science. However, our new visibility plus a favorable situation for appropriately augmenting our faculty to handle indicated growth of good students make the future look promising.

Although we have been quite fortunate in getting a reasonable share of fellowship support, teaching assistance support from management and mathematics, and research assistance support from Transportation and Environmental Engineering we are in need of more sponsored research to help not only with student support but with student training.

In response to some questions raised earlier, we would be interested in cooperating with the offering of training programs to the employees of other organizations. We would also be interested in the various forms of cooperative graduate student research with such groups as Dr. Cushen's Technical Analysis Division as he mentioned yesterday.

Joint Meeting of Government
Operations Research Users and Producers

Professor William P. Pierskalla
Southern Methodist University

The operations research activity at SMU is a new program (less than 1 1/2 years old) and is located in the Computer Science/Operations Research Center of the Institute of Technology. The underlying idea was to place operations research and computer science in close proximity in order to breed interlationships between the two areas and to allow for some new approaches to many computer science problems.

The curricula in operations research is based on the concept of building strength in the fundamental OR areas of mathematical programming and applied stochastic processes. The research interests of the faculty are also primarily oriented toward these fundamental areas; however, we are initiating new projects in several selected areas of OR applications.

I will now describe some of the research areas currently being investigated.

Dr. Harvey Greenberg and I are investigating generalized concepts of penalty functions and surrogate functions and their application to nonconvex programming problems. Also, I am working with some people from the Southwestern Medical Center in modelling their blood bank requirements as a perishable inventory problem. We have just added a new faculty member, Dr. U. N. Bhat, who is one of the leading young men in queueing theory. His primary interests are infinite queueing systems, networks of queueing systems with finite waiting room between the processing units, and traffic problems. Dr. Ronald Gue is working on large scale linear and programming problems with applications in hospital scheduling. Dr. Michael O'Hagan is solving microwave design problems using linear and also non-linear programming.

Now I'd like to describe some of the interdisciplinary work being conducted with the computer science faculty.

The major area of common research interest concerns a problem which is facing many agencies of the government. This is the problem of handling large and vast quantities of data at various hierarchial locations in a computer network. With the tremendous data storage capabilities which are now coming on the market (millions of words of storage) there is a major question as to what types of data should be stored on-line or off-line, when to store it, where to store it, how to access it in a computer network and when to destroy it. This is a problem that needs queueing, inventory, resource allocation and math programming ideas from operations research and software and hardware ideas from computer science. We're becoming involved in this area and I think this will probably be one of our major areas of research of the future.

Joint Meeting of Government
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Dr. Gerald J. Lieberman
Stanford University, Stanford, California

It's been alleged that there are at least four Departments of Operations Research at Stanford. That is really not true. However, let me say that I speak for the only one that has this title formally, namely, the Department of Operations Research. Let me also assert that it is one of the three best Departments in the country. I can say this with certainty because I believe there are only a total of three Departments in the country which have the title of Department of Operations Research.

Before turning to the question of what we can do for you, the government sponsors, and what you, the government sponsors, can do for us, let me describe very briefly the history of the Department of Operations Research at Stanford and attempt to give you a feel for our philosophy which I think is best expressed by our accomplishments.

Stanford recognized the significance of the emergence of OR, and the importance of developing an outstanding faculty to conduct research and teach courses in this new field early (at the end of the 1950's). Actually, extensive research and teaching activities were flourishing within several departments then, and the Provost of the University became worried about proliferation of effort. As a result of his concern we emerged with an interdepartmental, inter-school program in 1962. This was a graduate program which led only to the granting of a Ph.D. degree (no undergraduate program and, at that time, no Masters program was envisaged). This interdepartmental inter-school program was so successful that in 1967, in recognition of this achievement, the University set up an autonomous Department of Operations Research and at the same time it initiated a Master of Science program. Hence, for the past two years we have been operating as a Department; although the program has been in existence for the past seven years.

What has been accomplished during these seven years, the final two years of which we were a Department? When I say what has been accomplished I mean what has our product been. Our product can be described as the teaching and training of students, and the production of research. Let me turn to the first, namely, the teaching and training of students and review what has happened to our students over these seven years. I might say that three of them are here today making presentations. This is always very, very gratifying. We have had 27 Ph.D. degrees in Operations Research granted since 1962, and of these students, 17 are teaching and 10 are in "industry". I will explain the appearance of the quotes on the word industry in a moment. Where are these students who are now in universities; where are they teaching? They are teaching at the Air Force Academy, the University of Alberta, Columbia, Cornell, Harverd, MIT, SMU, University of California at Berkeley, UCLA, and Yale.

Where are our students who went into "industry"? We really have only one doctoral student who is employed by a "hard core" company. He is working at DuPont. The rest of them are at semi-research or non-profit type companies like Arthur D. Little, the Mitre Corporation, RAC, Rand, SRI, and that other non-profit organization, IBM. It is interesting that very few of our doctoral students are employed by industry. The conclusion that we've reached is that industry really is more interested in Masters students. We produce approximately 50 MS candidates a year now and almost all end up in industry. In fact, they are eagerly sought after and command high salaries.

The educational goal of our Department is to adequately prepare a student for a lifetime pursuit in any phase of OR that he chooses. More specifically it is our belief that the program should be, and is designed for the student who desires an OR education to meet his career goals in either business, government, or university. The faculty views its doctoral program and research endeavors primarily as an applied mathematical science. I would like to emphasize this becuase we train our students primarily in the areas of methodology as opposed to applications. We are not problem oriented; we are methodologically oriented, and I'll comment on this a little more in a moment.

This philosophy is, in a sense, reflected in the type of students that we have in our doctoral program. We have currently 50 full-time doctoral students and slightly more than half of these have undergraduate degrees in mathematics, about one-quarter of them in engineering with half in electrical engineering, about ten percent of them have physics undergraduate degrees, and then smatterings from chemistry, economics, and statistics.

Where do our students come from? We have nine doctoral students who have their undergraduate training from MIT, four from Harvard, four from Cornell, three from Stanford, and the remainder from other universities in this country and from all over the world.

This training in methodology, as opposed to application, is not meant to slight application; rather it has been our philosophy that a student has a limited amount of time to devote to his doctoral training. We anticipate that a student will complete his requirements, including the writing of the dissertation, in something like four years and this goal has been achieved. Almost all of our students have received their doctorate within three to four years. In this short period of time it is almost impossible to give thorough training in the applications of OR as well as in the theory of OR. Hence, one has to make a choice. I speak for our Department in saying that our choice is to pick that which we feel will better prepare the student in the long run, namely, the training in methodology. Our philosophy is that a student with this training can go out into the hard, cruel world of business or government, and within time develop the capability to solve real world problems. The reverse is not true. Somebody without thorough grounding in methodology will become obsolete over a period of time.

What about the faculty? Who is in the Department of Operations Research at Stanford, and what are their research interests? In addition to myself, whose interests are in the area of reliability and stochastic models, the faculty consists of the following:

George B. Danzig - linear and non-linear programming

B. Curtis Eaves - mathematical programming

Frederick S. Hillier - queueing theory, integer programming and production

Donald L. Iglehart - applied probability theory, dynamic programming and inventory

Rudolph Kalman - control theory

Alan S. Manne - mathematical programming

Arthus F. Veinot - mathematical programming and dynamic programming

Richard Cottle - linear and non-linear programming

Over the years this group of scholars has made significant contributions to the field of mathematical programming and stochastic models or applied probability theory. This is evidenced by publications that have appeared in technical journals and by the applications of these basic research results to real world problems. I want to point out that, although we teach methodology, each of us as individuals has serious applied interests and are often motivated in our research endeavors by real world problems. We have made contributions that have been used by our sponsors in the areas of reliability, large scale systems, multi-product inventory theory, dynamic programming, etc.

Finally, what can we do for the government sponsors, and what can they do for us? We can continue to provide you with high grade basic research and be available for consultation when you feel such assistance is valuable. You can continue to motivate our research by presenting us with your pressing unsolved problems, and continue to be a market for our products, namely, students and applications of our research.

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Professor Charles G. DeWald
State University of New York at Buffalo, Buffalo, New York 14214

The State University of New York at Buffalo is actively involved in the application of operations research methodology to urban problems. Situated in the nation's thirteenth largest city, surrounded by heavy industry and commerce, and confronted by changing social values, the University has responded to the exigency of the times by establishing a broader base to cope with the ensuing multitude of complex urban problems.

In anticipation of its new 700 million dollar campus, the University has instituted a new shcool dedicated to the study of urban problems especially those arising from the social-technical interface. The school will eventually span all seven of the faculties within the University, thereby emphasizing interdisciplinary research and study programs. The newly appointed Dean of this school is John P. Eberhard, former director of the Institute for Applied Research here at the National Bureau of Standards. With this background, I'm going to discuss some of the past and present research projects at SUNYAB as an indication of our future interests.

To date, we have been working primarily in five areas:

1. Transportation
2. health and medical services
3. criminal and justice systems
4. information systems

and 5. educational systems.

In transportation, we have worked closely with state and local agencies in developing new trip generation, modal split, and traffic assignment algorithms. We have also worked in unison with various other research groups in the area on special projects, such as the Urbmobile System at Cornell Aeronautical Laboratories.

Presently, a project is underway to develop transportation cost-benefit methodologies which include social considerations. In this vein, there exists another project to establish guidelines for "balanced" transportation systems which include such social considerations as access to work and non-work opportunities, especially as they relate to various ethnic groups. In addition to the aforementioned, there are two additional transprotation research projects. The first is entitled "The Design of Optimal Guideway Configurations for Future Automated Transportation Systems"; this project incorporates mathematical programming, graph theory, and systems analysis techniques for the purpose of designing transportation networks linking major urban activity centers.

