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Department of Housing and Urban Development

Office of Policy Development and Research

AN EXAMINATION OF PRODUCTIVITY-RELATED FINDINGS FROM THE "FOUR-CITY" PROJECTS AND THE RAND AND PTI FIRE DEPLOYMENT ANALYSIS APPROACHES

by The Urban Institute

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FOREWORD

In recent years, the Office of Policy Development and Research of the U.S. Department of Housing and Urban Development, in partnership with state and local governments, has been concerned with improving the delivery of public services. Four related programs have been sponsored since early 1974:

- *Capacity-Building Demonstration Program* — Strengthening the capabilities of local officials to fulfill their overall policy development, resource allocation, and management responsibilities. (1974-1976)
- *Capacity-Building Energy Conservation Program* — Promoting the practical application of technology and management to conserve energy. (1975-1977)
- *Capacity-Sharing Productivity Improvement Program* — Promoting the transfer and implementation of practical approaches to improve state and local government productivity. (1976-1979)
- *Financial Management Capacity-Sharing Program* — Collaboratively responding to the increasing problems facing local governments in their financial management practices. (1978-1980)

The products and practical tools from the first two programs have been available since early 1978. We are now making available the products from the capacity sharing productivity improvement program. Eighteen projects involving over 200 local governments have produced more than 85 training manuals, case studies, handbooks and computer programs.

Developed, tested and implemented by state and local governments, these products, in most cases, have also been carefully assessed by an independent contractor, SRI International, and a statement of its assessment is included with each product. In those cases where the results were inconclusive, the reader is so advised. For many of the projects, we are also publishing a complete assessment report. In other words, we have done our best to assure you that the products are sound and useable.

Five summary booklets that highlight the results from all eighteen projects and provide ordering information for their publications are available from HUD. Descriptions of the booklets and ordering information are given at the end of this volume.

Donna E. Shalala

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Assistant Secretary for Policy Development
and Research

ASSESSMENT STATEMENT

IMPACT ON SERVICE DELIVERY

This series of publications on productivity, employee motivation, program evaluation and performance measurement was prepared by The Urban Institute. Their inclusion into the Government Capacity Sharing Program was reviewed and recommended by an advisory group of state and local government practitioners. They provide supporting or additional information relating to many of the projects described in this series.

IMPACT ON COST/COST OF IMPLEMENTATION

SPECIAL REQUIREMENTS FOR IMPLEMENTATION

TRANSFERABILITY

SIMILAR PROJECTS ELSEWHERE

Prepared by SRI International, Menlo Park, CA 94025 February 1979

Contract H-2162R
Task Order 19

A report on research supported by *Department of Housing and Urban Development Office of Policy Development and Research*

AN EXAMINATION OF PRODUCTIVITY-RELATED FINDINGS FROM THE "FOUR-CITY" PROJECTS AND THE RAND AND PTI FIRE DEPLOYMENT ANALYSIS APPROACHES

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March 1978

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THE URBAN INSTITUTE
WASHINGTON, D.C.

An Examination of Productivity-Related Findings from
HUD-Supported and Related Productivity Improvement Efforts
(HUD Contract H-2162R, Task Order 19)

Abstract

This report is intended for use by local and state personnel interested in ways to improve productivity and by officials of federal agencies that are designing and supporting research and demonstration efforts in local and state government productivity. It examines productivity-related findings in available written materials for two sets of productivity improvement efforts recently sponsored by HUD.

Findings are first examined from three of "Four City" projects sponsored by HUD in Honolulu, Hartford and Dallas between February 1975 and 1976. (Written findings for a fourth effort in Fort Wayne were not available until after this study ended.) The report finds preliminary indication of possible efficiency or effectiveness gains and evidence of continued use from two sets of changes introduced in Honolulu sufficient to warrant their serious consideration by other governments. New work scheduling procedures and an evaluation system linked with photographic standards were associated with significant improvements in the appearances of parks in Honolulu's third district. (It is not possible to establish whether these particular changes actually caused the improvements, because other changes including performance of some maintenance tasks by a new district-wide unit, were introduced simultaneously.) Daily scheduling and weekly performance reports for repair crews and truck drivers resulted in significant improvements in apparent efficiency (in terms of amount of materials used per employee-day) for three street resurfacing and first aid crews. The evidence was weaker but also encouraging for improvements in reported "productive time" from the use of "productive time" reports which led management in Hartford's parks equipment maintenance division to balance workloads and make other specific changes (doing more work in-house and systematizing an existing preventive maintenance system). There was no evidence for significant efficiency or effectiveness gains from the 4-10 workweek implemented in Dallas's street repair and cleaning divisions.

Findings are next examined for systematic approaches for applying mathematical analysis to local fire department decisions on the number and placement of companies and stations--those developed by the New York City RAND Institute (RAND) and those developed by Public Technology, Incorporated (PTI). The report finds enough evidence on accuracy and probable productivity impacts for one of three RAND approaches reviewed, the Firehouse Site Evaluation Method (FSEM), to support the belief that it is capable of leading to productivity improvements in communities that are willing and able to use it to make major deployment changes. The accuracy and probable productivity impacts of the PTI approach in practice have not been documented (at least in the materials we reviewed or knew of), but a careful review of the procedure it uses to estimate travel times shows no reason to conclude that its accuracy is significantly more or less than that of the RAND approach cited above.

The report points out that the above statements on improvements need to be tempered by the fact that in no case was it possible to establish whether real productivity improvements had actually taken place. For the "Four City" projects, this was because of limited information reported on costs, quantity and quality of service, before or after the changes were introduced. For the RAND and PTI approaches, this was because there is little documentation on the accuracies of the various approaches in generating travel time estimates or on the specific costs and benefits that the approaches actually generate.

Based on the information gaps identified, the report concludes with specific recommendations for future research and demonstration efforts on these productivity improvement approaches and the need to collect comprehensive evaluative information on productivity impacts in future federally supported pilot and demonstration projects. It is emphasized that the arrangements for evaluation on any project should include a pre-project assessment of what evaluative information would be most useful in light of the nature of the innovation being demonstrated, the costs of obtaining each kind of evaluative information for that innovation, and the different uses and political decision-making contexts jurisdictions may have.

- The 4-10 workweek. The 4-10 workweek has been tried in a number of states and local governments in a variety of service areas. It appears to have been popular with employees in many jurisdictions. However, we know of little evalutive information published on the 4-10 except in the police area. Requirements for police work (such as the need to provide more protection during peak crime hours) are sufficiently different from requirements for street maintenance and street cleaning work to make information on the 4-10 for police of limited use in comparing the Dallas results with similar projects elsewhere.

- Evaluation systems linked with photographic standards. Evaluation systems linked with photographic standards have been used by several jurisdictions to measure the effectiveness of parks, street cleaning or other solid waste collection services. There appears, however, to be no systematically collected evaluative information in written reports on the impacts of such systems on productivity (the Honolulu system was introduced simultaneously with several other changes). Therefore their potential for generating productivity improvements has yet to be studied. When they are used for day-to-day management, the use of line supervisors to make ratings may be appropriate. However, for evaluation of overall service effectiveness, we recommend the use of trained observers to make visual ratings. These observers should be relatively independent of the staffs that perform maintenance work. In any event, such rating systems should not be undertaken without provision for regular feedback on the ratings to the appropriate managers and supervisors.

The RAND and PTI Fire Deployment Analysis Approaches

The New York City-Rand Institute (RAND) and Public Technology, Incorporated (PTI) have each developed systematic approaches for applying mathematical analysis to local fire department deployment decisions on the number and placement of companies and stations. These approaches all provide descriptive information on company travel times and other indicators, using computerized models applied to input data. Both PTI and RAND provide for modification of the models underlying the approaches to fit local circumstances, and both groups provide options on the amount of data required so as to permit users to trade off cost versus sophistication. This means that there are many ways in which use of the models can vary from one jurisdiction to another. There appear to be four principal approaches: (1) the RAND Parametric Allocation Method (PAM), (2) the RAND Firehouse Site Evaluation Method (FSEM), (3) the RAND Simulation approach, and (4) the PTI Fire Station Location Package.

The RAND Simulation and the RAND FSEM appear to provide sufficiently accurate information[1] that covers most of the aspects of deployment choices that are of interest. Both approaches appear to be capable of yielding deployment improvements (e.g., shorter travel times, lower manpower costs) worth more than the costs of using the procedures if they are used to make major deployment changes. However, the RAND Simulation involves considerable additional cost over that of the FSEM in return for accuracy improvements that

1. By this we mean travel time estimates whose margins of error are so small as to be unlikely to lead to errors in the comparison of deployment choices.

probably are not worth the additional cost, except in the very small number of cities with fire departments so busy that they have large portions of time in which 10 percent of their incoming alarms find at least one first-due company busy. The accuracy of the PTI approach in practice has not been documented, but a careful review of the procedures it uses to estimate travel times shows no reason to believe that it is substantially more or less accurate than the FSEM approach or the RAND Simulation approach. RAND's PAM appears to be susceptible to inaccuracies large enough to question its use in making final choices regarding fire deployment changes, and so RAND recommends it only as a fast, inexpensive device for reducing the set of alternatives to be examined by the FSEM.

Any conclusions about the productivity or other impacts of these analytical approaches must be very tentative and heavily qualified because there is little documentation on the accuracies of the various approaches in generating travel time estimates; on the projected costs, savings, and travel time changes produced by using the approaches; or on the costs, savings, and travel time changes that actually occurred when deployment changes selected with the help of the approaches were made. What is clear, however, is that versions of the PTI and RAND approaches have been used by a number of local governments. Moreover, their use had led many of these governments to adopt or modify plans for changes in the number and placement of fire companies and stations, often with large potential impacts on capital and operating expenditures and travel time to fires.

The existing documented evidence on the costs of use for RAND's PAM and FSEM approaches and for PTI's approach is quite sparse and permits only very rough statements about cost. The available user-reported cost estimates have varied considerably from one user to another. However, based on the documentation and some assumptions documented in Part Two of this review, we roughly estimate the typical cost of RAND's PAM to be $5,000 to $8,000, and the typical cost of RAND's FSEM to be $8,000 to $18,000. RAND's Simulation approach was estimated by a Denver study team to cost $80,000 in the one use of that approach without RAND assistance. A specific range for PTI's costs cannot be estimated from existing data, but it appears likely that the typical costs to users will be comparable to the costs of RAND's FSEM.

Recommendations for Future Research and Demonstration Efforts

As noted above, the documented information on the costs and effects of the productivity improvement efforts had many substantial gaps that would reduce the ability of local or state governments to assess the desirability of introducing similar improvements.

We recommend that federal agencies sponsoring trials, tests, and demonstrations plan and budget at the beginning of every project for an assessment of that project's evaluation needs. This assessment should determine what evaluative information would be most useful, in light of the nature of the innovation being demonstrated, the costs of obtaining each kind of evaluative information for that innovation, and the different uses and political decision-making contexts jurisdictions may have.

Appendices A and G provide more detailed guidelines on such evaluations. Among the types of information identified in these Appendices, the following were the most important types of information found to be missing in either or both of the Four-City projects and the PTI and RAND studies of fire deployment:

- understandable, detailed guidelines on the typical costs to jurisdictions undertaking an effort of the type studied;
- detailed information on conditions and decision processes prior to the project;
- productivity impact information that occurred under "normal" (as opposed to test) conditions, e.g., information from a period well after the introduction of new procedures (so as to remove "settling-in" effects);
- if the project introduced several changes, sufficient information on the productivity impacts of the effort as to permit measurement of the separate impacts of each of the changes.

Although project plans should provide for evaluation, there should also be an assessment of the procedures and their impacts by an independent source not involved in developing the procedures. (Judgments of officials in the jurisdictions that tested the procedures also should be systematically collected.) And documentation of the results should include complete, clear descriptions of test results and descriptive materials that can be used by state or local officials to implement the procedures on their own.

Specific recommendations for future research on the RAND and PTI fire deployment approaches and the "Four-City" and related productivity improvement efforts, based on the findings described above, are presented in Part Three.

Our final recommendation is aimed at individual local and state governments that undertake productivity improvement efforts and parallels the above recommendation to federal agencies. Government officials should provide for follow-up evaluations of the impacts (on efficiency, effectiveness, employee satisfaction, etc.) of changes stemming from these efforts. Many of the jurisdictions involved in the pilot studies discussed in this report made little if any provision for follow-up evaluations of this type, and our knowledge of other pilot projects indicates that such provision is rarely made. For these reasons, the suggestions in Appendix A (and to a lesser extent, Appendix G) apply to local and state governments as well as federal agencies. The findings of such evaluations should enable local and state government officials to make better decisions on continuation, modification, expansion, or curtailment of their pilot efforts.