The second project is an extension of my Ph.D. dissertation research and is concerned with the extension of network optimization techniques (Ford and Fulkerson variety) to include dynamic networks.

In health and medical services, a member of our staff, Professor Thomas, has been assisting the New York State Hospital Management Engineering Program. This program coordinates the efforts of operation researchers and industrial engineers in assisting the Hospitals in Western New York, Albany, Syracuse, and New York City. The group has been active in developing measures of performance, planning new facilities, streamlining and utilizing existing ones, scheduling such services as out-patient care, surgery, etc. More recently, the Program has been concerned with developing effective admission policies.

On another project, Professor Zionts has been involved in organizing a blood inventory system for Western New York.

Criminal and Justice Systems: Recently a joint student-faculty project analyzing 1968 robbery data for time, geographical, sex, age and patterns was completed. This effort, under the guidance of Professor Mogavero, was received enthusiastically by the Buffalo Police Department.

On another project, Professor Hoffman has applied computer information processing technology to the police function.

Future research interest centers around developing models for effectively allocating judges, setting expedient court calendars, etc., and also in determining how the completeness of a policeman's initial investigation report affects the likelihood of an arrest and conviction.

Information Systems: The State University of New York at Buffalo has a School of Information and Library Studies. There also exists a Technical Information and Dissemination Bureau (TIDB), which is rather unique. TIDB functions as an information service and research organization; it has designed and implemented a computer-based system for processing published information. In a single year, the system scans 25,000 government reports, 370,000 items, mainly articles, from all issues of 2,200 journals, selecting pertinent items relating to the subscriber's individual interests.

This organization is available for research in a broad spectrum of areas reflecting to information systems.

Educational Systems: Our research in educational systems has been limited to the development of bus scheduling algorithms. In the near future, Mrs. Rita Newton will complete her doctoral dissertation entitled "Bus Scheduling in a Multi-School System." This work is an extension of her previously published masters thesis algorithm.

For the future, in addition to expanding research in the five aforementioned areas, there are plans for developing research programs in the following:

1. Building systems design
2. waste management

and 3. pollution control.

I hope I've provided you with a cross-section of our operations research related interests.

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Professor Alan K. Halder
Johns Hopkins University, Baltimore, Maryland 21218

I'd like to start off by pointing out that, as I am only visiting Hopkins for the year, I'll be slightly more subjective than most in my presentation, because if I say anything too outrageous the University will probably disown me, so take my remarks with that in mind. At the same time, being visiting just for the year, I am possibly in a better position to be more objective about some of the aspects of the total system and so I'll attempt to view the total system as well as the situation at Hopkins. Lastly, since my background is in England, which is more of a problem-solving environment, this will color a lot of my remarks as well.

I'd like to put everything in a content that not many people have done, both in regard to Hopkins' particular program, and the general academic program as it relates to the government's problem, and then go on to consider some of the particular points about Hopkins.

At Hopkins in the Department of Operations Research and Industrial Engineering, we have 10 full-time faculty, and about 50 Ph.D. students. We have very few MA students at all. The ones we do get are mainly those who are sponsored by local industry. We don't encourage MA students on the program. There are a few more who enter the program via an MA in the evening college program run by the University, and this is very active as far as that Department is concerned. Hopkins has a strong graduate school reputation, and this means that the academic standards are somewhat rigorous, which colors the choice of the thesis topics within the Department, because we have some sort of compulsion to be academically respectable within the whole school environment. This places very severe constraints upon the relationship between the University OR Group and government departments. These constraints might be considered undesirable, but they're a function of the structure of society. I think it's a wider problem that we could well consider on another occasion but not here. Given that society places a large value on doctorates and also the University environment encourages vigorous academic standards, it can be very difficult for an OR group to stick to problem solving in their work.

Given this problem of compatibility between the two, I might well ask why do we need ties between the university department and the government agencies. There seem to be two related aspects of this. We need to keep the roots of the OR profession in position to stop it from drifting away into mathematics, and so we have to have a basis in the real world from which to operate. But also, the roots which are provided can feed the OR unit. They can keep it alive and active by providing the initiative on many occasions. I would argue that the relationship between the University and the government agencies is going to have to allow for this somehow, unless we try to restructure society as a whole. The University needs the continued exposure to the problems. At the same time it must be allowed to maintain some of its own standards in terms of the academic criteria set. So there is going to be some sort of trade-off between these two. Basically, a university is an inexpensive source of consultancy. In fact, often the money is not a very important aspect of the relationship, but at the same time anyone who employes a university department must expect that the university be allowed a greater degree of freedom in their choice of subjects and the way they handle the subjects. So therefore anyone who encourages research in a university is likely to be indulging in a more speculative process.

There seems to be two basic sorts of relationship that can exist between an OR Department in a university and something like a government department. If the contract is with a faculty member or a group of faculty, they might then be in a position to distill off small problems which they can feed in a watered down way to some of their Ph. D. students. This is one way. The alternative is to have a contract which directly involves the student, and in which he has a certain responsibility to that contract. This is bound to be unpopular with students since it is likely to increase their length of study. They have a dual responsibility, both to their academic program and also to the sponsor, but this arrangement is more meaningful for the sponsor. He gets work which is more directly relevant to the problem which he sees. So I think government departments should be aware of which relationship they are taking on when they set up a contract with a university, and also be aware that the direct responsibility given to students is likely to prove unpopular with them. We will see how this has turned out at Hopkins in some respects.

The whole situation is rather exacerbating in government research as opposed to industrial research because the problems are ill-defined by nature, and it is very difficult to distill parts of the problems off and treat them as nice self-contained exercises. Countering this is the natural appeal of working for government agencies. Many of the problems are compellingly interesting if you have enough time to sit down and work on them and also there's the sense of social responsibility, I think, which is arising within undergraduate and graduate bodies, in which they feel they wish to get involved in problems of social relevance rather than problems of how to get IBM their extra million profit for the year, say. So there is this counter pressure built up and the two somehow have to balance out. It seems also that what you might call the social realm is the new frontier of OR. It is the area where breakthroughs are needed and where breakthroughs would have great social significance. Possibly in the long term we ought somehow to rethink the position of the OR group within the university, and the relationship between that group and government agencies.

In terms of the work at Hopkins I think I can best illustrate this by showing you a list of the faculty (see table 1). As I mentioned, there are 10 full-time faculty. As many of you will be aware, Dr. Nemhauser is going on sabbatical this year and will be returning, not to Hopkins, but to Cornell, which is a great loss to the Department. At the same time, in 1970 Dr. James Case will be joining us and this will strengthen one of our fields of speciality.

If I might just take this list and present to you some of the natural groupings in terms of the techniques and problem areas in which we are concerned, it will give you an idea of the emphasis which we have in the Department. The first natural grouping consists of DRS. Flagle, Young, and Naddor, in that they are all extremely active in the Johns Hopkins School of Health and Public Hygiene. They hold, all of them, joint appointments between the two. Dr. Glagle is more or less fully involved in that activity and has done a lot of very useful work in the health field. John Young has been somewhat less active because of administrative duties but is still very much concerned with that field, and Dr. Naddor at the moment is using interactive computer systems for diagnosis, mapping a set of symptoms into a set of diseases. The health field has been very active. It rated many doctoral dissertations in the early 60's, and they're now moving into more general problems of models of health care systems on a metropolitan scale. But as the problems become more and more meatier, more and more interesting, this field has become somewhat estranged from the general student body. They are somewhat unwilling to go and serve their apprenticeship in the hospital to learn about health systems and provide the background which is needed to make a significant contribution.

I'll just give you a rough idea of some of the other groupings, because of the time. Drs. Nemhauser, Sparrow and myself have been involved in problems in transportation. We have been particularly active on contracts with the National Bureau of Standards on the Northeast Corridor Project. Particularly we've been concerned about some of the investment problems and it is an area which has brought a lot of interest from the student body.

Drs. Nemhauser, Bellmore and Elzinga have been concerned with mathematical programming in all its facets. Dr. Bellmore in particular has been concerned with network problems, multi-commodity flow networks which are relevant to many items which are the concern of the government. He has in fact worked on many contracts of that form.

A new sort of matching is Drs. Elzinga, Isaacs, and Case, when Dr. Case joins us. These are problems in continuous time, basically. Dr. Elzinga is a chemical engineer by training and has a strong feel for the problems of control theory. Problems of differential games are very similar in that there is a conflict in continuous time. You have strategies to consider, and all these subjects tend to merge together in the use of Hamiltonians and similar concepts.

Finally, outside the main stream of the Department, both Drs. Bellmore and Sparrow have been active in urban problems. Dr. Bellmore has been working on crime problems in the city; Dr. Sparrow on problems of poverty program evaluation for the OEO, and this is a field which I think they might eventually bring to the mainstream of the faculty.

I hope I've given you some of the flavor of the work at Hopkins, and also some feel for the problems of trying to figure the government contract into a university context, and given you some food for thought.

Table 1

The Johns Hopkins University
Department of Operations Research and Industrial Engineering

Dean Roy	Administration - bargaining and conciliation
Dr. Bellmore	Integer Programming; Graph Theory applied to networks
Dr. Duncan	Problems in Statistics
Dr. Elzinga	Control Theory; Non-linear programming
Dr. Flagle	Health Resources; Value and Decision Theory
Dr. Halder	Problems in urban transportation; Capital Budgeting
Dr. Isaacs	Differential Games
Dr. Naddor	Inventory Systems; Health Problems; Computer Interaction
Dr. Sparrow	Resource Allocation in Transportation; Regulation of Public Utilities; Evaluation of Anti-poverty Programs
Dr. Young	Health Resources; Stochastic Processes
Dr. Nemhouser	Going to Louvain on a Sabbatical and returning to Cornell
Dr. Case	Hope he will be joining us in 1970

Joint Meeting of Government
Operations Research Users and Producers

Colonel Robert W. Samz, Ord C
United States Military Academy, West Point, New York

I will talk about our Management Science Program. It is a modest one, mainly because we are an undergraduate institution, and, furthermore, the program has been in existence for only about five years. Also, our program is strictly an elective one. Our cadets are permitted, depending on their area of concentration, to take only six or eight electives during their four years at the Military Academy. Thus, a cadet may take no courses in our program, or up to eight if he wishes.

I can best describe our program by using figures. In doing so, I really feel that I am talking mainly to the faculty members who are here, because they will give you some idea of what subjects our cadets may have studied prior to undertaking your graduate programs in OR.

Figure 1 shows the program as it now exists. Later, I will cover in some detail OE 385, OE 487, EF 382, and SS 482. Our individual Ordance Project, OE 482, is of particular interest because we have had some interesting research under that title. In one project, a cadet developed a computer program to assist in the diagnosis of illnesses. His model used the Baysian approach in connection with subjective probabilities for certain illnesses, given a set of symptoms. These probabilities he obtained from the medical officers in our hospital. We plan to continue this project and hopefully the end result will permit a medical aide to take data form the patient and then using a remote computer terminal obtain a diagnosis.

Another interesting project attempted to determine if there is a correlation between ESP and military leadership potential. Actually this was an extension of work done by Milhauskey of the Newark College of Engineering. He hypothesized that people who exhibit high ESP are successful in business. If this hypothesis is correct, we could then identify our successful leaders early in their military careers. Our criterion of success was the rank attained by the cadet at the start of his fourth year at the military Academy. Fortunately, we have the capability of following through with the study after the cadet's graduation. By the use of personnel records we could determine whether or not a certain individual was promoted with or ahead of his classmates, and also whether or not he becomes a general. This long term study should be of great interest. So far, our conclusion is that the hypothesis should be rejected.

Two other projects of interest were the improvement of our dental clinic administration and redesign of our printing plant. Our Dental Surgeon was very pleased with the first.

Another course of interest, which does not show on the figure is our Honors Course in Ordinance Engineering. In this course, about 15 top ranking cadets study the standard course at an accelerated pace during the first semester, and then undertake research projects during the second semester. A few are now becoming interested in OR projects. Hopefully, this interest will expand. These cadets should be able to produce high quality work because of their high academic standing.

Figures 2 through 5 show you the details of some of our courses. They are self-explanatory and so I will not comment on them.

Management Science Field:

a. Elective Course List:

Principal	Associated
OE 385 Managment Engineering	MA 486 Numerical Analysis with digital Computation
OE 487 Operations Research	MA 482 Abstract Algebra
MA 481 Linear Programming	MA 483 Vector Calculus
EF 382 Computer Sci Fundamentals	OE 482 Individual Ordnance Project
PL 481 Managerial Psychology	P1 485 Behavioral Science Research
SS 482 Economic Analysis: Theory & Defense Applications	

b. Elective courses required for credit for elective concentration in the Applied Science and Engineering Area:

1. OE 385, OE 487, SS 482, and

2. At least two electives chosen from the combined lists of principal and associated electives.

c. Course Selection Guidelines:

Above average competence in mathematics, especially probability and statistics is desirable.

d. Suggested Course Sequences:

1. OE 385, OE 487, SS 482, EF 382, MA 486

2. OE 385, OE 487, SS 482, PL 481, PL 485

3. OE 385, MA 481, OE 487, SS 482, OE 482

Figure 1

OE 385 - MANAGEMENT ENGINEERING - 2 1/2 Credit Hours

Elective Course - Prerequisite: MA 202

TEXT: Analysis for Production and Operations Management, by Bowman and Fetter, Fetter, Third Edition
Operations Planning and Control by James H. Greene

PURPOSE: The purpose of the course is to introduce the student to the analytical approach to solving managerial problems and to help him develop a facility in the use of quantitative techniques currently used to aid the decision maker. This course provides necessary background for later in-depth study in the field of Operations Research and Management Science.

SCOPE: This course provides a comprehensive survey of quantitative methods currently used in managing military, industrial and government organizations. Emphasis is on problem solving from the systems viewpoint. The course begins with a study of the general production system, schematic models, work measurement, methods improvement and decision theory. Statistical analysis provides clearer insight into "Management by Exception" through the study of quality control and acceptance. Economic analysis introduces inventory control theory, queueing theory (waiting line analysis), and Monte Carlo simulation. Project management develops network techniques such as CPM and PERT for scheduling and controlling large scale projects. Engineering programming emphasizes the general problem of optimizing with limited resources. A case study and an educational trip relate course material to real world problems.

LESSON DISTRIBUTION - Length of Normal Lesson: One Hour

Schematic Models	Decision Theory	Statistical Analysis	Economic Analysis	Proj Mgt.	Engineering Programming	Case Study
4	4	11	10	4	5	3

No laboratory Periods

Figure 2

OE 487 - OPERATIONS RESEARCH - 2 1/2 Credit Hours

Elective Course - Prerequisite: OE 385 and be in the upper one-half of the class in mathematics, or permission of Department.

TEXT: Operations Research:Methods and Problems by Maurice Sasieni, Arthur Yaspan, and Lawrence Friedman.

PURPOSE: The purpose of the course is to provide an introduction to current methods of Operations Research used to quantitatively analyze and solve managerial problems. This introduction will be an adequate foundation for later in-depth studies of any of the methods covered. In addition, it will provide the student with an appreciation and understanding of the usefulness and limitations of the methods of Operations Research as an aid to the decision-making process. Also, it will serve as a sueful background for rational decision-making all during the future officer's military career.

SCOPE: The course is initiated with an overview of the decision-making process and a review of probability and statistics. After the introductory phase, the following topics are covered: (1) Sampling Theory, (2) Curve Fittings, (3) Monte Carlo Methods, (4) Inventory Theory, (5) Replacement Theory, (6) Reliability Theory, (7) Maintainability Theory, (8) Queueing Theory, (9) Competitive Strategies, (10) Allocation of Resources, (11) Dynamic Programming, and (12) Macrocombat Models. Emphasis is placed on problem identification and definition, variable identification, word-to-mathematical model transformations, seeking optimum analytical solutions of these models, and verification of solutions.

LESSON DISTRIBUTION: Length of Normal Lesson - One Hour

Decision Making Process	Review of Probability and Statistics	Sampling and Curve Fitting	Monte Carlo Methods	Inventory Theory	Replacement Theory
4	6	4	3	4	4

Maintainability and Reliability	Queueing Theory	Competitive Strategies	Allocation of Resources	Dynamic Programming	Macro Combat Models
2	3	2	4	2	3

No Laboratory Periods

Figure 3

EF 382 - COMPUTER SCIENCE FUNDAMENTALS - 2 1/2 Credit Hours

Elective Course - Prerequisite: EF 101 or EF 151 - 152

TEXTS: Systems Analysis: A Computer Approach to Decision Models, McMillan. Claude, and Gonzalez, Richard F.
A Guide to Computer Programming, Staff & Faculty, U. S. Military Academy

PURPOSE: To provide the cadet, who already possesses a basic familiarity with the use of the digital computers, a comprehensive introduction to the computer science field.

SCOPE: EF 382 introduces the student to the computer as a tool to assist in the solution of a number of military, business, and engineering problems. By the end of the course the student should be aware of both the capabilities and limitations of the computer when used to solve these types of problems. Heavy emphasis is placed on developing skill in writing computer programs using the FORTRAN II programming language with punched card input and printed output. Introductions to FORTRAN IV magnetic tape operations, and geographical output techniques are included. Topics stress include Monte Carlo simulation techniques, random number generation, and information retrieval. A term problem must be completed by each cadet. The problem is an exercise in the application of computer programming skills to the solution of a specific military problem. A four-hour battalion level computer assisted 'war game' may be included subject to availability of time.

LESSON DISTRIBUTION: Length of Normal Lesson - One Hour.

FORTRAN II Language	Graphical Output Techniques	Data Processing	Random Number Generation	Simulation Techniques	FORTRAN IV Language	WAR Game
8	4	8	5	9	5	2

Figure 4

SS 482 - ECONOMIC ANALYSIS: THEORY AND DEFENSE APPLICATIONS - 2 1/2 hours

Elective Course - Prerequisite: SS 301

TEXTS: Economic Theory and Operations Analysis, W. J. Baumol
Economics of Defense in the Nuclear Age, C. J. Hitch and R. N. McKean
Analysis for Military Decisions, E. S. Quade

Purpose:

The cadet should: (1) learn thoroughly the principles of marginal analysis, (2) increase his familiarity with microeconomic theory, (3) acquire an appreciation for the use of basic mathematics in economic analysis, and (4) become acquainted with the application of economic analysis in decision-making within the Department of Defense.

SCOPE:

This course covers the main body of microeconomic theory as it explains behavior in a market economy. The objects of investigation are individual households and business firms as consuming and producing units. We seek to discover the principles which guide their activity connection with the use of productive resources for the fulfillment of their wants and needs. The concepts and principles of marginal analysis are applied to the development of effieient defense policies regarding force structure, force levels, and weapon systems.

The unifying theme of the course is a model of rational decision-making. This model, long the basis of microeconomic theory, provides the rationale for planning in the Planning, Programming, Budgeting System (PPBS) which was introduced by the Department of Defense in 1961. (In 1965 the President ordered that PPBS be employed by the other agencies and departments of the Federal Government.) The model also constitutes the logic of systems analysis and operations research.