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We greatly appreciate the cooperation, reviews, and comments provided to us by Jan Chaiken of the Rand Corporation; Costis Toregas of Public Technology, Inc.; and Warren Walker of Urbatronics, Inc., formerly with the New York City-Rand Institute. We also appreciate the reviews by Dale C. Carter, Harold A. Hovey, and John S. Thomas of drafts of the report. We received numerous suggestions from Bob Baumgardner, Hartley Fitts, and Alan Siegel of the Office of Policy Development and Research of the U.S. Department of Housing and Urban Development.

Responsibilities of the Urban Institute team were as follows: the examination of the "Four-City" project was principally the work of Virginia B. Wright. The examination of the Fire Deployment Analysis approaches was principally the work of John R. Hall, Jr. The Executive Summary and recommendations on research were prepared jointly by them with the assistance of Harry P. Hatry, who also was overall project coordinator and prepared Appendices A and G.

- In Honolulu's street repair operations, daily scheduling and weekly performance reports for repair crews and truck drivers resulted in significant improvements in apparent efficiency (in terms of amount of materials used per employee-day) for three street resurfacing and first aid crews.

The evidence was considerably weaker but also encouraging for changes introduced into Hartford's Parks Department's equipment maintenance division. The introduction of "productive time" reports apparently led management to balance workloads and make other specific changes (doing more work in-house and systematizing an existing preventive maintenance system), which resulted in significant improvements in reported "productive time."

The material presented showed no evidence of significant efficiency or effectiveness gains for the 4-10 workweek implemented in Dallas's street repair and cleaning divisions.

The above statements on improvements need to be tempered by the fact that in no case was sufficient evidence provided in the written materials to establish whether real productivity improvements (defined as maintaining the same quantity and/or quality of service at a lower cost, or increasing the quantity and/or quality of service at the same or lower cost) had actually taken place. This was because of limited information reported on costs and on quantity and quality of service, before or after the changes were introduced. There also was no way to ascertain the extent to which each of the several changes introduced into each city affected productivity.

Based on findings in written materials on these productivity improvement efforts and similar efforts elsewhere (on which there is also some limited evaluative information), we have drawn these conclusions about the three approaches to productivity improvement that appear to have been most potentially important in the Honolulu, Hartford and Dallas demonstrations:

- Work planning, scheduling and reporting procedures (other than the 4-10 workweek). Relatively simple approaches appear to have potential for generating productivity improvements in local (and probably state) governments. Simple reporting techniques, such as tables of "productive" hours, may be particularly attractive because of their low cost and the speed with which they can be implemented. For planning and scheduling uses, new engineered work standards may not be required. Engineered standards developed for other jurisdictions, "flat rate" standards developed by private companies, or local foremen's estimates of how long particular tasks should take may suffice, at least in the early stages of introducing more systematic work planning and scheduling procedures. We recommend that a jurisdiction undertake an initial diagnostic study, using techniques such as work sampling, before it chooses new procedures. Such a study would be aimed at identifying and measuring the approximate magnitude of problems (such as causes of idle employee time) and would give indications of where the greatest potential productivity improvements are. For example, better procedures for scheduling work are not likely to generate significant productivity improvements in street cleaning if the crucial problem causing idle employee time is equipment downtime.

EXECUTIVE SUMMARY

This report is intended for use by local and state personnel interested in ways to improve productivity and by federal agency officials who are designing and supporting research and demonstration efforts in local and state government productivity. The research on which the report is based has been limited to an examination of productivity-related findings in available written materials for two sets of productivity improvement efforts recently sponsored by HUD (supplemented by a few written materials on related efforts known to the authors). We have not conducted independent evaluations of the projects themselves. Our aim has been to assemble whatever systematically collected, valid information was available that local officials could use to decide whether they should implement similar productivity improvement efforts in their own jurisdictions. In assembling this available information, we have also identified major information gaps, that is, information that would be particularly useful in deciding whether to use a particular productivity improvement approach but that does not now exist. The kinds of information we include under this heading are measures of the costs, quantity and quality of service, before and after the introduction of innovations. Some of the gaps in information are quite substantial. Such gaps reflect in part the sizeable cost and difficulty of obtaining relevant evaluative information. Therefore, the existence of a gap does not necessarily imply that the demonstration projects themselves were inadequate.

The "Four-City" Projects: Work Scheduling and Planning Procedures

HUD sponsored four productivity improvement demonstration projects in Honolulu, Hartford, Dallas and Fort Wayne between February 1975 and March 1976. Only the first three projects had produced final reports at the time of this study; the findings in this report thus primarily reflect the findings of these three.

These projects were designed as tests of the productivity impacts of various work scheduling and work planning approaches, but each project introduced other changes that could also have affected productivity. Several changes introduced into Honolulu appear to warrant serious consideration by other governments, based on preliminary evidence of their continued use and impact on efficiency and effectiveness:

- In Honolulu's Parks Department, scheduling changes, supervisory and organizational changes, and a photographic evaluation system apparently resulted in significant improvements in the appearances of parks in Honolulu's third district, during a period when the total number of maintenance employees was being reduced by about ten percent through attrition.

INTRODUCTION

What new approaches to improving productivity are being tried in local governments? How effective are they in generating productivity improvements? What do the results of demonstrations in one jurisdiction suggest to other places considering similar approaches? What additional research or demonstration efforts are needed? This report attempts to synthesize answers to these questions to the extent possible from written findings for two sets of productivity improvement efforts recently sponsored by the U.S. Department of Housing and Urban Development (HUD).

The first set of projects (Part One) includes demonstration projects in four cities--Honolulu, Hartford, Dallas, and Fort Wayne--which focused on parks and/or street maintenance activities. All four involved new work planning, scheduling and reporting procedures. (Dallas focused on the 4-10 workweek; Honolulu included an evaluation system linked with photographic standards.) The second set of projects (Part Two) involves two groups of systematic approaches for applying mathematical analysis to local fire department deployment decisions on the number and placement of companies and stations developed by Public Technolocy, Incorporated and the New York City Rand Institute.

Following separate discussion of findings from these two sets of projects in Parts One and Two, this report presents recommendations for future research and demonstration efforts in Part Three.

Our study has been limited to an examination of the projects' written findings related to productivity improvement. A productivity improvement is defined as maintaining the same quantity and/or quality of service at a lower cost, or increasing the quantity and/or quality of service at the same or lower cost.

We have not conducted an independent evaluation of the projects themselves. Our effort has been to identify what valid information local or state officials could use as a basis for assessing the probable results of implementing similar productivity improvement efforts in their own jurisdictions. Such information could be objective (such as the number of miles of streets swept per employee-hour) or subjective (such as employee ratings of their own satisfaction with their jobs); in either case, we were interested in the information if it was systematically collected, seemed reasonably valid and was relevant to other potential governmental users.

This report is intended for two audiences: (1) local and state officials interested in ways to improve productivity; and (2) officials of HUD and other federal agencies who are designing and supporting research and demonstration efforts in local and state government productivity.

The report is based on two types of sources: (1) available written materials on the productivity improvement efforts and (2) written materials on related efforts known to the authors. (Sources are listed later.) Follow-up telephone calls were made in a few cases to clarify points for which information in written materials was unclear. However, no new data collection was involved in preparing the report.

PART ONE:

THE "FOUR CITY" AND RELATED PROJECTS

Four productivity improvement demonstration projects sponsored by the U.S. Department of Housing and Urban Development (HUD) were undertaken in Honolulu, Hartford, Dallas and Fort Wayne between February 1975 and March 1976. This synthesis of their findings is based on written materials primarily regarding the first three projects (reports on the Fort Wayne project were not available until the late stages of this effort; that information does not appear to alter the findings described below), supplemented by information in written reports on similar types of productivity improvement projects known to the authors.

This synthesis is presented in two sections. In the first, the major findings for the productivity improvement efforts in Honolulu, Hartford, and Dallas are discussed separately. In the second, the findings of the three HUD-supported demonstration projects are synthesized. Findings from these three demonstration projects are then compared with published information on similar efforts elsewhere in a more general synthesis on three approaches to productivity improvement which were judged by the authors of this report to be most important in this set of demonstrations: (1) new work planning, scheduling and reporting procedures; (2) the 4-10 workweek; and (3) evaluation systems linked with photographic standards.

Major Findings from Productivity Improvement Demonstration Projects in Honolulu, Hartford and Dallas

HONOLULU PARKS MAINTENANCE[1]

What approaches aimed at improved productivity were tried?

On June 30, 1975, a set of three organizational and scheduling changes were implemented in District III (one of Honolulu's four park districts). These changes, based on a study of parks operations undertaken by Honolulu parks officials and the project consultant, Griffenhagen-Kroeger, Inc., at the beginning of the demonstration (February-June 1975), were as follows:

(1) Eighteen District III employees were transferred to a new unit covering all park areas within the district. This unit was responsible for grass cutting (using larger power mowers), gardening, non-routine heavy-duty maintenance, and providing relief personnel for absent employees. This change limited the responsibilities of groundskeepers assigned to particular parks to routine custodial tasks.

(2) The total number of foremen positions for District III was increased from 2 to 4, to provide a more balanced and increased level of supervision of maintenance employees. This resulted in one foreman for each of the three geographic sections (each included several parks) and one foreman for the new district-wide unit described in (1) above.

(3) A new system of weekly work scheduling and reporting was established. It included a weekly task schedule, based on engineered work standards, for each groundskeeper assigned

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[1] This review of findings from the Honolulu productivity improvement demonstration in parks maintenance is based on five sources: (1) a draft project report entitled "Productivity Demonstration Project: City of Honolulu, Hawaii," submitted by the project consultants, Griffenhagen-Kroeger, Inc. (G-K) in June 1976; (2) a revised draft report entitled "Productivity Demonstration in Honolulu," submitted by G-K in March 1977; (3) a case study entitled "Closing the Efficiency/Effectiveness Gap: City and County of Honolulu, Hawaii," in Improving Governmental Productivity: Selected Case Studies, John Thomas (Washington, D.C.: National Center for Productivity and Quality of Working Life, Spring 1977); (4) background notes collected by the author of the Honolulu case study in (3) above; and (5) a project status report, "Midterm Report - Productivity Improvement Program, Department of Parks and Recreation," February 20, 1976, prepared for the Honolulu government's internal use by the Department of Parks and

> to a particular park and each crew rotated among the parks. Employees checked off each task they had completed during the week. The system also included a set of weekly performance reports, based on groundskeeper or crew reports on tasks completed as compared with tasks scheduled. Engineered work standards were not used to monitor the performance of particular employees or crews on particular tasks.[1]

In addition, a calculation of District III staffing requirements, made at the beginning of the project using an inventory of maintenance tasks and engineered work standards which had been developed prior to the demonstration project, indicated that the parks maintenance staff could be reduced by 12 persons. Within this general guideline, a reduction of 9 employees, from 88 to 79 (10 percent), actually took place from the beginning of the project through February 1976. This reduction was achieved by attrition of 9 temporary employees supported with federal revenue-sharing or CETA funds.

To assess the impacts of these changes on the quality of parks maintenance services, the project developed a procedure for evaluating the appearance of parks in District III. The system was introduced six weeks in advance of the changes described above, to provide baseline data for an earlier period (May 19-June 30) against which service quality after the changes were introduced could be compared.

Each of the three section foremen rated the parks in his own section on Wednesday of each week, following guidelines provided in a manual of pictorial standards developed for the project. The foreman recorded the number of units for each element (for example, the number of drinking fountains) which he rated

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Recreation. A revised version of the G-K report has subsequently been issued: "Improving Performance in Honolulu's Parks and Street Maintenance," Griffenhagen-Kroeger, Inc., November 1977.

[1]Engineered work standards are estimates of how long particular tasks should take, based on systematic study of the work elements comprising each task and how long it takes to complete each element under local conditions (such as type of terrain, weather), with particular tools, and with employees having particular levels of skill and training.

in "excellent," "good," "fair," or "poor" condition. For elements not in the park, a "not applicable" was recorded. Individual foremen's ratings were spot-checked for reliability by the district maintenance supervisor or the district superintendent; they independently rated 3 parks in each section each week (9 of the district's 48 parks). A numerical index reflecting the quality of overall maintenance was calculated by assigning values ranging from "1" for "poor" to "4" for "excellent," and calculating a weighted average for each park, each section and District III.[1]

Weekly performance reports, based on these ratings, were provided to park foremen and discussed at a weekly meeting of the foremen with the grounds maintenance supervisor. Summary reports based on these performance ratings were also preparaed for district and parks department management. Parks which received poor ratings were subjected to more detailed analysis and follow-up corrective action (such as changes in scheduling or work procedures). In cases where the reasons for poor performance could not be identified from weekly work reports (for example, if a report did not identify the park as one in which there had been a major equipment breakdown or excessive employee absences), an analyst was assigned to observe field operations and determine what was wrong with the scheduling or work procedures being used.