The rational decision-maker has an explicit awareness of his goals. He compares the courses of act on available to him with regard to their relative ability to attain his goals and the relative extent of their use of his valuable resources. In view of the fundamental scarcity of these economic resources, he is considered to shoose that course of action which either achieves his goals while using the least amount of resources or affords greater goal-attainment for a given amount of resources. Such behavior explains the supply and demand curves of economics on the one hand and leads to effi ient use of scarce resources in the pursuit of national defense goals on the other.

LESSON DISTRIBUTION: Length of Normal Lesson: One Hour

Theory of Demand	Production and Cost	The Firm and Market Structure	General Equilibrium and Capital Theory
7	10	5	9

Defense Applications of Economic Analysis - 11

Figure 5

Joint Meeting of Government
Operations Research Users and Producers

Dr. J. R. Borsting
Naval Postgraduate School, Monterey, California

I'd like first to describe the various programs that we have at Monterey. It is an institution of roughly 1400 students, all military officers from various services, Army, Navy, Air Force, and Marine Corps, with a staff of about 240 faculty. In the Operations Analysis Department we have a BS program, an MS, and we are going to start a Ph.D. program next year in Operations Research. We also service all the other programs at the School by giving survey courses in Operations Research.

At the moment the student body enrolled in the Master's Program in Operations Research at the school is 240; this is a fairly significant number when you realize that the total student body is 1400. Of these 240 students, 50 percent are Navy, 25 percent Army, 25 percent Marines. There are a few foreign officers, some Coast Guard, and a few different type of students but they are small in number.

Next, I would like to make a few comments about our Master's Program. It has the normal course work that you would find in most OR programs, plus some specialized course work in military OR. A thesis is required for the MS degree. It also has an experience tour in which the student will go for six weeks in an OR organization like the Center for Naval Analysis, the Rand Corporation, SRI, Navy Labs, and other similar places to work on applied OR problems. Many times a dissertation topic is picked up during this time. Another way the student gets his master's thesis is to work with a faculty member on one of our sponsored research projects.

Faculty in the department is composed of 32 full-time faculty members, 29 of which have a Ph.D. The faculty have varied backgrounds. Some have their Ph.D. in Operations Research, some in Mathematics, some in Mathematical Economics, some in Systems Engineering, and some in Physics. One of the strong points of the Department is its interdisciplinary nature.

To give you some idea of some of our student research areas, on Figure 1 you will see some recent theses that are theoretical mathematical programming. Many of these have been submitted for publication in ORSA and TIMS or related journals. On Figure 2, you will notice some applied theses. The first thesis, for example, is an analytical model for use in studying underway replenishment at sea. This specific research is sponsored by the Ships System Command.

Figure 3 shows some applied thesis topics. The first topic is a Marine Corps Helicopter Requirement Model. This was a project that stemmed from operational problems in Southeast Asia and was sponsored by the Advanced Research Project Agency. Most of these problems on the last two figures were chosen either by the student during his six weeks experience tour or by working with a faculty member on our faculty research projects. As the figures indicate, the research is both theoretical and applied.

Besides the projects sponsored by the Ships System Command and ARPA, I would like to mention a few of our other projects.

Spectrometric oil analysis for naval aircraft; war gaming and simulation; theory of cost benefit studies; exponential smoothing and forecasting; demand and inventory systems; optimal record accuracy; policies for multi-item inventory control subject to financial constraints; systems studies in counter-insurgency; reliability models; optimazation methodology of systems with alternate success paths; use of discount rating and cost benefit studies; human factor data collection research projects.

We also have faculty working on internally sponsored research and also on their own in various areas of research. The various areas of research are mathematical programming, integer programming, non-linear programming, dynamic programming, various topics in mathematical economics, reliability, search and detection, pattern recognition, human factors, OR management information systems, queueing problems, etc.

I guess what we as a Department of Operations Analysis could use from a sponsor is either research support or possibly placing one of our students for a six weeks experience tour doing applied OR techniques.

Dr. Lieberman mentioned this morning that Stanford was one of the top three Operations Research departments in the country and pointed out that there were only three departments in the country called Operations Research. I would like to point out that we are the top Operations Analysis Department in the country. Of course, I don't know of any other departments that are officially called this but if that is the case we can have that title without difficulty.

RECENT OA/SA M/S. THESES

ON NETWORK ANALYSIS

COMPUTATION OF MAXIMUM FLOWS IN NETWORKS

A TECHNIQUE FOR SPEEDING CONVERGENCE IN SOLVING LINEAR PROGRAMS

A BRANCH AND EXCLUDE ALGORITHM FOR THE KNAPSACK PROBLEM

ON INTEGER LINEAR PROGRAMMING

AN ALGORITHM FOR THE SOLUTION OF LINEAR PROGRAMMING PROBLEMS

METHOD FOR COMPUTING THE GREATEST COMMON DIVISOR AND APPLICATIONS IN MATHEMATICAL PROGRAMMING

THE USE OF THE GENERALIZED INVERSE IN THE GENERAL LINEAR STATISTICAL MODEL

Figure 1

RECENT OA/SA M.S. THESES

AN ANALYTICAL MODEL FOR APPLICATION TO THE OPERATION OF REPLENISHMENT AT SEA

OPTIMAL INVENTORY OPERATING POLICIES UNDER RELAXED DELIVERY ASSUMPTIONS

COSTS OF OPERATING AN INVENTORY SYSTEM WITH INACCURATE RECORDS

AN EVALUATION OF A PROPOSED METHOD FOR DETERMINING THE BAYESIAN LOWER 100 (1-a)% CONFIDENCE LIMIT ON SERIES SYSTEM RELIABILITY

A STUDY OF OPTIMUM TARGETING GEOMETRY FOR MIRV SYSTEMS

AN EXPERIMENTAL STUDY OF INTERPRETER PROFICIENCY AS A CRITERION FOR IMAGE INTERPRETATION PERSONNEL ASSIGNMENTS

A BAYES SEQUENTIAL DECISION RULE FOR THE TRACKING AND ATTACK PROBLEM

NAVERR PENETRATION MODEL: A COMPUTER SIMULATION

DESCRIPTIVE MODELING TECHNIQUES FOR ANTISUBMARINE WARFARE SYSTEMS

Figure 2

RECENT OA/SA M.S. THESES

HELICOPTER REQUIREMENT MODEL FOR UNITED STATES MARINE CORPS REGIMENTAL LANDING TEAM

PARAMETER ESTIMATES FOR MATHEMATICAL MODELS OF CONVOY AMBUSHED

COMPUTER SIMULATION OF FIELD ARTILLERY LOW ANGLE INDIRECT FIRE OPERATIONS

A SEQUENTIAL DECISION-MAKING APPROACH TO POPULACE SCREENING IN COUNTERINSURGENCY OPERATIONS

A STUDY OF THE HAMLET EVALUATION SYSTEM USING FACTOR ANALYSIS

NAVAL RECONNAISSANCE IN NORTH VIETNAM JAN-MAR 1967

A PROBABILITY OF ACQUISITION MODEL FOR A DASH-LAUNCHED MARK-46 TORPEDO

AN INVESTIGATION OF CIRUCLAR, FINITE QUEUEING SYSTEMS IN AMPHIBIOUS OPERATIONS

A METHODOLOGY FOR INVESTIGATING THE FACTORS AFFECTING THE OUTCOME OF A SUBMARINE VERSUS SUBMARINE ENCOUNTER

A PARTIAL ANALYSIS OF ASROC-LAUNCHED MK-44 MOD 2 TORPEDO ATTACK

AIRCRAFT SURVIVABILITY INDEX FOR LOW ALTITUDE PENETRATION

Figure 3

Joint Meeting of Government
Operations Research Users and Producers

Professor B. Curtis Eaves
University of California, Berkeley, California

My comments pertain to the Management Science Group of the School of Business at the University of California at Berkeley.

Our group offers the Master of Science and the Ph.D. Our students receive broad training in the theory and application of Operations Research techniques. The course work is divided more or less evenly over the following subjects: Economics, Organization Theory, Linear Programming, Dynamic and Nonlinear Programming, Stochastic Models, and Computer Applications.

Our Master's students are not trained to create algorithms but rather to apply them.

The Ph.D. program is designed to enable, encourage, demand that the student do fundamental work. Most of our students have an engineering background, a few do not. The Master's thesis and the Doctoral dissertations are chosen from both pure and applied areas. We encourage student and faculty interaction. The group size fluctuates around 10, normally all of whom are Ph.D.'s The background of the group is varied. We have degrees in OR, Mathematics, Statistics, Economics. Only two have degrees in Business.

Research projects of the group are as varied. Some projects are distinctly applied while others are equally pure. Long run interests of the group include in a very real sense Mathematical Programming, Dynamic Programming, Inventory Theory, Large Scale Systems, Network Theory, Organizational Theory, Economics, Scheduling, Game Theory, Computer Simulations, and Languages.

Active topics of current interest of the group are the Use of Computer Planning and Debate in Planning, Morality in Planning, the Linear Complementarity Problem, Fixed Point Theory, Job Shop Scheduling via Computer Driven Gantt Chart Displays, Algorithms for Computing the Probability of the Paradox in Voting, Games with Incomplete Information, Rational Choice Models, Unique Determinate Solutions in Games (this is a book that is being written by John Harsanyi), Computer Implementation of the Convex Simplex Method, Transitivity of Choice, Dynamic Oligopoly, Games defined in Characteristic Function Form, Maximum Likelihood Estimates under Constraints, Decision Rules of Savings and Loan Associations, Cooperativeness in Duopoly, Comparative Theory of Resource Allocation, Economics of Information, R&D Models (this is a book by Thomas Marschak), Price Comparison and other Adjustments Processes in Organizations, Quarterly Forecasting for the State of California, Urban Planning Models, Minimizing Concave Functions of Polyhedra, Multi-commodity Flows, Large Scale Linear Programs (Willard Zangwill has a new book on Non-Linear Programming), Cutting Plane Methods, Stochastic Network Problems.

Our group has interacted with user groups and wants to continue to do so, in two senses. One, consulting, and, two, from the standpoint of students, seeking projects. The latter has, to date, been free to the user.

Joint Meeting of Government
Operations Research Users and Producers

Dr. Ronald W. Shephard
University of California, Berkeley, California

I'm here to speak for the Department of Industrial Engineering and Operations Research in the College of Engineering at Berkeley and also for the Operations Research Center which is a kind of a captive research organization of that Department. I think that I can put my remarks in perspective by just a brief history.

I returned to the campus at Berkeley in 1957 for the express purpose of developing the program of research and instruction in Operations Research in the Department of Industrial Engineering.

I became the Chairman of that Department in 1960 and remained so until 1964, and, following our usual policies at the Berkeley campus, I was rotated out of that administrative position, and, when Professor Dantzig was hired away from us by Stanford University, I rotated back as the Chairman of the Operations Research Center.

The situation I was confronted with in the late 1950's when I returned to Berkeley was that there were little if any identifiable programs in Operations Research. The few available, and I do not wish to slight anyone, that come to my mind are: One in Johns Hopkins, one at Case, and a certain collection of activities around Morse at MIT. When I looked at these programs it did not appear to me that they were very well structured so I proceeded to recruit faculty for our Department and set about structuring the program. Well, what has happened is that during those three or four years I was Chairman, we did develop a highly structured program in Operations Research, largely of theoretical content.

The structuring was somewhat at variance with the team concept then popular around the late 1950's and early 1960's, but it was the consensus of opinion in our College that this subject matter should be developed as a field of Engineering Science, at least so far as the College of Engineering was concerned, and that it therefore ought to be a structured program in some way.

We decided to develop this program as a field of applied science and this accounts for developing it as a theoretical program. Concomitant with the establishment of the program in the Department, we were fortunate enough to get the assistance of the Office of Naval Research to initiate a funding for research programs in what we then set up as the Operations Research Center.

This Center serves as a means to develop the subject matter and for the faculty to do research, and I believe the courses we have now, I am not going to list them, are the standard subjects that appear in most curricula today.

Supplementing this program of regularly scheduled courses, we have frequent seminars. There are two or three each quarter, and then a host of individual studies carried on by students under Course 299. The Operations Research Center still provides a means for the faculty to continue to develop the state of knowledge in this field of applied science. It also serves as a means for financial support of graduate students and for their education in their individual study. The Center is located in Etcheverry Hall, consisting of a meeting room for students, a student area with desks and a library. The Center cooperates with the Institute of Traffic and Transportation Engineering as an adjunct to the College of Civil Engineering, also with the Sanitary Engineering Research Laboratory, and with the Systems Engineering Group in Electrical Engineering.

Our sponsors have been largely the Office of Naval Research, the United States Army Research Office - Durham, the National Science Foundation (Mathematics Division), the National Science Foundation (Engineering Division), and the United States Department of the Interior (Water Resources), and also, the State Department of Water Resources.

Now, all of our students participate in the activities of the Center as graduate students whether they are supported by fellowships, both foreign and domestic, or whether they are research assistants.

We currently have twelve faculty, and I will briefly review these faculty and indicate their areas of interest. I will start with myself. My basic research interests are in the mathematical economic theory of production, sequential decision procedures and institutional planning.

Professor David Gale, I am taking them in order of age, is well known to some of you, perhaps. He is a man who has done much research in linear programming and game theory and, more recently, has been engaged in optimal economic development.

My younger colleague, Professor William S. Jewell, has done considerable work in flows in networks and Markov renewal processes and continues to be interested in these areas.

My colleague, Professor Robert M. Oliver, has done work in traffic theory and is not engaged in institutional planning.

One of our new colleagues, Professor Richard Karp, is a man whose main field of interest is in computer science, and his specialties are in integer programming and combinatorial problems.

Professor Richard E. Barlow, on our staff, may be well known to some of you. He works in the mathematical theory of reliability and also does research in statistical estimation and testing in this subject matter.

My colleague, Professor Stuart Dreyfus, is working in dynamic programming and variational problems and control theory.

My colleague, Professor C. Roger Glassey, works on scheduling and mathematical programming.

And getting younger now, Professor Richard Van Slyke works on mathematical programming and optimal control problems. He holds an appointment jointly with Electrical Engineering and our Department.

Professor Ronald W. Wolff has been working in queueing theory.

Two of our new younger colleagues, who were Ph.D. 's from Stanford, our friendly rival down on the Peninsula: Sheldon Ross is doing work in Markov decision processes and Donald Topkis is working in non-linear programming and inventory theory.

We have about 100 students now. I think originally we started with about 10 students, went to 125, and cut it back to 100 because we could not sensibly handle the number of students we had. The students in Civil Engineering and Electrical Engineering take our courses to supplement their studies in applied science. The students in Civil Engineering need the subject matter as much as our students in Industrial Engineering particularly in hydraulics, sanitary engineering, and transportation engineering. Over the past six years we have produced 50 Ph.D. degrees. I will not try to list their theses. They average about eight a year.

Where have the students gone? Well, they have gone into universities, research laboratories, consulting firms, industry and government.

Universities which have hired our output are Stanford, UCLA, Business Administration at Berkele , Yale, Harvard, Purdue, University of Pennsylvania, MIT, Naval Postgraduate School, a technical college in England, an Australian college whose name escapes me, and I think there was one student who went to Case, but I am not sure.

In the research laboratories, they have gone to Bell, Boeing Scientific Laboratories, and Rand. In consulting they have gone to Arthur D. Little and a local consulting company called Optimum Systems, and several others which I cannot recall. In industry they have gone to Esso, (Standard Oil), IBM, and several others I cannot recall. The one government man was sent to us from the Bureau of Mines and he has returned to his duties there.

The publications of the Operations Research Center are too numerous for me to enumerate. During the past six years there have been some 275 research publications, of which about 224 are available, and, in lieu of having these research reports available. I have told the people at the National Bureau of Standards that I will send them a complete set of those available so that they can put them in their library for those of you in the government service who may wish to see them.

If you look at these publications, you will see that we are strongly oriented to a theoretical approach in this subject matter. That decision was made very early because it was our judgment that in keeping with the tradition of our College, a College basically of applied science and not procedural engineering, we should try to develop the basic knowledge in the field and continue to do so. Yet we have certain professional objectives, and we have tried various applied projects with questionable success. I think in balance that a university cannot effectively work on real operating problems in industry, and the sort of things we have done, I believe, basically are fairly superficial, so we still cling to our theoretical work. However, in view of our professional aims, and bec use applied studies are needed to mature our students and provide our faculty with the stimulation of real problems, we are going to try cautiously to see a problem area that has enough depth and variety so that we can attack various kinds of issues. We hope that we may find a sponsor in the government who will give us long term research support in this area without expecting us to be at all close to the operating solutions of their problems, and hopefully we can begin to develop theory and methods and procedures that will be of some use to them.

Joint Meeting of Government
Operations Research Users and Producers

Professor R. C. Wilson
University of Michigan, Ann Arbor, Michigan 48104

My hope is to give you a subliminal picture of The University of Michigan since in the short time available I obviously cannot give you a description of the complete complex.

First, some statistics on the size of the University: an enrollment of 22,000 undergraduates, 14,700 graduate students, 2,800 Masters Degrees granted per year; 500 Ph.D.'s; 950 professional degrees, e.g., medicine, law, dentistry; $150 million annual operating budget of which $62 million a year is in research expenditures.

Because I am representing only the Industrial Engineering Department, I must slight the complex of bureaus, institutes, centers, and other schools and colleges which comprise the University.

The table below provides a summary by title of the diversity of academic and research programs of the University.

SCHOOLS AND COLLEGES

Architecture & Design	Flint College	Music
Business Administration	Graduate	Natural Resources
Dearborn Campus	Law	Nursing
Dentistry	Library Science	Pharmacy
Education	Literature, Science & the Arts	Public Health
Engineering	Medical	Social Work

MAJOR BUREAUS, INSTITUTES AND CENTERS

Institute of Continuing Legal Education
English Language Institute
Institute for Fisheries Research
Institute of Gerontology
Highway Safety Research Institute
Institute for Human Adjustment
Institute of Industrial Health
W. K. Kellogg Foundation Institute for Graduate and Postgraduate Dentistry
Kresge Hearing Research Institute
Institute of Labor and Industrial Relations
Mental Health Research Institute
Michigan Memorial-Phoenix Project
Neuropsychiatric Institute
Institute of Public Policy Studies
Institute of Science & Technology
Simpson Memorial Institute
Institute for Social Research
Institute for the Study of Mental Retardation
Audio-Visual Education Center
Center for Chinese Studies
Center for Continuing Education of Women
Center for Human Growth and Development
Human Performance Center
Center for Japanese Studies
Legislative Research Center
Center for Near Eastern and North African Studies
University of Michigan Population Program
Center for Research on Conflict Resolution
Center for Research on Economic Development
Center for Research on Language and Language Behavior
Center for Research on Learning and Teaching
Center for Research on Social Organization
Center for Russian and East European Studies
Center for the Study of Higher Education
Computing Center
Center for Continuing Engineering Education
Bureau of Industrial Relations
Bureau of Business Research

The college of Engineering has an enrollment of 3,300 undergraduates, and 1,000 graduate students; grants roughly 100 Ph.D. 's per year, 500 Masters Degrees, 600 Bachelors Degrees, drawing on an engineering faculty of 300, and an annual budget of about $20 million.