Did use of the approaches lead to improved productivity?

The appearance index for all of the parks in District III, an aggregation of the ratings of individual park foremen compared with the project's pictorial standards, rose significantly, from 2.27 in the baseline period (May 19-June 30,

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[1]There was no explanation in the source reports on how ratings for individual elements or parks were weighted to arrive at park, section or district averages.

1975) to 2.79 in January 1976, the last month in the demonstration. The percent of parks elements rated "excellent" or "good" rose from 48 percent in the baseline period to 75 percent in January 1976.[1]

It was not possible to determine which of the several changes introduced made the greatest impacts on the ratings. The presence of the evaluation system itself could have been responsible for some of the improvement noted (such as by providing an incentive to improve the regular ratings). It was the view of the project consultant, documented in the draft reports, that the presence of the evaluation system had increased the competition among groundskeepers.

There was no information on how the average costs of producing the park services provided by District III after the changes were introduced compared with unit costs earlier. The changes probably resulted in a small net total cost increase to the City-County in the short term. This was so because some additional costs associated with the changes ($400 to produce six manuals of photographic standards, and the increase in wages—amount not reported--associated with shifting two nonsupervisory positions to foremen positions) were not offset by any reported short-term cost savings to the City-County.

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Unfortunately, the project period was not long enough to provide before and after implementation ratings for the same months so seasonal factors could conceivably have affected these findings. However, according to the project report, Honolulu's weather tends to be consistently mild, with somewhat heavier rain during the winter months. Therefore seasonal variations in weather and workload were not believed to cause a major problem in the comparability of these ratings. In addition, since individual park foremen rated their own parks, there was some question about the validity of these ratings (an approach using outside trained observers would have been preferable). However, reliability checks made during the project, in which a parks department manager made independent ratings for a sample of parks each week that were compared with those of park foremen, showed no pattern of bias which would offset the general indication that appearance of the parks improved after the new procedures were implemented.

The only actual cost savings reported for the demonstration occurred with the attrition of temporary personnel who had been paid from federal CETA or revenue-sharing monies. With fewer such employees being paid out of revenue-sharing or CETA funds, Honolulu obtained positions it could allocate to other services. However, in neither the revenue-sharing nor the CETA case would there have been a reduction in City-County expenditures if positions in the other services were filled (written reports did not indicate whether or not this occurred). The possibility of some future savings in equipment repair and replacement costs was reported, as $47,000 worth of equipment on hand was no longer required because of the creation of the new district-wide unit.[1]

The net costs of implementing a similar set of changes in another jurisdiction could vary significantly. For example, additional costs to the government making the changes could be <u>higher</u> if the jurisdiction did not have several resources Honolulu had, such as (a) federal support for analysts who designed and implemented the new organizational and scheduling changes, and (b) a set of engineered work standards adapted to local conditions and equipment and a detailed task inventory, for use in estimating staffing requirements and setting up weekly schedules. No specific time requirements or dollar estimates were reported for these activities in the Honolulu project reports. On the other hand, net costs could be <u>lower</u> if the engineered standards and inventory of maintenance tasks suggested changes which involved reducing the number of regular employees and thus provided direct cost savings to the jurisdiction itself, rather than a reduction in federally-supported temporary workers, as was the case in Honolulu.

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[1]Conceptually, if the new techniques were used, the Parks Department might have been able to achieve the baseline level of quality with reduced staff. However, in practice such a staff reduction could also introduce the potential for new labor-management problems and not result in the targeted quality.

Were there any effects on employee satisfaction or labor-management relations?

Some initial employee dissatisfaction with detailed time reporting was reported. It was handled by modifying the reporting system to allow employees to simply check off tasks when they had been completed (no effort was being made to compare performance on individual tasks with engineered work standards). No other information on employee satisfaction was mentioned.

No impacts of the organizational, scheduling or evaluation procedures on labor-management relations were reported.

Were there any significant implementation problems or special implementation procedures?

According to the Honolulu project report, the major implementation problem in the parks effort involved coordinating activities of the several crews responsible for grass mowing, heavy maintenance and finishing; weekly foremen meetings were helpful. The project report also noted that because grounds-keepers often developed feelings of proprietorship, a special effort was made in setting up the new organizational structure to retain some permanent association of groundskeepers to specific park sites.

Were the changes continued beyond the demonstration period?

All of the changes introduced in District III were continued in that district beyond the demonstration period. The evaluation system linked with photographic standards was also transferred to Honolulu's three other park districts. These procedures were still in use as of September 1976.[1]

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[1]Thomas, Background notes for Honolulu case study.

HONOLULU STREET REPAIR[1]

What approaches aimed at improved productivity were tried?

Honolulu had installed a comprehensive management system in street repairs several years before the HUD-supported project began. This system included the use of eight production planners who had been trained in the use of work measurement techniques. They reviewed all repair work (except pothole patching) and prepared work orders which included standard times to do each job. Actual employee-hours and materials used on each job were reported on the work order as each job was completed. Bi-weekly performance reports and monthly backlog reports were issued, based on information from the work orders.

A work sampling study of repair work of Honolulu's six urban crews was undertaken at the beginning of the HUD-supported demonstration. The work of a crew was sampled at two-minute intervals, to determine whether each crew member was working or idle, and to identify reasons for observed idle time. Observations were made for approximately nine days for each of the six crews studied. This analysis found that "significant amounts of idle time were attributed to waiting for the delivery of materials and to a lack of short-term planning to insure that each crew had sufficient work to keep it busy for the entire day."[2] To alleviate these problems, the project focused on procedures better to coordinate delivery of materials and the planning of daily work assignments.

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[1] This review of findings from the Honolulu productivity improvement demonstration in street repair activities is based on four sources: (1) a draft project report entitled "Productivity Demonstration Project: City of Honolulu, Hawaii," submitted by the project consultants, Griffenhagen-Kroeger, Inc. (G-K) in June 1976; (2) a revised draft report entitled "Productivity Demonstration in Honolulu," submitted by G-K in March 1977; (3) a case study entitled "Closing the Efficiency/Effectiveness Gap: City and County of Honolulu, Hawaii," in Improving Governmental Productivity: Selected Case Studies, John Thomas (Washington, D.C.: National Center for Productivity and Quality of Working Life, Spring 1977); and (4) background notes collected by the author of the Honolulu case study in (3) above.

[2] Thomas, "Honolulu," p. 56.

In advance of implementing daily planning and monitoring procedures, the project developed a set of tables showing production rates for different types of repairs (such as the number of tons of asphalt which can be laid down per hour, by depth and width of coverage and roadway condition--minimum, medium or heavy traffic) and trip times to various sites. A working foreman and his supervisor first used the tables in deciding how each individual job should be done and the amount of labor and materials required. They then turned their estimates over to a section planner, who used their job estimates and the same tables to construct two types of daily schedules:

- Daily work plans for each street repair crew;
- Daily trip schedules for each driver delivering materials to street repair sites.

Drivers and crew foremen were to indicate on each day's schedule how much of the planned activity was actually completed. The planner then used this information and estimates for new jobs to make up the next day's schedules. Information from these daily schedules was aggregated into performance reports presented to various levels of management at weekly and monthly meetings.

These new procedures were implemented in the Division's six street repair crews that served urban Honolulu. Employees involved included 2 supervisors and 37 asphalt paving workers, laborers and working foremen, plus the truck drivers who delivered materials to the six repair crews. The project began with the three crews (one resurfacing and two first aid) which the work sampling at the beginning of the project had identified as having the greatest potential for productivity improvement if daily planning procedures were instituted. Trench patch (one crew) and pothole (two crews) operations were expected to show lower productivity increases, based on these new planning procedures, because crews moved from one site to another during the day in response to complaints received during the day. Project reports were not specific as to starting dates for the new procedures in each type of activity; apparently the new procedures began for the resurfacing crew in October 1975 and later for other crews since the new procedures were implemented for one crew at a time.

Did use of the approaches lead to improved productivity?

Tons of asphalt used per employee-day was higher by 96 percent for the street resurfacing crew and 54 percent for the two first aid crews combined, for the 6-month period of the new work planning, scheduling and reporting procedures (October 1975-March 1976) as compared with the baseline period (July 1974-July 1975). The new procedures were also implemented for the remaining three trench patch and pothole crews, but very late in the demonstration. Both because of this and because productivity-related statistics in the project report regarding these crews were inconsistent, meaningful findings on productivity impact during the demonstration period for these two activities were not available.

The data presented did not provide a comparison for the same months for two years, so it is not known whether seasonality factors could have been a reason for the increase.

According to the project report, gains made during the demonstration would have been still higher if it had not been for equipment and materials availability problems.

There was insufficient information reported on labor and materials costs before and after the new procedures were introduced to permit an assessment of whether cost savings were actually achieved. Honolulu paid $15,000 to a local industrial engineering consultant to coordinate the development and implementation of the new daily planning and monitoring procedures (and the work sampling study which began the project). Presumably, this cost would not be repeated after implementation, but such tasks would likely be needed for implementation in other jurisdictions.

Though not representing actual dollar outlays, other employee time was also spent in this effort. Two department employees were assigned to work full-time under the engineering consultant (a startup time requirement). A section planner who had worked on a previous management system made up the daily schedules. This planner's time and the time of other city employees (management, supervisory and nonsupervisory), who were able to undertake the planning and reporting tasks assigned to them during regular working hours, would continue to be required if the new procedures were continued. No estimates of how much time was spent in these activities were reported.

There were no additional output measures presented in the written reports (such as square feet of streets resurfaced) other than amount of materials used per employee-day reported; these could have been used to check whether any of the increased materials used had been associated with wasted materials rather than additional work done. There was no information on how the quality of service (such as the quality of the road repairs and rideability of roads) had changed during the period in which the new procedures were in effect.

Were there any effects on employee satisfaction or labor-management relations?

According to the project report, initially there was "significant employee resistance" to changing the ways they had been doing things and filling out the new reports. No additional information for a later point (after employees had become more accustomed to the new procedures) was reported. One minor incident involving the union and truck driver dissatisfaction with filling out new work reports was resolved quickly.

Were there any significant implementation problems or special implementation procedures?

No signficant problems or special procedures were reported.

Were the changes continued beyond the demonstration period?

The new work planning, scheduling and reporting procedures were continued for the six urban repair crews beyond the demonstration period. As of September 1976 they had not yet been transferred to repair crews in other street divisions in Honolulu, but Honolulu officials indicated they hoped to do so in the future.[1]

HARTFORD PARKS EQUIPMENT MAINTENANCE[2]

What approaches aimed at improved productivity were tried?

To improve the performance of the Parks Department's equipment maintenance unit, a new work control system was inaugurated on December 8, 1975, and continued to the end of the demonstration period on February 29, 1976--a period of about three months. This system included four major components:

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[1]John Thomas, background notes on interviews with Honolulu officials, September 1976.

[2]This review of findings from Hartford's productivity improvement demonstration in parks equipment maintenance activities is based on four sources: (1) a draft project report entitled "Productivity Demonstration Project: City of Hartford, Connecticut," submitted by the project consultants, Griffenhagen-Kroeger, Inc. (G-K) in June 1976; (2) the City of Hartford's comments on that draft report submitted to G-K in a September 17, 1976 letter from Allan Medoff, Special Assistant to the City Manager; (3) a revised draft report entitled "Improving Park Maintenance Productivity in Hartford," submitted by G-K in April 1977; and (4) a telephone conversation which the author of this review (Virginia Wright) had with Carl Faggaini, Administrative Clerk in the Hartford Parks Department, on October 27, 1976, to clarify points made in the draft report.

There were a few other procedures considered, and in a few cases implemented, during the Hartford demonstration. However, no evaluative information which could be used in this synthesis of findings was reported.