The Department of Industrial Engineering enrolled 250 undergraduate students, and 100 graduate students. We are granting 60 Bachelors Degrees in Industrial Engineering each year, 30 Masters Degrees, and roughly six Ph.D.'s per year. The Industrial Engineering faculty comprises 19 full time members.

This faculty, together with graduate students and a small research staff are enriching their teaching and research capabilities through sponsored research and grants in the areas of operations research, information processing, human performance, and industrial systems design. The Department is interested in additional support of a similar nature where it is compatible with the educational objectives of the students and the University. The research interests of the Department fall into the eight categories shown below:

1. Optimization Theory
2. Stochastic Process Theory
3. Defense Systems Theory
4. Human Performance
5. Health Systems Design
6. Information Processing Systems Design
7. Industry Operations Analysis
8. Higher Education Systems Analysis and Design

We briefly describe some of the research interests of the faculty in more detail:

Mathematical Programming, Network Flows, and Graph Theory:

Interests toward developing algorithms that would enumerate all complementary feasible solutions and tests for the uniqueness of a complementary feasible solution. Developing an algorithm for the traveling salesman problem which has been transformed into the problems of minimizing a differentiable convex function on the finite set of extreme points of a convex polyhedron described by a small number of linear constraints. Other interests include branch and bound algorithms, integer programming and stochastic programming.

Optimal Control and Calculus of Variations:

An investigation of necessary and sufficient conditions, as well as existence theorems for optimal solutions to various types of control systems, such as deterministic, stochastic, and distributed parameter systems with applications of these results to dynamic operations research models.

Stochastic Processes and Queueing Theory:

The study of Semi-Markov Processes arising in stochastic flows in networks. The analysis of time shared computer systems using queueing theory models.

Military Operations Research:

Development of resource planning methods for next generations air defense systems (U.S. Army Missile Command); a parametric design cost-effectiveness study (U.S. Army Weapons Command); development of methods to ascertain trade-offs in combat functions (Headquarters, Department of the Army); and development of mathematical theories of conflict (Office of Naval Research).

Man Machine Systems Performance:

Prediction and optimization of the performance of humans in the man machine systems. The use of learning rates of humans and the appropriate job assignment of people with respect to anthropometric, psychological, physiological, and medical viewpoints.

Quantitative Methods for Medical Management:

Present work includes methods for determining optimal strategies in disease control, and in the allocation of funds and personnel with special focus on rheumatic fever. Other projects include the development and evaluation of instruments for measuring hospital performance, the evaluation of alternative approaches to organizing the patient care service of hospitals, and a study to evaluate and design a health delivery systems for the diagnosis and treatment of cancer on a community level.

The Design of Informational Processing Systems:

Current work is concerned with the development of a problem statement language and techniques for automatic analysis of requirements and the optimization of the design of information processing systems. The eventual goal is to automate as much as possible the effort involved in designing and constructing such systems. Other work includes the development of programming languages for computer graphics for designers.

Operations Analysis:

Current research includes scheduling a flow shop producing for a finished goods inventory. Markov renewal programming is being applied to scheduling decisions involving sequencing, lot size, overtime, with stock-outs not permitted. Other work includes failure and maintenance management for multi-component machines, and stochastic models of supply problems.

These are areas of current activity and interest in which we expect to continue. In addition, exploration into the potential of application of operations research to management of the resources of institutions of higher education is being investigated.

Finally, let me comment very quickly about our Engineering Summer Conference Program. The College of Engineering offers more than 40, one- or two-week short courses each summer for people in government, industry, and other educational institutions. These range broadly over topics such as numerical methods, simulation, nuclear power engineering, computer graphics for designers, fundamentals of remote sensing, operations research, etc.

If you have need for further information about any aspects of The University of Michigan, please feel free to contact:

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Joint Meeting of Government
Operations Research Users and Producers

Dr. A. W. Wymore
University of Arizona, Tuscon, Arizona

The Department of Systems Engineering is a full-fledged Department in the College of Engineering at the University of Arizona, coexisting with such other Departments of Engineering as Nuclear, Mechanical, Electrical, Civil, and the other classical disciplines. We offer the Masters and Ph.D. in systems engineering and a Bachelor of Science degree in engineering mathematics.

The program and the curricula roughly revolve around six basketsful of ideas, one of them being classical engineering mathematics; another basket of ideas is probability and statistics; the third basket of ideas is computer science; the fourth is operations research and optimization techniques; the fifth is human factors; and the sixth is system theory.

All our undergraduates take sequences of courses in each of these six areas. The graduate students all have to pass qualifying exams in the six areas, but aside from that the program at the graduate level, at least, is extremely flexible and can be tailored very closely to the student's individual needs and goals, etc.

We tend to look at some of these programs, these basketsful of ideas, rather broadly, and in some sense, not with the usual interpretation. For example, human factors we tend to think of in very much a generalized way, that is, human factors involves not only the interaction of human beings with machines in the classical, design-a-better-knob sort of school of thought, but generalized to include the role of human beings generally in systems, the role of human beings in relationships to one another in organizations and even the study of the interface between technological systems of one kind or another and the surrounding social environment. So we have the man-machine interface, the man-man interface, and the system-society interface that we include in the human factors aspect of our program.

We have approximately 40 graduate students, typically, and approximately 130 or so undergraduates at any given moment. Of the 40 graduate students typically eight to 10 are bona fide Ph.D. candidates. We have 11 full-time faculty members and their backgrounds are extremely varied as one might expect in a systems engineering program.

If there is any one point of view or aim for the Department I would have to say that this is undoubtedly the point of view of acceptance of the responsibility for total system design, whatever that happens to be in a given client/problem context. Another point of view, which we espouse, is the development of mathematical models to enable this total system design, so that almost all our research, one way or another, is devoted to the development of mathematical models of very complex system phenomena almost always involving human beings in one role or another, or even exclusively involving human beings. We are taking on this broad spectrum of responsibility and point of view.

To give you an example of the kind of thing which we are most interested in: we currently have a contract with the Indian Health Service to do, at least, the very preliminary design of a total health delivery system for the Papago Indian Reservation which is close to Tuscon and the University of Arizona. This is a Reservation extending for several hundred miles in the east-west direction, and north-south direction too, involving some six thousand Indians spread over this territory; so the problem of communications, of deployment of health personnel, of providing transportation and information flow as well as the interrelationships between doctors and nurses and social workers and all this sort of thing is the problem of the total system design that we have undertaken in this case, at least in the preliminary stages. And this is the kind of work, I think, we are most interested in at the moment.

We are developing a systems engineering laboratory where we hope, based on the work which is being done in the Department in mathematical system theory, to develop models which will have some unique and novel character to them, and then to calibrate these models under rather controlled laboratory conditions. This is our basic research aim for the foreseeable future, at least now that we will be disengaged somewhat from computer science aspects. We have in the past done a lot of work in computer science and pattern recognition and information retrieval systems and standardized language design and that sort of thing, but we are now spinning off from the Systems Engineering Department, a Computer Science Department, independent in its own right, and can now devote more of our Departmental resources to the development of the generalized human factors aspects. And that's the primary direction that we will be going in the future.

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Dr. William R. King
University of Pittsburgh, Pittsburgh, Pennsylvania

Any university which has some competence in operations researchers would like to feel that the range of its capabilities is wide. At the University of Pittsburgh, we have as broad a scope of operations research as most universities and some unique interests which serve to define our "OR personality." In discussing operations research at the University of Pittsburgh, I will purposefully limit myself to describing ongoing research activities rather than vague interests or competencies. This, the projects which I will note are indicative of our interests but are certainly not an exhaustive listing of them.

Like most large universities, we have people with operations research orientation in many schools and departments. The primary centers of operations research activities are in the Graduate School of Business and the Department of Industrial Engineering, Operations Research and Systems Management Engineering.

The Graduate School of Business offers a strongly analytical MBA degree, a Ph.D. in business in which a specialization in operations research is possible, and a range of specialized programs of which the Management Program for Executives--one of the oldest, yet most modern in the nation--is illustrative. In the Industrial Engineering Department, degree programs are offered at the BS, MS and Ph.D level.

One of the unique features of the University of Pittsburgh is that it has been quite successful in breaking down traditional academic disciplinary barriers. While this is a goal of most universities, it has been realized by few. The three primary media for interdepartmental and interschool activities have been research centers, university-wide projects and close personal contacts between faculty members in the various academic organizations.

The University's Learning Research and Development Center and the Knowledge Availability Systems Center both conduct research in areas of interest to operations researchers. Both these and other centers have drawn on the operations research resources of the university. The Graduate School of Business' Management Research Center provides a framework for the support of research of a management orientation.

A university-wide task force on urban problems has been in existence for some time. This task force is developing the university's research plan in the urban area--now being undertaken through a HUD-sponsored urban transportation study. This study indicates the interdisciplinary nature of our interests, since it involves operations researchers, economists, sociologists and public health specialists. We have or are conducting studies of intermodal freight transportation, the timing of the impact of government expenditures (NASA-sponsored), planning and network analysis for the United States Air Force and program budgeting for the Department of Transportation. Other major ongoing interests include Management Information Systems, Logistics and Operations research as applied in hospitals and educational institutions.

To sum up, let me say that our OR interest is problem oriented rather than methodological oriented. We believe that the best motivation for the development of new theory is the existence of real-world problems and that a range of activities across the spectrum from application to theory is the best way that our university can fulfill its role in operations research.

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Professor F. J. Gould
University of North Carolina, Chapel Hill, North Carolina 27514

I'd like to just briefly outline the prospects for the development of an operations research program at the University of North Carolina.

At this University there has been faculty interest for a number of years in operations research. However, there has been no organized program. Several years ago a committee was formed to explore the prospect for operations research, both on the Raleigh and Chapel Hill campuses. You have already heard from Professor Elmaghraby, I believe, a discussion of developments that are particularly related to the Raleigh campus.

Concerning Chapel Hill, an ad hoc committee was formed during this past year under the leadership of Professor George Nicholson to formulate a specific program for the Master of Science and Ph.D. program. At this point the inevitable philosophic discussions began to be heard concerning, in brief, theory vs. applications.

The resolution has been to view the program from the mathematical sciences perspective with a rigorous core rooted mainly in the Departments of Statistics, Mathematics, Computer and Information Science, and with considerable cooperation and interest from the School of Business. This resolution is partly due to existing faculty interests and also to the fact that whenever the question of teaching applications is raised the question of how to teach applications is also raised, and nobody seems to have a good answer to the latter question.

I wonder if there isn't a good deal of mythology associated with the concept of teaching students to be skillful appliers of operations research. Perhaps the most realistic answer is to teach the theory during the doctoral training and let the applications follow, possibly during the dissertation or even at the post-doctoral level.

On the other hand, the other side of the story on the campus at Chapel Hill is that in the past few months, somewhat to our surprise, there has been considerable expression of interest in the OR program from various sides of the campus. For example, at the University of North Carolina there is a huge Health Affairs campus and very recently the Vice Chancellor for Health Affairs and various Deans and Department Heads associated with the health disciplines have expressed a desire to formalize certain relationships with the operations research program. For example, it is felt that such relationships can be formalized through the appointment of OR faculty who are active in health applications research, such as health delivery services, hospital scheduling, etc. Then through the research interests of this faculty, students may be brought into the applications area in their doctoral research, for example.

Another interesting example is the Population Center at the University which has recently received a large contract for systems applications. Still another enthusiastic response for OR has come from -the Department of City and Regional Planning, and as a result the OR program allows for possible specialzations in transportation, urban studies, environmental sciences, water resources, etc. As a result of the broad spectrum of interest which extends, for example, into the Department of Sociology via the Institute for Social Research, it has been decided to title the program "Operations Research and Systems Analysis" with an intent to develop the systems research area further in the future.

There are presently 20 faculty associated with the proposed program, six from Statistics, two from Mathematics, three from Computer and Information Science, two

from Economics, two in the Graduate School of Business, and five individuals from other various departments.

Related research is currently in process in mathematical programming, stochastic processes, automata theory and pattern recognition, and water resource systems. The program will hopefully become a reality in the fall of 1969 this coming fall, and will initially be administered as an interdisciplinary curriculum rather than a Department with the possibility of evolving to a department as the need becomes justified in the future.

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Dr. Matthew J. Sobel
Yale University, New Haven, Connecticut

I'm going to talk briefly about our program and then I'm going to address myself to the extent to which our needs and capabilities can be related to those expressed by the various federal agencies, and then since we're a cozy group, I'll voice some personal opinions regarding why we've gone form such a large group yesterday morning to a tightly knit group this afternoon.

First, the Management Science/Operations Research program at Yale has evolved in the context of the Department of Administrative Sciences. It focuses upon those administrative problems to which the concepts and methods of economics, applied mathematics, probability theory, engineering, and statistics are particularly relevant. We have Bachelor's, Master's, and Doctoral degree programs in operations research/management science. The Department of Administrative Sciences also offers degree programs in organizational behavior as well as specially designed programs that combine operations research and organizational behavior.

Besides the nine operations research faculty in our own Department, there are many people in other Departments of the University whose research and course offerings have OR content. Some of these Departments are Forestry, Public Health, Political Science, Mathematics, and Psychology. In Statistics, for example, there are L. J. Savage and Frank Anscombe. In economics, which houses the Cowles Commission, there are Herb Scarff and T. C. Koopmans.

The OR research capabilities and course offerings are oriented more to theory and to basic research than to areas of application and to training in applications. That characterization suggests that Yale University, in general, and the Department of Administrative Sciences in particular, lack any resources that can be used idrectly by federal agenices to enhance their managerial capabilities in on-going programs. Descriptions of the programs and capabilities by quite a few of the universities whose representatives have spoken during the past two days suggest that they also are unprepared to be useful to operating agencies with public programs. This is a mistaken impression, I feel, and I'll address the extent to which I think it's mistaken in a moment. Nevertheless, let me ke it clear, Yale University is not seeking -- or at least our Department and in general the University is not seeking -- contract support regardless of focus and simply because it might happen to exist and be sueful to the federal agencies. So the question is, what are the capabilities that can be used by federal agencies.

Firstly, and as I'm sure would be true with respresentatives of every other university that has spoken, we'd be delighted to have broad research program development grants. In that respect we'd be delighted to be helpful but, of course, that wouldn't be helpful to agencies who operate public programs.

Late last year the University announced the creation of an Institute of Social Science. The Department of Administrative Sciences is in the Social Science Division of the University so the Institute will affect us. More to the point of being relevant to federal agencies, the Institute will be oriented towards applications and quite probably to contract research work. The areas in which it's likely that Centers will be formed with the Institute of Social Science include urban problems, educational policy and planning and operations, and also managerial problems or areas. The Institute is in an early stage of development and ground won't be broken for a building until next year. Those are two ways in which some help might be provided, the first being help in name only.

The third kind of help is the capabilities of faculty members. I'm certainly not speaking for any of the other universities which left the impression of unwillingness to confront the issues Jack Carlson sounded in his keynote: there are very real problems

that have to be met soon, if not immediately, and the generality or elegance of a project's theoretical underpinnings was not the criterion.

In that respect, not many of the universities have responded positively, and I haven't either. On the other hand I think it's true of most of the universities that left that negative impression, as it certainly is with our Department at Yale, that all the faculty members are motivated, at least partly, by very real applied problems. Most ar experienced at applications, provided on an individual consultative basis. However, contract work that's directly responsive to the current managerial needs, be they of federal agencies or companies, is not about to be provided by the Department. On the other hand, let me indicate the range of research interests relative to the applications interests of various people among the operations research faculty in the Department. By this I'm not trying to indicate the range of research interests they have, but simply to show that in every instance they do have genuine interests in applied problems as well as in fundamental research and this is actively encouraged. It's not an accident.

Bob Fetter, who's Chairman of the Department, is experienced in the design and operation planning for health care facilities, as well as interested in the conjunction of linear programming with simulation models.

Martin Shubik is concerned with budget controls and experimental data libraries in on-going systems, as well as with game theory and gaming.

Harvey Wagner is concerned with managerial control systems and their implementation, and he's experienced in that, as well as with mathematical programming and inventory theory.

Eric Denardo has had experience in airport design as well as fundamental research in dynamic programming.

Gordon Bradley has considered distribution problems as well as integer programming.

G. Wolf uses his research on models of communication and cooperation between members of small groups -- he's a social psychologist and applied mathematician -- to facilitate cooperation between members of hospital work groups.

I have experience in the design of water pollution abatement systems, and do research in stochastic games, inventory and production theory, and queueing systems.

Now I'm not going to speak for the other OR faculty in our own Department. I'll speak for myself. Why don't I leap at the chance (and not many were offered by the way, but there were one or two agencies that said they would welcome unsolicited proposals) - why don't I leap at the opportunity? Why is it likely that few people from the universities will respond positively? In my case it's because my water resources interests are just part of my interests. I'm not interested in committing myself for a long period of time into the future, even two years, to spend the bulk of my time on a water resources project. Mind you, it would even be water resources research but servicing a very specific current need of a water resources agency. I think similar comments could be made by most of the other people here (and people back in their departments) who quite clearly did not respond positively to the plea from Carlson and many of the other agency representatives for immediate help. I don't think there is going to be a positive institutional response from many of the schools. There will be from others but not from some and not from ours.

Individuals, not institutions, are available. I would say that in many universities, the prinicpal resource is the genuine interest and experience of individuals on the faculty and students. By contrast, there is a lack of willingness to enter institutional arrangements to provide assistance for current managerial problems.

One excuse for why we have such a sparse audience now is that most of the university people took a plane today. That isn't an excuse for why the agency people aren't here, because they work in Washington. I would guess that they are absent because they made pleas yesterday, and to some extent, this morning. With very few exceptions they heard the university representatives respond negatively. There are very few universities that said "Yes, we'll be delighted to provide current assistance for your immediate managerial problems." They heard one ofter another of us come up and turn them down, and after hearing a dozen or so they had no need to stay. I'm afraid they didn't realize that what is true institutionally for the majority of universities is not necessarily true of their faculty as individuals. They are willing on an individual basis to provide exactly the kind of assistance that was requested but not on the basis of an institutional commitment. That's my own opinion.

Dr. Cushen: Matt, before you leave the microphone there, let me ask a couple of questions about this. In part I think your diagnosis of why we dropped from 300 to 25 people here is correct, and it's probably due only a little to the impending airplane strike at 6 o'clock this evening. As we wander through government agencies and I guess we've wandered through about 80 of them so far, we keep hearing the question, how can we get to the universities, because we know they've got something that we want; and we go to the universities and they keep saying, Who all in government has any kind of an interest in what we're doing.

Now, what is the mode of discourse or what are the grounds for possible communication here that would be productive?

Dr. Sobel: I don't know. Earlier this year Jack Carlson sent a memo, or copy of a memo, to university departments throughout the country. I don't know if you're aware of that. I know that it was circulated throughout our Department and I would imagine it was circulated throughout many. I responded to people in Interior and Health, Education and Welfare because those happened to be concerned with environmental pollution problems in which I'm interested, but that isn't the point. The point is that I got a response from one of the two which said "We've been swamped with responses and we'll file your letter," and no response at all from the other. My own guess is that they got a response of some kind and then weren't prepared to handle a positive response.