(1) A new garage foreman position, with responsibility for day-to-day work scheduling and supervision of the five persons doing repair work; the foreman was to do no maintenance work (prior to the new system there had been no on-site person responsible for scheduling or supervision--a support services supervisor with other responsibilities had checked in at the garage sporadically and scheduling had been unsystematic and frequently handled by individual maintenance workers);

(2) A new work-order report, which was to include information on the type of work requested and task beginning and completion times (previously work order reports had often not been completely or intelligibly filled out, and had not provided for information on mechanic work-time, by task);

(3) The development of time estimates for the types of tasks performed by maintenance personnel (these were not engineered work standards, but were primarily rough time estimates made by the new Hartford garage foreman, and persons who had previously held the job[1]; average times from Chilton's automotive survey of private dealers, service stations and garages were incorporated in estimates for the small proportion of parks equipment maintenance tasks for which they were relevant[2]);

(4) A set of monthly or bi-monthly reports to Parks Department managers on (a) the proportion of mechanics' time which was being devoted to actual "productive" maintenance work, rather than for "non-productive"

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[1]Immediately preceding the demonstration there was no garage foreman position, but there had been such a position earlier.

[2]More specifically, for maintenance tasks covered in Chilton's Motor/Age Labor Guide and Parts Manual, 1975, the time estimates were calculated as follows:

$$\frac{(2 \times \text{Chilton's Survey Time}) + \text{Departmental Time Estimate}}{3}$$

"Chilton's survey times" are averages of the times reported as being required to perform the tasks specified in private dealerships, garages and service stations covered in their biennial survey. "Departmental time estimates" (garage foremen estimates of how long tasks should take) were incorporated in the Hardford calculations to allow for the fact that the private operations covered in the Chilton's survey often had better maintenance tools and facilities, vehicles that were used with less intensity and abuse, for shorter periods of time, and mechanics with more extensive and more specific training. The higher (two-thirds) weighting given to the Chilton's estimates was to compensate for the fact that the estimates of the garage foremen were relatively crude. The time estimates thus derived were approved by Hartford's Parks Department management personnel for initial use in performance reports.

time for wash-up, diagnosis, waiting for parts, or otherwise idle (monthly); (b) performance on individual maintenance tasks which was below the Department's time estimates (monthly); and (c) pieces of parks equipment with the longest downtimes and the highest repair volumes (bi-monthly).

The first management report on how the equipment maintenance personnel were utilizing their time revealed that a low proportion, 31 percent, was actually being spent in "productive" maintenance activities in December, 1975. Prior to this report, management had expected such utilization rates to be acceptable to them, at about 65 to 75 percent. It was discovered that the utilization rates varied significantly among employees, with one serviceman having a rate of 16 percent. Other information from the new system indicated that pieces of Parks Department equipment which had been sent to the Department of Public Works garage were the majority of those with the highest downtimes.

The Parks Department therefore implemented the following additional changes (and continued the four components of the work control system listed above) during January and February 1976:

- The maintenance workload was scheduled more evenly among the five mechanics (this also meant paying a less skilled workman a higher rate for tasks requiring higher skill levels);
- The amount of preventive maintenance work being done by the unit was increased and put on a more systematic schedule;
- The Parks Department began to perform some types of maintenance services in their own garage which had previously been sent to the DPW garage (in January this involved 37 man-hours, or 10 percent of all Parks Department "productive" maintenance time; in February it rose to 46 man-hours, and 11 percent of maintenance time).

Did use of the approaches lead to improved productivity?

The presence of the new work control system combined with management actions based on performance information generated by that system were associated with an increase in the average proportion of the five mechanics' time spent on "productive" maintenance. This proportion rose from 31 percent in December 1975 to 55 percent in January and 82 percent in February. This, coupled with the fact that the Parks Department's workload was increased by the additional preventive maintenance and former DPW work, indicates that the Parks Department's five repairmen were probably doing more work in January and February than they had in December.

Such an increase is, however, not sufficient information for assessing whether a significant improvement in the productivity of parks maintenance activities was the result of the new work control system. No baseline data were developed on conditions before the changes were introduced. Also, benefits hoped for from the additional preventive maintenance work would take place in future months (since it is intended to lead to fewer repairs required and thus shorter periods of downtime).

It is also unclear how seasonal factors affected the results of this demonstration. According to a Hartford official, "in December the workload is the lowest of the year with the most people available (some of the drivers assigned to the maintenance area to do repair work."[1] These additional workers were probably doing some of the jobs which would ordinarily be handled by the regular mechanics.

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[1]September 17, 1976 letter from Allan Medoff, Special Assistant to the Hartford City Manager, to Griffenhagen-Kroeger, Inc.

No information was presented on worker performance relative to the time estimates for individual maintenance tasks developed by the project, nor on downtimes or turnaround times for the equipment being repaired, nor on return rates for equipment being repaired. The latter information could help in determining whether there were any improvements or degradations in the quality of service. The comparison of actual performance with the time estimates would be helpful in ascertaining that workers are not "overcharging" productive hours (by taking longer to do their work). Hartford officials indicated that they expect that it will take at least a year's experience to refine the initial set of time estimates to the point that they can be used as reliable standards against which employee performance can be evaluated.

Though Parks Department officials had found no significant work backlog for the Parks Department's own equipment maintenance unit, these officials apparently did not seriously consider a reduction in the size of their equipment maintenance staff. Rather, they undertook to increase the work accomplished by the unit.

According to the project report, additional "cash costs" associated with operating the set of changes introduced in the Parks Department's equipment maintenance devision would probably total less than $1,000 per year. This estimate included the difference between the salary of the working supervisor and a regular mechanic,[1] the costs of producing and processing forms required for the

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[1]During the demonstration, the Parks Department added another employee, the garage foreman, to the equipment maintenance staff. Thus they also increased the costs of the Parks Department's equipment maintenance services by about one-fifth (the foreman's salary and fringes). Since the person filling the new foreman position was transferred from other parks maintenance activities, the costs of the Parks Department as a whole did not rise commensurately. The report indicates that this salary should be considered a "startup cost," since the Department's plans call for converting one mechanic position to the foreman level (this position would call for supervisory and maintenance work), at only

new data collection system, and the increase in materials costs associated with the preventive maintenance schedule.

In addition to factors which could lead to additional dollar costs, there were also changes introduced which, according to the project report, would routinely take the time of city employees but not necessarily increase the city's actual dollar outlays. A two-week test indicated that two data processing personnel (a senior account clerk and a stock clerk) spent 35 percent of their available data-processing employee-hours on tasks associated with the changes introduced during the demonstration, with no displacement of other responsibilities.

There were also startup costs and time requirements associated with the project's initial study and development of a work control system suited to Hartford's needs. There were not specific dollar amounts or time estimates given in the project report for such activities, some of which were paid for by HUD and undertaken by the project consultant.

Because of the increased decentralization of maintenance services, which is taking place as the Parks Department sends fewer maintenance requests to the Department of Public Works, assessment of changes in <u>overall</u> efficiency (such as unit costs and equipment downtimes) for <u>both</u> the Parks Department's and the Department of Public Works' (DPW's) maintenance services need to be examined. The long downtimes for Parks Department equipment being serviced by DPW,

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a slight (perhaps $1,000) increment in salary and returning to a five-person staff. When that happens, performance information on how the system works when the supervisor also does maintenance work would be required to evaluate the productivity impacts of such an arrangement.

mentioned at several points in the report, might be reduced by improving Parks Department or DPW equipment maintenance services. No information on which to base such an assessment was presented in the project report.

Were there any effects on employee satisfaction or labor-management relations?

According to the report, mechanics and park foremen were not enthusiastic about the implementation of the new work control system, particularly the need to fill out the new work order report forms. There was no information in the report on how employees felt about the changes after they had worked with them for three months.

Discussions with union representatives were held at the beginning of the demonstration. No other union activities or subsequent responses to the changes were reported.

Were there any significant implementation problems or special implementation procedures?

No significant problems or special procedures were reported.

Were the changes continued beyond the demonstration period?

The future of the changes implemented in the Hartford equipment maintenance division during this demonstration was uncertain, as of October 1976. At that time they had also not been transferred to the equipment maintenance staff (about 40 employees) in Hartford's Department of Public Works; such a possible transfer was one justification for undertaking the demonstration project in the relatively small (6 employees) parks unit, according to the draft project report.[1]

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[1]Virginia Wright, telephone interview with Carl Faggaini, Administrative Clerk in the Hartford Parks Department, October 27, 1976.

DALLAS STREET REPAIR AND CLEANING[1]

What approaches aimed at improved productivity were tried?

The 4-10 workweek (employees working four 10-hour days each week rather than the traditional five 8-hour days) was implemented in the City of Dallas's street maintenance and street cleaning divisions for a period of 5 2/3 months, from May 6, 1975, to October 26, 1975. These dates were chosen by the city to correspond with longer daylight hours and favorable weather conditions (such as high temperatures for mixing hot asphalt) which were expected to facilitate the performance of street repair and cleaning services. During the remainder of the year, work on these activities was to revert to a standard 5-day, 8-hour per day workweek. Approximately 400 field, clerical and supervisory personnel in the street maintenance division were included in the demonstration. About 130 street cleaning employees were covered (headquarters staff and night shifts were excluded).

In addition, several new planning and scheduling procedures were introduced in the street maintenance division. These included: (a) estimates of time and material requirements added to work order sheets (time estimates were made by general foremen based on their own experience--engineered work standards were not used); (b) new job tickets for delivery trucks; and (c) advance work

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[1]This review of findings from Dallas's productivity improvement demonstration for street repair and cleaning activities is based on six sources: (1) a draft project report entitled "Productivity Improvements in Dallas Street Maintenance and Cleaning Operations," submitted by the project consultants, Griffenhagen-Kroeger, Inc. (G-K) in April 1977; (2) a draft project report entitled "Productivity Demonstration in Dallas," submitted by G-K in March 1977; (3) a draft project report entitled "Productivity Demonstration Project: City of Dallas, Texas," submitted by G-K in June 1976; (4) a case study entitled "Productivity and the Four-Day Workweek: Streets and Sanitation Services, Dallas, Texas," in Improving Governmental Productivity: Selected Case Studies, John Thomas (Washington, D.C.: National Center for Productivity and Quality of Working Life, Spring 1977); (5) background notes collected by the author of the Dallas study in (4) above; and (6) a telephone conversation between Virginia Wright (the author of this review) and Harold Bird, Dallas Superintendent of Street Cleaning, on January 12, 1977, to clarify points made in these reports. A revised version of the G-K report listed in (1) dated November 1977, has subsequently been issued.

location reports submitted daily to headquarters. Implementation of these changes began about mid-August and so some of these changes were in effect for a little more than two of the six months in which the 4-10 workweek was in effect. It is unclear from written reports when each of the procedures began or how uniformly these procedures were being used (that is, if they were used to the same extent for all street repair crews).

Did use of the approaches lead to improved productivity?

Street Repair

The amount of materials used per employee-hour (the measure used in the project as the indicator of efficiency) increased by 5.6 percent for the total group of seven street maintenance activities examined, for the six months in which the 4-10 workweek occurred as compared with the same period a year earlier. (These seven activities consumed approximately 80 percent of the street maintenance division's resources in 1974.)

Changes in materials used per employee-hour ranged from a gain of 29.8 percent for curb and gutter repair to a decline of 17.6 percent for penetration street repair. There were also wide monthly variations for each of seven activities studied and differences among Dallas's four service districts for the same time period. These differences led some Dallas officials to conclude that such factors as weather, traffic, extent of preparatory work required, and proximity and availability of asphalt contributed to these variations, and overwhelmed the relatively small potential impacts of the 4-10 workweek.[1]

New planning and scheduling procedures might have affected the amount of materials used in the last two months of the 4-10 demonstration, regardless of the existence of the 4-10 workweek. There was also a higher proportion of

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[1] Thomas, "Dallas," p. 71.

temporary employees during the demonstration as compared with the baseline period. However, no information was available to separate out the effects of these differences.

There was no information on how level or quality of service might have changed. Additional information on output (such as number of potholes filled) could have been used to check whether any of the increases in materials used per employee-hour had been associated with wasted materials rather than additional work done.[1]

Conflicting information on cost changes occurring between the 6-month demonstration period and the same period a year earlier made it impossible to tell if these increases in material used per employee-hour were accompanied by actual total or average cost reductions.

The project report indicated that the City of Dallas personnel who were associated with implementing the 4-10 workweek and the new planning and scheduling procedures did so during their regular working hours, at no additional dollar cost to the City. This included department management, the project coordinator, and supervisory staffs in the street maintenance and street cleaning divisions. No estimates of the amount of time spent in implementation or planning and scheduling were presented in the draft reports. Thus the project apparently did not cost the city government additional wages for implementation, but staff time was needed for project activities (including planning and review meetings).

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[1] One of the reviewers of an earlier draft of this report indicated that he had seen information on other output measures which confirmed that the additional materials had been used to do more work, but this information was not documented in materials available for this review.

Street Cleaning

The number of curb miles swept per employee-hour rose 1.9 percent for mechanical street sweeping for the 6 months in which the 4-10 workweek was implemented as compared with the same period in the previous year. Mechanical street sweeping (the only street cleaning activity whose productivity was evaluated during the deomonstration) included approximately 17 percent of the street cleaning employees participating in the 4-10 demonstration.

Without information on cost and effectiveness changes over the same time periods (which were not reported), it was not possible to establish whether this apparent (small) improvement had actually led to reduced costs or improved service quality. As noted in the previous section, implementation of a 4-10 workweek apparently did not result in any additional out-of-pocket costs to the city government.

Were there any effects on employee satisfaction or labor-management relations?

The results of a questionnaire administered at the conclusion of the 4-10 experiment in Dallas indicated that 75 percent of the street repair and cleaning employees responding (58 percent of the employees covered) favored the plan; 21 percent of the respondents did not like it and 4 percent had no opinion. In Dallas the plan was implemented only for 5 2/3 months, a period when longer daylight hours and warmer weather facilitated street repairs and cleaning. When continued for longer periods of time in some places, the plan has been associated with fatigue effects and family problems.

Contrary to expectations that the 4-10 would decrease absenteeism, this statistic increased by 5.3 percent during the Dallas demonstration (over the same period a year earlier). This change may have been associated with a higher proportion of temporary employees during the demonstration as compared with the baseline period.

Street repair and street cleaning employees were not represented by a union or employee association in Dallas.

<u>Were there any significant implementation problems or special implementation procedures?</u>

No significant problems or special procedures were reported.

<u>Were the changes continued beyond the demonstration period?</u>

The 4-10 workweek was not continued after the demonstration and there are no plans to renew it. The new work planning and scheduling procedures were being continued as of September 1976.[1]

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[1] Thomas, background notes from Dallas field visit in September 1976.

Synthesis of Findings from "Four City" and Related Projects

FINDINGS FROM THE "FOUR CITY" PROJECTS[1]

What approaches aimed at improved productivity were tried?

The major changes included in the Honolulu, Hartford and Dallas demonstrations are compared in Exhibit 1. As this exhibit shows, changes in work planning and scheduling were a component of every demonstration effort.

The information in Exhibit 1 also highlights other important features of this group of demonstration productivity improvement efforts. One is the degree of confounding in the demonstration, that is the extent to which determination of the productivity impacts of individual changes was complicated by the number and types of changes which were introduced during the demonstration. Honolulu's street repair effort was the simplest; it included only new daily work planning and scheduling procedures supplemented by new performance reports on how work actually accomplished compared with that planned. The Hartford parks equipment and the Honolulu parks efforts were the most complex; each project included a variety of changes, including new work planning/scheduling procedures, more day-to-day supervision, and other changes.

A second major feature is the considerable range in the scale of activities covered. Hartford's changes involved only 6 employees, while Dallas introduced the 4-10 workweek in activities covering over 500 employees. Honolulu's projects covered 6 urban repair crews (37 nonsupervisory employees) and 1 park district (88 employees).

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[1]Findings from the Fort Wayne demonstration will be added to this synthesis when written materials on this productivity improvement effort become available to the authors.

Exhibit 1

Changes Introduced in Honolulu, Hartford and Dallas Demonstration Projects

City/Type of Maintenance	Honolulu Parks Maintenance	Honolulu Street Repair	Hartford Parks Equipment Maintenance	Dallas Street Repair	Dallas Street Cleaning
Number/Type of Employees/ Activities Covered	One of four park districts; 88 maintenance employees	Six urban street repair crews (37 nonsupervisory employees) and truck drivers serving them	Division of 6 employees (including new foremen)	About 400 employees (including field, clerical and supervisory personnel)	About 132 employees (excluding headquarters staff and night shifts)
Changes in Planning/ Scheduling of Work	New weekly task schedule (based on engineered work standards) for each groundskeeper assigned to a particular park and each crew rotated among the parks	New daily work plans for each street repair crew and daily trip schedules for each driver delivering materials to street repair sites (based on previously prepared tables showing production rates and trip times)	Centralized scheduling by new on-site foreman (scheduling had previously been unsystematic and frequently handled by individual maintenance workers); more systematic scheduling of preventive maintenance work	New 4-10 workweek; also some other new work planning and scheduling procedures implemented to a limited extent in the latter half of the test period but nature and extent unreported	New 4-10 workweek; no other new work planning/scheduling procedures reported
Changes in Performance Reporting/ Uses of Performance Information	New weekly performance reports including information on (a) completed as compared to scheduled work, and (b) appearance ratings for 35 elements in individual parks using photographic standards developed by the project; management followup for parks/tasks having poor performance reports	New weekly performance reports for management on crew and driver work completed, as compared with daily schedules	New monthly or bi-monthly performance reports for management on (a) the proportion of mechanics' time devoted to "productive" maintenance work (monthly), (b) performance on individual maintenance tasks which was below the project's time estimates--these were not engineered work standards (monthly), and (c) pieces of parks department equipment with the longest downtimes and highest repair volumes (bi-monthly)	Work reporting procedures were altered slightly to provide separate information on materials laid per man-hour for different activities (such as for street resurfacing as compared with potholing), but no new performance reporting procedures were reported as having been introduced during the project	No changes reported
Changes in Day-to-Day Supervision/ Supervisory Staff	The number of foremen was doubled (from 2 to 4), to increase and better balance supervision	No changes reported	A new foreman was added to provide on-site supervision	No changes reported	No changes reported
Changes in Nonsupervisory Staff	The total number of maintenance employees was reduced by 10 percent through attrition of 9 temporary employees funded with federal CETA or revenue-sharing monies	No changes reported	No changes reported	An increase of 12 percent (from 370 to 416) in number of maintenance employees, primarily as a result of federal funds available for temporary workers	No changes reported
Changes in Organizational Structure	Creation of a new district-wide unit (to be responsible for non-routine, heavy-duty maintenance, grass cutting using larger power mowers, gardening, and providing relief personnel for absent employees) and an associated reduction in responsibilities for groundkeepers assigned to individual parks	No changes reported	No changes reported	No changes reported	No changes reported

Did use of the approaches lead to improved productivity?

There was sufficient preliminary indication of possible efficiency or effectiveness gains from the following changes introduced in these three demonstration projects to warrant their serious consideration as approaches to productivity improvement:

- In Honolulu's Parks Department, scheduling, supervisory and organizational changes and a photographic evaluation system apparently resulted in significant improvements in the appearance of parks in Honolulu's third district, during a period when the total number of maintenance employees was being reduced by about ten percent through attrition.
- In Honolulu's street repair operations, daily scheduling and related weekly performance reports for repair crews and truck drivers apparently resulted in significant improvements in the amount of materials used per employee-day for three street resurfacing and first aid crews.
- In Hartford's Parks Department's equipment maintenance division, the introduction of "productive time" reports apparently led management to balance workloads and make other specific changes (doing more work in-house and systematizing an existing preventive maintenance system), which resulted in significant improvements in reported "productive time."

The 4-10 workweek in Dallas's street repair and street cleaning divisions did not provide similar strong indications of either efficiency or effectiveness gains.

In no case was it possible to establish whether a productivity improvement (defined as maintaining the same quantity and/or quality of service at a lower cost, or increasing the quantity and/or quality of service at the same or lower cost) had actually taken place. This was because of limited information reported on costs and quantity and quality of service, before or after the changes were introduced.

Each of these productivity improvement efforts used federally-funded technical staff or services, or staff and experience with work measurement which had been developed in earlier projects. These might not readily be available in other jurisdictions.

Were there any effects on employee satisfaction or labor-management relations?

In each of the efforts where there were new planning/scheduling/reporting procedures which required filling out new forms (all except Dallas's street cleaning effort), initial employee resistance to filling out the new forms was reported. In each case, this resistance does not appear to have seriously impeded implementation.

No systematically collected information on employee satisfaction, before and after the changes were introduced, was collected for any of the demonstration efforts, so information on attitude changes was generally slight if not non-existent. However, in Dallas a questionnaire was administered at the conclusion of the 4-10 demonstration. It found that a majority of the employees responding (75 percent) favored the plan.

A 5 percent increase in absenteeism occurred during the Dallas demonstration, as compared with the same period a year earlier. This may have been due to a higher percentage of temporary employees during the demonstration.

Union or employee association involvement in this set of demonstrations was very limited. In Honolulu, there was one minor incident involving the union; it concerned truck driver dissatisfaction with filling out new work reports and was resolved quickly. In Hartford, discussions with union representatives to appraise them of proposed changes were held at the beginning of the demonstration but no other union activities or subsequent responses to the changes were reported. In Dallas, employees in street repair and cleaning were not formally represented by a union or employee association.

In no case did the cities make any layoffs associated with the new procedures, according to project reports. In only one case was a reduction in employees through attrition reported, and this involved temporary employees being paid with federal CETA or revenue-sharing funds.

Were there any signficant implementation problems or special implementation procedures?

In the Honolulu parks effort, coordinating the efforts of the several crews responsible for moving, maintenance and finishing was reported as difficult; weekly foremen meetings were helpful. A special effort had also been made to set up a new organizational structure which would maintain some groundskeepers responsible for particular parks, in recognition of constructive feelings of proprietorship.

No other significant problems or special procedures were reported.

Were the changes continued beyond the demonstration period?

Changes introduced in Honolulu's parks and streets demonstrations were continued beyond the demonstration period, an indication of the general support these changes had received from Honolulu officials. The fact that the evaluation system linked with photographic standards was also transferred to Honolulu's other park districts provides an even stronger indication of support for this system in Honolulu. The new planning and scheduling procedures implemented in Dallas's street repair division were also being continued beyond the demonstration, but the 4-10 workweek was not. The future of Hartford's work control system in its parks department's equipment maintenance unit was uncertain, as of October 1976.

FINDINGS ON THE PRINCIPAL TYPES OF APPROACHES TRIED

As was noted earlier, each of the three HUD-supported demonstration efforts whose findings have been reviewed for this report included changes which represented more than one type of approach to productivity improvement (see Exhibit 1). Even the simplest in terms of number of approaches, Honolulu's street repair effort, included both new work planning and scheduling procedures and new performance reports. There also was no way to ascertain from the evaluative information reported which of the changes introduced had which impacts on productivity. Thus it is not possible in a synthesis of findings from these projects and similar efforts elsewhere to indicate which types of approaches were most effective in generating productivity improvements.

This section is therefore confined to a general discussion of what is known about three types of changes which appear to have been most important in this set of HUD-supported demonstrations, either because they (a) appeared to have been the major innovations tested during the demonstrations, or (b) were common to more than one demonstration effort. The three types of approaches discussed are: (a) work planning, scheduling and reporting procedures (other than the 4-10 workweek); (b) the 4-10 workweek; and (c) evaluation systems linked with photographic standards.

This section is based on a review of selected written materials on demonstration efforts using these three approaches known to the authors, as well as the information from the HUD-supported efforts cited earlier. More specific sources are referenced in footnotes.

Work Planning, Scheduling and Reporting Procedures (Other than the 4-10 Workweek)

In comparing the findings from the "Four City" projects with findings from similar efforts elsewhere, it is clear that there are two major types of work planning, scheduling and reporting procedures--(1) those that incorporate engineered work standards and (2) those that do not. We did not find any information which could be used to compare the relative gains possible from the use of procedures which did and did not use engineered work standards.

In Honolulu, engineered work standards were linked with two efforts which showed potential for generating productivity improvements. (We can only say they "showed potential" because (a) several changes--in addition to the use of work standards--were introduced simultaneously, and any of these could have caused the impacts measured, and (b) data limitations made it impossible to know whether there had been productivity improvements in the sense discussed earlier in this report.) In the first of these, work standards were used to estimate staffing requirements and to prepare weekly work schedules in the parks department. The second application of work standards appears to have been in connection with Honolulu's street repair activities, where the standards apparently played a role in the preparation of daily schedules for Honolulu's street repair crews (the precise role of the standards is unclear from the project report).

Dallas introduced planning and scheduling procedures for street repair work as did Honolulu. However, instead of using engineered time standards, Dallas relied on time "standards" estimated by the general foremen on the basis of their own experience. Unfortunately, there was insufficient information for an assessment of the productivity impact of the Dallas procedures.

In Hartford, the introduction of planning, scheduling and reporting procedures was accompanied by the use of relatively simple "productive" time calculations. This made it possible for management to assess (a) how little time was spent on "productive" equipment maintenance tasks, and (b) how evenly "productive" activity was distributed among employees. The availability of such information appears to have been partially responsible for a subsequent increase in the amount of time the five parks department mechanics spent on "productive" equipment maintenance.