Dr. Cushen: We did get only partial response to the requests that we had given to the government agencies to tell their story. One of my feelings is that a lot of the university proposals and commercial proposals are only moderately close to what was needed. Agency people cannot afford the time to work with you at revising proposals to a point where they are acceptable to all parties.

Dr. Sobel: Yes, right. In fact I functioned as a contract officer at one point. I understand the problem but I'm not sure what the solution is. I've been outside the government now for at least three or four years but from the outside it seems as if there has been a proliferation of agencies which were willing to take a close look at, and perhaps try, OR. I was an experiment in the Public Health Service, the Sobel Experiment, and now they have many OR people and I'm sure it's true in many other agencies. But I really don't know anybody well. In fact I don't know you personally but you're probably the only person I know or recognize who does OR in any federal agencies now.

Dr. Cushen: Well, nobody else does OR in many of the federal agencies!

Dr. Sobel: That's true to some extent. Look, when you're hiring somebody on a consultative basis you're not really hiring him. Legally it may be on the basis of a proposal, but you bank on your faith in the individual. I'm not sure there's any effective short-cutting of the process of building up trust.

Actually, this two-day session may be more profitable than the present attendance indicates because I had a couple of ideas yesterday and I'm sure other people did. Also, I'm sure the circulation of the one-space summary sheets will receive a wider distribution than simply the attendance at the meeting. It may yet, in spite of the very few of us

here now, be quite productive.

I would have very much liked to talk to a representative of an environmental resource agency. I spoke to Mr. Felton very briefly about Eric Denardo's interests in airport design. But I would have liked to be able to talk to someone who could have confronted me regarding water resources: "Yes, you say you're interested in water resources, but here are our problems. Is there anything you can do there?" In some sense we've all been trotting out our lists of interests and no agency representative has challenged us and said, "You say you're interested in inventory but the kinds of inventory problems we have are such-and-so. The formal models existing don't seem to handle them. What kind of quick help is there, or is there any?" I don't recall anybody being challenged when he said, "Here's our theoretical competence" and an agency representative saying, "That's all well and good, but can you use it for our problems?" A suggestion for 1970 is that they be encouraged to do just that. No interchange occurred, I think.

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Dr. Herbert Maisel
Georgetown University, Washington, D. C. 20007

I want to talk about: Consulting, Course work, and Contract assistance that might be available from Georgetown. These are the three C's. Equivalently, there are the three D's: Diehard advice associated with consulting, Degrees that might be associated with the course work, and Dollars that might be associated with the contract work. I think, of the three areas, the one that should be of most interest to this audience, considering both your needs and the resources at Georgetown, is the course work. Therefore, the summary sheet in the proceedings merely contains a list of all courses, both graduate and undergraduate, at Georgetown that might be of interest to persons whose profession is operations research.

I won't elaborate on the list of courses except to say that if your interest is a degree, rather than merely getting some additional professional information via courses, then I think it most likely that at the graduate level you would tend to major in Economics at Georgetown. At the undergraduate level the major would tend to be either Economics or Management in the School of Business Administration. There has been a change of leadership in the Mathematics Department. I may tend to affect the choice of an undergraduate major subject. It is likely that in the future a more appropriate undergraduate major for someone who wants to learn operations research and wants to get his degree at Georgetown, will be Mathematics.

I am associated with the Computation Center and we offer several computer science courses via the Physics Department. These courses are listed in a one-page description in the proceedings. I also have available a more detailed listing of two of the graduate courses, one a Simulation, which should be close to the hearts of many of you, and another on File Management, which should be close to the hearts of many of you but, perhaps, isn't. Much of what is done in operations research, and certainly almost all of what is done in simulation is implemented in fact via computer programs. It is becoming more and more important, I think, for the operations researcher to be aware of what's going on inside that computer. Not what the programmer tells him is going on, but what is actually happening.

With respect to consulting and contract services, I think it fair to say that Georgetown, in fact, does not have extensive contract services to offer the OR community. There isn't any large body of operations research-oriented faculty members.

Individual members of the faculty can provide assistance, but I classify that as consulting. There are people on the faculty with systems analysis capability. There are people on the faculty, particularly in the Economics Department, with budget and management capability. There is no Department of Statistics, and the statisticians are largely in the Economics Department. There are people in the School of Business Administration with management-oriented capabilities who would also be available for consulting.

With respect to publications or software packages that might be available for the use of government agencies, my immediate reaction would be that nothing is available but I'm not sure. There is some research and contract work going on in the Economics Department on a relatively small scale and reports of that work might be of interest to the operations research community. I would suggest that you contact the Chairman of the Economics Department, Henry Briefs. Also, there are a few general purpose computer programs that might be of interest to the OR community. For example, we have a program that computes cost tabulations for a variety of inputs using one to as many as six levels of control.

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Concluding Remarks

Dr. W. E. Cushen
Technical Analysis Division, NBS

As Dr. Sorrows indicated when he opened the Conference, we were delighted that you came, and now that it's over, we're delighted that you have been here.

If I were to offer a judgment it would be not quite so pessimistic as some of the later speakers that I've heard here, because I think that several things have happened. One, although you haven't been heard by as many people as other people have, the fact of the matter is that you found out what was going on in government. You found out directly what was going on in government and you found by absence what was not going on in government. You found also some of the things that were bugging these people. Their willingness to appear and expose their programs to you suggested a readiness to discuss these problems and possible modes of support that you might offer to them. I myself do believe that there is adequate excuse for a 1970 conference conducted in a somewhat different mode. As I mentioned before earlier this afternoon, please let me know if you disagree with that conclusion because there's no point in placing this time and expense on a large number of people.

The exercise that we're engaged in, of course, cannot really adequately go without notice that the professional societies in the field, the Operations Research Society of America, The Institute of Management Sciences, the local Washington Operations Research Council, and more recently the local chapter of TIMS ahve themselves been quite active in trying to stimulate government agencies into the more adequate use of these procedures that have come to be known as the systems technique. And so to them we offer our sincere gratitude for having broken open the field and making it possible for the existence of the government group who can afford the time to do some things on a full time basis rather than only on an evening basis after a cocktail party.

Watch for the semi-annual meetings of ORSA and TIMS because problems in the public sector, as you well know, are beginning to become far more prominent on the national programs. For the local chapters of WORC and TIMS, they have been more active rather than the national societies in scheduling seminars to instruct people on Capital Hill into what they might be in for should they decide to use operations research, and giving them a few ideas about how to read the reports that do come out of the government agencies, partly authored by your own hands.

In conclusion, we thank you for your participation. The conference proceedings will be published.

Attendees

Name	Organization
Alfandary-Alexander, Dr. Mark	Atomic Energy Commission
Ammann, Wilbert H.	Department of the Army, OACSI
Anderson, Richard L.	Management Science Systems
Andrews, Jr., Karl F.	Army Map Service
Ashcraft, Robert L.	LEASCO Systems & Research Corporation
Attarian, Raymond V.	USACDC Institute of Systems Analysis
Avery, Carlos P.	Central Intelligence Agency
Baker, Richard J.	AMC AMXAM-E
Banghart, Dr. Frank W.	Florida State University
Barcynski, II, Casimir A.	UNIVAC
Barish, Professor NOrman N.	New York University
Barmby, Dr. John G.	IIT Research Institute
Bartfeld, Dr. Charles I	The American University
Bartlett, R.	Department of Agriculture
Bartocha, Dr. Bodo	National Science Foundation
Bathke, Dr. William L.	Battelle Northwest
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Bernens, John C.	Carswell, Vandiver & Associates, Inc.
Blackburn, Jr., Vice Adm. Paul P.	Trident Engineering Associates, Inc.
Bulmer Jr., Raymond O.	Westinghouse Electric Corporation
Bock, Edwin	Post Office Department
Bordner, Kenneth R.	The Franklin Institute
Borkman, John	Office of Emergency Preparedness
Borsting, Dr. Jack R.	Naval Postgraduate School
Boughton, Dr. James M.	Duke University
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Bowie, Dr. Patrick C.	USA DATCOM
Branham, Wallace F.	Redstone Arsenal
Brown, Professor Fred R.	Industrial College of the Armed Forces
Brown, Robert A.	Red Lake Laboratories
Bull, Elwyn M.	Research Analysis Corporation
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Callan, Lt. Col. Paul C.	U.S. Army Management School
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Cerino, Raphael	Bell Telephone Laboratories
Cervi, John	Martin Marietta Corporation
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Cheslow, Melvyn	Department of Transportation
Clark, James	Wolf Research and Development Corp.
Cogan, Dr. Eugene A.	HumRRO
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Combs, Jr., Carlton	Technical Operations, Inc.
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Cunningham, Professor Andrew A.	University of Toronto
Cushen, Dr. W.E.	National Bureau of Standards
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Facine, Michael L.	Veterans Administration
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Frequently government agencies are unsure as to whom to contact when they want Operations Research/Systems Analysis studies made, and many agencies know very little about what other agencies might be doing in the field of operations research. Many public and private agencies have little knowledge as to which government agencies might derive the most benefit from their kinds of expertise and experience.

The Joint Meeting of Government Operations Research Users and Producers was organized to improve the communications among Users of operations research within the government, and Producers of operations research in public and private organizations.

Government agencies were invited to report on exactly what they expect of their OR producers, what they expect to have done with the results, what the purpose and their users of systems analysis are, and to give a general profile of their in-house work.

Universities were invited to report on their capabilities and their desires and to discuss the OR projects currently in progress on their campuses.

This meeting was the second in a planned series of meetings, which has for its purpose the longer range goal of providing more responsive and more adequate studies for improving government agency management and productivity.

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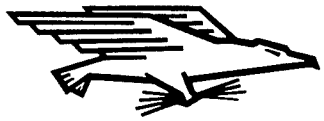

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