Such "productive hours" tallies were also found in another recent study to be an inexpensive, simple, and yet useful tool for management in Harrisburg, Pennsylvania's Vehicle Maintenance Center (VMC).[1] Productive hours tallies, along with "flat rate" work standards published for use by private sector automotive repair shops,[2] were used to balance the workload among mechanics, to estimate staffing requirements, and to determine training needs in the VMC. VMC management also attempted to use the productive hours tallies to evaluate the performance of individual employees. However, this application turned out to have drawbacks. For instance, it created an incentive for certain employees who normally worked fast to take longer to complete their repairs (and thus increase their "productive" hours), even though the extra time might not have been well spent.

Other local governments (Kansas City, Missouri, and Philadelphia) have used work standards to attempt to motivate public employees.[3]

In only one of these three cases of work standards usage (Harrisburg, Kansas City and Philadelphia) "could significant savings and productivity improvements be clearly attributed to the use of work standards. This was in Philadelphia, where the standards were coupled with a bonus." Employees in

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[1]John M. Greiner, Roger E. Dahl, Harry P. Hatry, and Annie P. Millar, Monetary Incentives and Work Standards in Five Cities: Impacts and Implications for Management and Labor (Washington, D.C.: The Urban Institute, forthcoming 1977). The work standards and "productive hours" efforts undertaken in Harrisburg's Vehicle Maintenance Center are discussed in chapter 3.

[2]"Flat rate" work standards for vehicle repairs are prepared and published by private companies and revised annually. Most are not engineered; they are meant to serve as guidelines, typical of vehicle repair times in private firms throughout the country. Standards published by Motor, Inc., in Motor's Standard Parts and Time Guide, were used in Harrisburg. (These are similar to the Chilton's standards used for the relatively few vehicle repair tasks in Hartford's parks equipment maintenance work control system; see discussion on p. 1-13.)

[3]Greiner et al., Incentives and Standards.

Harrisburg and Kansas City "observed that there was no reason for them to work faster, since the work standards were not tied to rewards. Management in both Harrisburg and Kansas City was reluctant to use the work standards to motivate better performance after experiencing difficulties with employees" during their introduction.[1]

The experiences of several other state and local governments which have used engineered work standards have been described in published reports.[2] These taken together indicate that local governments generally have not used work standards to develop monetary incentive plans (a use common in private industry). Instead, the major explicit application of work standards has been to plan and schedule work. Another benefit from the introduction of work standards, if accompanied by a methods improvement effort prior to setting the standards, has been their role in the improvement of work procedures.

There is, however, insufficient documented evidence and analysis in the published reports on the impacts of the standards on the overall efficiency and quality of government services to permit us to compare, comprehensively, those applications of engineered work standards with the cases discussed above.

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[1]Ibid., chapter 7.

[2]For example, see the discussion of the experiences of Phoenix (Az.), Riverside (Ca.), Solano County (Ca.), New York City, Santa Clara County (Ca.), and Kansas City (Mo.), Utah's Highway Department, Arizona's Highway and Economic Security Departments, and several departments in the state of California, as reported in John M. Greiner, Lynn Bell, and Harry P. Hatry, Employee Incentives To Improve State and Local Government Productivity (Washington, D.C.: National Commission on Productivity and Work Quality, March 1975), pp. 112-130. See also Seattle's work standards programs in its water and engineering services, Fairfax County's program in inspections, California's activities in its Motor Vehicle Division, described in Improving Governmental Productivity: Selected Case Studies (Washington, D.C.: National Center for Productivity and Quality of Working Life, Winter 1977); and work standards efforts used by Los Angeles' parks and recreation services and San Diego's facilities maintenance services in U.S., Joint Financial Management Improvement Program, Annual Report to the President and the Congress, Productivity Programs in the Federal Government, FY1974, Vol. II, pp. 139-145.

The 4-10 Workweek

It is questionable whether the 4-10 workweek introduced in Dallas's street repair and street cleaning efforts had generally favorable impacts on productivity. A number of other local and state governments have tried the 4-10 workweek in a variety of service areas. (Dallas itself had previously introduced 4-10 in its solid waste collection and police activities.) In some cases the plan has resulted in longer service hours for the public at no extra cost; in other cases the plan has resulted in higher costs.[1]

The fact that overtime actually increased in the street maintenance division during the introduction of the 4-10 workweek in Dallas is contrary to one of the major reasons, reduction in overtime costs, which is often cited for introducing the 4-10 workweek and has been found to be associated with its use in some other jurisdictions. Dallas's experienced increase in absenteeism (possibly due to a greater proportion of temporary workers) was also inconsistent with the experience of some other jurisdictions that have reported decreased absenteeism associated with the 4-10 workweek. The fact that participating employees generally favored the 4-10 workweek was consistent with the general support for the plan that has been found in other jurisdictions; however, the shortness of the demonstration (six months) could have meant that fatigue effects and family problems found in some places had not yet had a sufficient chance to become a problem in Dallas.

The Dallas report provided no specific information on how management-level employees felt about the 4-10 plan. Some managers have had difficulties with it, particularly in some small cities, where the plan has tended to intensify

[1]General findings on the 4-10 workweek reported in this section are based on an Urban Institute survey of 4-10 efforts reported in Greiner et al., Employee Incentives To Improve State and Local Government Productivity, pp. 102-104.

management problems (such as scheduling difficulties), communications problems, and staff constraints (resulting in the need to cross-train personnel to fill in when other workers are off).

On the whole, there appears to be little evaluative information published on the 4-10 except in the police area.[1] Requirements for police work (such as the need to provide more protection during peak crime hours) are sufficiently different from requirements for street maintenance and street cleaning work to make information on the 4-10 for police of limited use in comparing the Dallas results with similar projects elsewhere.

Evaluation Systems Linked with Photographic Standards

It seems likely that the presence of Honolulu's evaluation system linked with photographic standards played a role in generating the increases in appearance ratings measured by the system over the demonstration; as noted

[1]The experiences of another Texas city, Denton, which tried the 4-10 workweek in its street maintenance activities in 1972 and 1973, are generally described in an article by Joe Erwin, Street Superintendent of Denton, in "Why a City Street Department Shelved the Four-Day Workweek," Rural and Urban Roads, April, 1976, pp. 39-40. Denton decided the disadvantages of the 4-10 outweighed the advantages, and so shelved it. Disadvantages mentioned in the article included "loss of time, work scheduling difficulty, strenuous and repetitive employee exertion, interdepartment jealousy, and citizen inconvenience." Advantages mentioned included possibly increased employee morale because of the extra day off and reduced time spent on travel to the job site and lunch/coffee breaks. The only statistical information presented in the article refers to output changes (such as change in square yards of patching) for six activities, from the two years (1972 and 1973) during which the 4-10 was introduced to two years (1974 and 1975) after the return to the 5-day workweek. Three street maintenance activities showed increases in output, three showed declines. However, it is also noted in the article that there was a 10 percent reduction in total street maintenance employment after the return to the 5-day workweek, so output per man-hour may have increased for some of the activities which showed output decreases. Several changes in addition to the type of workweek (such as closer policing of time off and lower turnover, which may have been associated with the slowing of the economy) were also mentioned in the article. These could have accounted for some of the output changes between the two periods, but they were not specifically related to output changes in the article.

earlier, this cannot be determined with certainty because several changes were introduced simultaneously. We know of no reported experience of other jurisdictions using such evaluation systems for parks. However, similar visual evaluation systems have been used for street cleaning and other solid waste collection activities in other jurisdictions. Published information is insufficient for determining the extent to which the presence of such systems actually helped to stimulate productivity improvements (as distinct from just measuring changes in effectiveness).[1]

A validity problem associated with foremen rating their own parks was noted earlier for the Honolulu procedures. The cleanliness rating systems in some jurisdictions use trained observers with more independence from the operations they are rating. For example, Washington, D.C., uses regular city sanitation inspectors; New York City uses persons employed by the mayor's office. Regular reliability checking of a sample of ratings, as well as adequate training for new observers and retraining for observers whose ratings appear no longer to be reliable, is recommended based on the Urban Institute's study of rating

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[1]New York City has used cleanliness ratings to compare various sanitation districts and their performance against targets and over time. After a layoff of almost 1,500 sanitation workers and reductions in the frequency of garbage collections in July 1975, and a 19-month low level in the ratings for August 1975, the cleanliness level of the city's streets and sidewalks in October 1975 had returned to the level recorded for the same month a year earlier. This information was reported in a release for a press conference held by Mayor Abraham D. Beame and Project Scorecard, Fund for the City of New York, November 29, 1975, and "Study Finds City as Clean as in '74 Despite Layoffs," New York Times, November 30, 1975. More information for subsequent months would be needed to see whether New York City was able to sustain performance at the previous year's levels. Also, the role of the rating system in stimulating performance is unclear.

Savannah used 1973 street cleanliness ratings for different neighborhoods to allocate an addition of about 20 employees (mostly CETA-funded) throughout the city; the 1974 ratings subsequently showed improvement in the neighborhoods in which the new employees had worked. This use of cleanliness ratings was reported by Arthur A. Mendonsa, City Manager of Savannah, and Sam Halter, Assistant City Manager of Savannah for Public Services, in interviews with John Hall of the Urban Institute, January 25 and 26, 1977.

procedures in several cities.[1] Reliability tests using separate ratings made by parks management personnel were incorporated in the Honolulu demonstration, but the limited information presented in the project report does not indicate that such tests necessarily reduced the problem of potential bias so as to warrant confidence in the ratings reported. We therefore believe that a system of trained observers relatively independent of the staffs who perform maintenance work would probably have been preferable for Honolulu, and should be used by other jurisdictions instituting similar procedures. However, such rating systems should not be undertaken without provision for regular and even feedback on the ratings to the appropriate managers and supervisors.

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[1] How Effective Are Your Community Services: Procedures for Monitoring Their Effectiveness (Washington, D.C.: The Urban Institute, forthcoming in 1977).

PART TWO:

THE RAND AND PTI FIRE DEPLOYMENT ANALYSIS APPROACHES

The New York City-Rand Institute (RAND and Public Technology, Inc. (PTI) have each developed systematic approaches[1] for applying mathematical analysis to local fire department deployment decisions on the number and placement of companies and stations. These approaches all provide descriptive information on company travel times and other indicators such as company workloads (in percent of time active), using computerized models applied to input data. Both PTI and RAND provide for modification of the models underlying the approaches to fit local circumstances, and both PTI and RAND provide options on the amount of data required so as to permit users to trade off cost versus sophistication. This means that there are many ways in which use of the models can vary from one jurisdiction to another. This review distinguishes four approaches (whose general characteristics are identified in the next section of this report)--(1) the RAND Parametric Allocation Method (PAM), (2) the RAND Firehouse Site Evaluation Method (FSEM), (3) the RAND Simulation approach, and (4) the PTI Fire Station Location Package.

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[1] In this review, the term "model" is used to apply only to the mathematical representation of a community's deployment situation: the choice of data sources and the estimates of travel time and other relevant deployment information that are provided. The term "approach" is used to encompass the decision-making process of which the model is a part; thus "approach" covers such elements as provisions for technical assistance, provisions for model calibration, and understandability of written materials, as well as the model and adequacy aspects covered under the term "model."

As of late 1976, PTI's approach had been used or was being used in over one hundred cities and counties[1] while RAND's approaches had been tried or were being tried in eleven cities and counties.[2] At least two localities--Denver, Colorado and San Jose, California--had used approaches based on elements of approaches from both RAND and PTI.

Despite the large number of local governments that have used at least one of these approaches, there is little detailed published material on what deployment changes users of the approaches selected, what other choices they considered, what costs and benefits they expected to get from the changes, what they learned about the accuracies of the models they used, and what they had planned to do before they used the approaches (to see whether use of the procedures actually led to changes in decisions). Only six cities have documented user experience with enough detail to permit some useful assessment of the experience: New York City (where some of the RAND approaches were first developed); Denver (which did its study using local variants of RAND and PTI approaches under a grant from HUD); three other cities that RAND assisted in the use of the approaches with some development funding from HUD--Yonkers, Wilmington, and Jersey City; and Trenton, which worked with RAND during this same period.

Written materials on the approaches of RAND and PTI were reviewed for evidence on whether use of the approaches leads to improved productivity and if so, under what conditions. (The limited size of this assessment effort

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[1]Conversation with Costis Toregas, PTI, December 29, 1976.

[2]Letter from Jan Chaiken, Rand Corporation, and Warren Walker, formerly of the Rand Corporation, May 5, 1977.

precluded use of experiences not described in the written materials.) The term "productivity" was taken to include both efficiency and effectiveness concerns. That is, changes in the quality of service delivered (measured by "proxy" measures such as average travel time to fire incidents; direct quality measures such as expected changes in fire loss are much more difficult to estimate) were considered as important as changes in the amount of resources required to deliver that service.

As noted above, the documented experience available for this review and synthesis was far less than the actual experience in the field and was very short on material regarding use of the PTI approach. The tentative conclusions in this synthesis reflect these limitations. Nothing in this review should be considered an assessment of the quality or adequacy of the projects that PTI and RAND conducted to develop, test, and transfer their analytic approaches. This review is solely an assessment of the approaches themselves to the extent that the documented material on those approaches made such an assessment possible.[1] It is the authors' view that no inexpensive expansion of the project methodology--such as the addition of telephone surveys of the user communities--would have sufficed to fill the gaps in information on the accuracy of the models, which is one of the most important issues.

This review of findings regarding the extent to which use of the approaches is likely to generate improved productivity and related impacts is presented as answers to five questions:

A. What are the characteristics of the approaches that were tried?

B. Did use of the approaches lead to improved productivity?

C. Were there any effects on employee satisfaction or labor-management relations associated with using the approaches?

D. Are the models underlying the approaches sufficiently accurate?

E. Which of the approaches is best and under what conditions?

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[1]See Appendix F for a list of the materials reviewed in making this assessment.

A. What Are the Characteristics of the Approaches That Were Tried?

The characteristics of the RAND and PTI fire deployment approaches may be briefly summarized as follows:

- RAND Parametric Allocation Method (PAM). This is the simplest of the RAND approaches. Its principal inputs include data on fire alarm rates and other characteristics (size in square miles, current number of fire companies) for individual regions of the city. The average travel times by region are averages over all alarm boxes; differences in alarm rates among boxes are not reflected. Average travel times for the city reflect differences in alarm rates among regions. Other outputs include percent of times companies are busy and "best" allocations of companies to regions, given (a) a total number of companies to allocate, (b) the value of an input parameter, specified for each individual community, that trades off extra coverage of areas with more property or people at risk versus extra coverage of areas that have historically had more fires, and (c) input values of hazard factors (how much more extra time is worth because of the property and people at risk) for each region of the city.

- RAND Firehouse Site Evaluation Method (FSEM). This is the model of medium complexity within the RAND group of approaches. It is also the approach RAND recommends for use in almost all communities. It involves dividing the city into a fine, relatively uniform grid of zones (geared either to existing alarm boxes or, in communities without alarm boxes, to "phantom boxes." It then involves determining alarm rates for the areas served by those boxes and fitting mathematical formulas to data on travel distances and travel times. With this input, the model then estimates average travel times to structural fires and to alarm boxes; it can also provide a distribution of the estimated travel times to alarm boxes.

- RAND Simulation Approach. This is the most complex of the three RAND approaches, and RAND recommends it for use only if there is a "busy company" problem (that is, there are sizeable portions of the day when companies are busy at least 10 percent of the time on the average). Like the FSEM, it involves dividing the city into "phantom boxes." It requires additional types of input data (such as the number of pieces of equipment used at each type of incident and the dispatch policy that determines how they are called in) plus data used in the FSEM. Its outputs include estimated average travel times to incidents, by type of incident, and "percent of time available," by company.

- PTI Fire Station Location Package. This approach involves identifying classes of property types deemed to pose similar hazards, dividing the city into a set of "fire demand zones" with properties of approximately equal fire hazard and setting a maximum travel time for each zone which cannot be exceeded if that zone is to be considered "covered" (with some analyses making allowance for a "safety margin"). It also requires distance and speed data on a network of nodes and links (which is developed separately for each city) as well as data on alarm rates and potential fire station locations. The model then estimates travel times to points in the community. The model can use speed estimates based on (a) local data on speeds actually achieved by fire companies, for each link in the network, or (b) other data, such as PTI's table of suggested speeds for each type of road (such as 20 miles per hour on all segments of arterial road located in the central business district).

More detailed descriptions of data and procedures used in and output produced by each of the RAND and PTI approaches are presented in Appendix B.

Exhibit 2 shows which of these four approaches were used in each of the six cities for which published case materials were available. As noted earlier, there was very little published information on user experience with the PTI approach--only Denver, which did one of its two analyses using a locally developed variation of the PTI approach.

B. Did Use of the Approaches Lead to Improved Productivity?

In each of the cities shown in Exhibit 2, use of the various approaches was followed by adoption of plans for deployment changes involving one or both of the following:

(1) Reducing the number of companies planned for the community, either by cutting back from the current authorized number of companies or by cutting back the size of a planned expansion in the number of companies. These changes are aimed at reducing or averting most of the costs associated with the companies eliminated.

(2) Revising the planned locations of some companies, by some combination of relocating existing companies and revising planned locations for some companies due to be added. These changes are aimed at improving travel times to incidents.

Responses to a PTI mail survey (from 42 of the 52 communities that had implemented its approach as of October 1976) indicated that the results of using their approach were as follows: Plans for the future were changed in 90% of the jurisdictions, with 33% projecting lower costs and lower travel times, 14% projecting reductions in either costs or travel times with no increases on the other side, and 43% projecting either lower costs with higher travel times or lower travel times with higher costs. Current operations were changed in 52% of the jurisdictions, with 3% estimating lower costs and lower travel times, 19% estimating reductions in either costs or travel time with no increases on the other side, and 30% estimating either lower costs with higher travel times or lower travel times with higher costs.[1]

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[1] "The PTI Fire Station Location Package: Effectiveness Analysis," PTI Draft Paper, May 25, 1977, Figure 4.

EXHIBIT 2

APPROACHES USED IN EACH OF THE CITIES WITH PUBLISHED CASE STUDY MATERIAL

	RAND Parametric Allocation Method (PAM)	RAND Firehouse Site Evaluation Method (FSEM)	RAND Simulation Approach	PTI Fire Station Location Package
Trenton		x		
Wilmington	x	x		
Yonkers	x	x		
Jersey City	x	x		
New York City	x	x	x*	
Denver		**	x*	**

*In New York City, the Simulation approach does not appear to have been used for decisions involving fire station location or fire company location. Instead, the model was used to justify changes in dispatch policy and changes in relocation algorithms (i.e., the real-time procedures for deciding which idle companies should be temporarily relocated into areas with several incidents in progress, so as to preserve coverage for any additional alarms that may occur in those areas).

In Denver, the Simulation approach was used in the station and company location decisions; it was used to check the severity of the busy company problem--now and with projected higher alarm rates in the future.

**A locally developed variant approach with elements of the PTI Fire Station Location Package and the RAND FSEM approach was used.

Other major deployment decisions, such as determining the required number and locations of new companies in an expansion, can be made using the approaches, but no such uses have been documented.

The use of an approach and the adoption of plans for deployment change can be said to improve productivity if the sum of (1) cost savings (or costs avoided) by reduction in the number of companies planned, if any, plus (2) benefits attributable to net improvements in travel time, if any, plus (3) cost savings, if any, in total time and effort required to make the decisions and get them adopted,[1] is greater than the sum of (1) costs involved in relocating stations that were not scheduled to be rebuilt or relocated, if any, plus (2) penalties attributable to a net worsening in travel time, if any, plus (3) net increase in costs in total time and effort required to use the approach, make the decisions, and get them adopted, if those costs do go up.

This general criterion is used as the basis for assessing whether the published information on the experiences of five cities suggests that use of the approaches led to choices that probably will lead to productivity improvement in those five cities.[2] But there are substantial limitations on the information presented in the five case studies on each of the six components in the comparison described above. For example, as of the end of the case studies, most deployment changes were only planned. Since the changes had not yet been made,

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[1]The costs of decision-making could go down if the analysis is done by an existing analytic unit with few competing priorities of analysis and if the use of analysis made agreement on the deployment decision occur more quickly.

[2]Although there is published material on a sixth city, New York City, the documentation is insufficient for making even a rough estimate of probable productivity impact such as was possible for the five other cities. The New York City material does provide evidence on the accuracy of the underlying models, which is discussed later in this report.

the cost savings and travel time changes had not yet occurred. Even if some users had completed all planned deployment changes, many of these elements would be very difficult to compute. This is so, if for no other reasons than that it will never be clear how much a given deployment decision has been shaped by the use of analysis as opposed to other factors, and that it is usually unclear what deployment changes and capital expenditures would have occurred in the absence of the analytic input. Thus, it has been necessary for us to qualify carefully our assessments and reasons for those assessments. In particular, most calculations had to be based on what the costs and benefits would be if a plan such as that which the city seemed to have adopted as of the end of the case study were eventually carried out in full.

Costs of Using the Approaches

The cost information is very sketchy for all the approaches. RAND's documentation includes the following cost information:[1]

- The only use of the Simulation approach without RAND assistance was in Denver and was estimated to cost $80,000.
- User-supplied estimates (in response to a mail questionnaire) of the "total personnel and computer cost for . . . the first year" for RAND's PAM and FSEM approaches ranged from a low of $5,000 (for one of the communities that used only PAM) to a high of $30,000 (for one of the communities that used both PAM and FSEM) with an average reported cost of $14,000. (These figures do not include any costs for RAND assistance.)

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[1]Jan M. Chaiken, Implementation of Emergency Service Deployment Models in Operating Agencies, Report P-5870 (Santa Monica, Calif.: Rand Corporation, May 1977), pp. 23-26.

It is not known whether the cost figures provided included staff benefits, supervisory time, overhead, and other indirect costs. Separate ranges and averages for the costs of PAM and FSEM were not obtained. RAND has published some estimates of staff-time and the computer component of cost, as shown in Exhibit 3.

Given all these open questions, rough estimates of the costs for RAND's PAM and FSEM were estimated by assuming that (1) a total cost, including indirect costs, of $20,000 per year is typical for the level of local staff employed on the FSEM, (2) the estimated person-months shown in Exhibit 3 are typical requirements for the FSEM, and (3) the low figure of $5,000 reported for PAM use is a good guide to the true lower bound of the cost range for users of PAM. With these assumptions, cost ranges of $5,000 to $8,000 for PAM and $8,000 to $18,000 for FSEM appear to be reasonable.

The documentation on the PTI approach includes the results of a mail survey in October, 1976, of the 52 communities that had implemented the PTI Fire Station Location Package as of that date.[1] (The survey drew responses from 42--or 81%--of these 52 communities.) Even more than with the RAND survey, the responses indicated an extremely wide variation in the cost of using the package,[2] even when communities were compared only to other communities of comparable population size. PTI believes the largest part of this variation was due to ambiguities in question wording that might have led respondents to count all local persons involved in the study as full-time during the entire length of the project, whereas the work time of an individual on the study is typically only a fraction of the calendar time elapsed during the project. And in fact, PTI confirmed by phone call that several of the largest estimates of required staff time were inflated in this fashion.

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[1]"PTI Survey Analysis."

[2]For all respondents, the estimated number of person-months required ranged from 2 to 264 with a median of 14.

EXHIBIT 3

PUBLISHED COST-RELATED INFORMATION FOR THE RAND APPROACHES

Parametric Allocation Method (PAM)	Firehouse Site Evaluation Method (FSEM)	Simulation Approach
About 1/2 to 1 1/2 person-months usually required	About 5 to 11 person-months required	About 24 person-months required
The computer model may be obtained in either BASIC or PL I language. It requires storage equivalent to 16,000 bytes on an IBM 360/370 computer. The estimated cost per run was $0.20 in September 1975. RAND estimates that it takes about 1-1/2 person-weeks to set up the data as input and to set up the model plus another 2 person-months if the data need to be collected and processed. Time to run the model and test out options would be additional and would probably not exceed a few person-days.	The computer model is written in FORTRAN language. It requires storage equivalent to 108,000 bytes on an IBM 360/370 computer. The estimated cost per run was $5.00 in September 1975, though the Wilmington case study--conducted earlier--reported the cost as $10.00 per run. RAND estimates that it takes about 2 1/3 to 3 ½ person-weeks to set up the data as input and to set up the model plus another 2 person-months if the data needs to be collected and processed. Time to run the model and test out options would be additional and would probably be close to a person-week.	The computer model is written in SIMSCRIPT 1.5 language. It requires storage equivalent to 228,000 bytes on an IBM 360/370 computer plus two auxiliary storage tapes or disks. The estimated cost per run was $100.00 in September 1975. RAND estimates that 2 person-years are required for all facets of preparation and use.

Sources: Warren E. Walker, The Deployment of Emergency Services: A Guide to Selected Methods and Models, Report R-1867-HUD (Santa Monica, Ca.: Rand Corporation, September 1975), pp. 16, 20, 24, and Jan M. Chaiken, Implementation of Emergency Service Deployment Models in Operating Agencies, Report P-5870 (Santa Monica, Calif.: Rand Corporation, May 1977), pp. 23-26.

Given this major problem with the user-supplied cost estimates, no specific cost ranges can be estimated for the PTI approach. However, it appears likely that PTI's costs will be comparable to the costs of RAND's FSEM. This will be true if (1) most project staff in each of the PTI test communities worked half-time or less on the project during its life, but (2) most users estimated total staff time on the project by simply multiplying the total staff size by the total life of the project. If both (1) and (2) are true--which seems likely but could not be checked out--then the PTI and RAND user costs should be comparable. A complete comparison of costs for the various approaches should also consider such factors as ease of use, costliness of staff required (to get sufficient sophistication), and extent of data required. There appear to be significant differences between the various approaches on these factors, and these differences could result in significant differences in costs to typical users, but the current documentation is insufficient to indicate the magnitude or effects of those differences.

PTI has also provided estimates to prospective users as to the minimum team size and minimum calendar time required to implement their approach (see Exhibit 4).

It should be emphasized that the preceding characterizations of user estimated costs are very rough and are based on very limited information. Potential users of the PTI approach also might have to pay the fee charged by PTI to non-PTI subscribers; almost all users of the PTI approach thus far have been PTI subscribers. Also, since almost all these costs are in local government staff time, the out-of-pocket costs could be very small if a community has analytical staff available for work on the analyses.

EXHIBIT 4

PUBLISHED COST-RELATED INFORMATION
FOR THE PTI APPROACH

Population Size of User Community	PTI's Estimate of Minimum Team Size Required (may be part-time during project)[1]	Actual Range Reported for Team Size (in Full Time Equivalents)[2]	Median Team Size Reported (in Full Time Equivalents)[2]	PTI's Estimate of Minimum Implementation Time in Months[1]	Actual Range Reported for Duration of Project[2]	Median Time Reported for Duration of Project[2]
1,000,000 and above	5	none surveyed	none surveyed	8	none surveyed	none surveyed
500,000 - 1,000,000	4	2.0 - 5.1	3.5	7	4 - 11	6
250,000 - 500,000	3	0.9 - 24.0	5.0	5	7 - 11	9
100,000 - 250,000	2	1.1 - 5.7	1.8	4	3 - 22	6
50,000 - 100,000	2	0.4 - 2.7	1.8	3	5 - 27	8.5
25,000 - 50,000	1	0.7 - 12.5	1.9	2.5	2 - 9	6
10,000 - 25,000	1	1.5	1.5	2.5	2	2

[1]Source: Adapted from Public Technology, Inc., "Fire Station Location Package," Project Leaders Guide, Table 1.

[2]"PTI Survey Analysis," Figure 8.

Despite the considerable uncertainty remaining as to the typical costs of these approaches, it seems clear that the potential benefits (discussed in the next section) of using the approaches in major deployment decisions can be greater than the costs. The net benefit of using the approaches will be easiest to demonstrate if the approaches lead to previously unplanned reductions in the number of companies relative to what was planned, without causing a significant drop in travel times. This generally leads to annual savings or cost avoidance of over $200,000 for each company that is eliminated or not added in an expansion. In the absence of any change in operating costs, major improvements in travel times will probably be needed to justify the costs of any hitherto unplanned relocations selected using the approaches. If relocations (say, of stations) are planned anyway, and their costs can be regarded as "sunk" costs that will occur no matter what else is done, then the cost of using at least the less expensive approaches (i.e., FSEM and PTI) will probably be justified by even modest travel time improvements because the only cost remaining to be offset will be any net increase in the cost of making decisions as a result of using the approaches.

Productivity Impacts in Five Cities

As Exhibit 5 shows, the current documentation on user experience does not cover the full implementation of deployment changes selected with the help of the approaches in any of the communities. Therefore, this assessment of productivity impact uses information on the projected impact from planned changes in fire company deployment or fire station locations. That is, the review estimates whether or not certain planned changes would be of net benefit to the communities if they were to be adopted. We have also taken into account the

EXHIBIT 5

RESULTS OF USE OF THE APPROACHES IN THE
SIX CITIES WITH PUBLISHED CASE STUDY MATERIALS

	Deployment Changes Selected During Case Study Period by City Officials Using the Approaches	Implementation Status as of Last Information (early 1977, except when indicated otherwise)
Trenton	Eliminate 2 companies. Close 1 station. Rebuild or relocate 6 other stations--already being considered because of stations' ages.[1] No details provided on how manpower would be reduced or reallocated as a result of the elimination of the two companies.	Planned changes are under consideration pending results of a study of city fire defenses by the Insurance Service Office, scheduled for early 1978.[2]
Wilmington	Eliminate 1 company. Relocate 3 stations and several companies--some already planned, then halted because of fiscal crunch.[3] Elimination of company would permit reduction in overtime; no reduction in authorized strength planned.	Company to be eliminated was closed by city over objections of fire fighters union.[4] Two of three proposed new stations built at suggested sites; application is in to Public Works Department for approval of construction of third site. Movement of companies into planned new locations has begun.[2]
Yonkers	Relocate 2 stations--already planned because of dilapidation and planned highway construction.[5]	One of two planned relocations made, other relocation rendered unnecessary when highway project fell through. Since end of case study, city has used FSEM for major deployment changes, including elimination of at least 3 companies, but cuts were dictated by budget pressures and not due to use of FSEM.[2]
Jersey City	No plan for deployment changes adopted.[2]	Since end of case study, city has used FSEM to develop plans related to the possibility of consolidation of all fire services in city and surrounding county.
New York City	Cut at least 13 companies—documentation does not give full details.[6]	No unified case study written on New York City, so these details are missing.
Denver	Eliminate 5 companies by end of 1980, according to a phased program starting in 1975. Convert 2 engine companies to mini-pumper companies and 2 other engine companies to multi-purpose vehicle companies. Relocate some companies and stations. Staff cuts would be made by attrition.[7]	As of end of 1976, plan had been cut back from 5-company net cut to 2-company net cut; one of those company cuts had been made. Reduced plan is consistent with but less than original plan.[2]

[1] Jack Hausner and Warren E. Walker, An Analysis of the Deployment of Fire-Fighting Resources in Trenton, New Jersey, The New York City-Rand Institute, S-1566/1-TRNTN, February 1975, pp. 1-2.

[2] Jan M. Chaiken, "Classification and Catalog of Local Government Experience in Adopting Six Emergency Service Deployment Models," Unpublished RAND report to HUD, May 1977.

[3] Warren E. Walker, David W. Singleton, and Bruce A. Smith, An Analysis of the Deployment of Fire-Fighting Resources in Wilmington, Delaware, The New York City-Rand Institute, R-1566/5-HUD, July 1975, pp. 1, 51.

[4] Warren E. Walker, The Deployment of Emergency Services: A Guide to Selected Methods and Models, Santa Monica: Rand Corporation, R-1867-HUD, September 1975, pp. 42, 44, 46, 48.

[5] Jack Hausner, Warren Walker, and Arthur Swersey, An Analysis of the Deployment of Fire-Fighting Resources in Yonkers, New York, The New York City-Rand Institute, R-1566/2-HUD/CY, October 1974, pp. 38, 42.

[6] Edward J. Ignall, et al., "Improving the Deployment of New York City Fire Companies," paper presented at the 45th Joint National Meeting of the Operations Research Society of America and the Institute of Management Sciences, Boston, April 22-24, 1974, RAND Paper P-5280, p. 22.

[7] Thomas E. Hendrick, et al., An Analysis of the Deployment of Fire-Fighting Resources in Denver, Colorado, The New York City-Rand Institute, R-1566/3-HUD, May 1975, pp. 11-12.

limitations of the measures (principally averages) used in making the decisions. We have tried to assess whether additional information on the distribution of travel times would have substantially altered the attractiveness of the deployment option selected relative to the old deployment.

Among the RAND user cities, Trenton executive branch officials selected a plan for changes expected to yield annual cost savings of about $740,000 from the elimination of 2 companies. Citywide average travel times of first-due companies to points in the city[1] were expected to be cut by 0.09 minutes for engine companies and 0.27 minutes for ladder companies, as a result of relocations of the remaining companies.[2] The cost savings alone would pay for the costs of using the RAND FSEM in less than a month after the changes were completed if the full personnel reductions were achieved through layoffs or attrition and if it is accepted that the 7 city fire stations would have been replaced whether the FSEM were used or not, given the fact that city officials acknowledged the stations were badly deteriorated and needed to be replaced. We believe that the procedure for estimating travel times is sufficiently accurate that errors in the estimates probably would not be large enough to warrant concern that travel times would actually increase under the new deployment. Trenton officials do not appear to have been planning any specific cuts or other major deployment changes prior to their use of RAND's FSEM; hence, it appears that the projected net productivity improvement of these changes, if made, could be attributed to the use of the RAND approach.

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[1]Travel times were not calculated on the same basis in all cities. For Trenton and Yonkers, the only averages given treated all alarm boxes equally, regardless of their alarm rates. In Wilmington, averages weighted by the rate of structural alarms were also given. In Denver, averages weighted by the rate of all alarms were given.

[2]Jack Hausner and Warren E. Walker, An Analysis of the Deployment of Fire-Fighting Resources in Trenton, New Jersey, The New York City-Rand Institute, R-1566/1-TRNTN, February, 1975, pp. 2, 42, 57.

In Denver (which used its own variants of the RAND Simulation and the PTI approach), the changes originally selected by the executive branch, if implemented, were expected to yield annual cost savings reaching $1,200,000 in the year after all changes were completed, as a result of the elimination by attrition of personnel from 5 companies. Citywide average travel times of first-due engines to alarms were projected to rise by 0.14 minutes.[1] We made a very rough estimate of the ratio between the additional fire loss likely to occur as a result of the increase in average travel time and the expected cost savings; the savings probably would have been several times as large as the increase in monetary value of losses and casualties.[2] The accuracy of the travel time estimating procedures is considered good enough that random errors were likely to be too small to reverse this conclusion of a net benefit.

It is not known whether or not the reduced plan summarized in Exhibit 5 would also be expected to produce a net improvement in productivity. Denver officials were initially interested in the approaches because they wanted to plan for future demand, which they expected would require the addition of more companies. Therefore, the plan they developed using the approaches could be credited with not only the cost savings associated with cutting the companies scheduled for elimination but also the cost avoidance associated

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[1] Thomas A. Hendrick et al., An Analysis of the Deployment of Fire-Fighting Resources in Denver, Colorado, The New York City-Rand Institute, R-1566/3-HUD, May 1975, pp. 113, 119.

[2] We used Jane Hogg's estimates of the monetary value in expected extra loss and extra casualties of extra travel time, updated to reflect inflation and assuming a particular mix of residential and non-residential structural alarms. Her figures assumed a value in 1967 of 30,000 English pounds for a lost life. See Appendix C for more details on Jane Hogg's figures and how they were calculated, summarized from Jane M. Hogg, "A Distribution Model for an Emergency Service," Imperial College of Science and Technology, University of London, September 1970, Table 2.

There are clearly problems involved in using estimates made ten years ago in another country with different fire code provisions, traffic patterns, fire safety habits, and the like. But the rough conclusions stated here would have held up if the imputed cost of extra travel time were several times higher than we estimated, and available evidence suggested such a large discrepancy was unlikely.

with not adding the number of companies Denver officials has expected they would have to add (an unknown number since Denver officials had not estimated the number of companies they thought they would have to add).

In Wilmington (which used RAND's PAM and FSEM approaches), a plan was adopted involving the elimination of one company and the relocation of several others. The elimination of the company was expected to yield annual cost savings of $240,000 through attrition and reduced use of overtime. The company was eliminated before the end of the case study, but the compensating relocation of stations took longer to get started. Since partial implementation of recommended plans can occur, it is useful to consider what the net outcome would have been if the company cut had remained the only change implemented by the city. In that case, there would have been an increase in citywide average travel time by first-due engines to structural alarms of 0.06 minutes, with the travel time increase concentrated in an area of non-residential buildings.[1] Our rough comparison of the expected cost savings and the monetary value of additional loss and casualties due to increased travel time indicated the savings probably would have been greater than the losses in this case, but by a much narrower margin than in the Denver calculation. It is quite possible that random errors in the estimation of travel times could have been large enough to imply that the extra losses would have more than exceeded the cost savings.[2] However, even in that case the picture is complicated by the difficulty of determining what would otherwise have happened. Since the city officials were using the approaches to find ways to cut the budget--something they might have done anyway--it may be that use of the RAND, PAM and FSEM approaches resulted in a smaller increase in travel times--and consequently less

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[1]Warren E. Walker, David W. Singleton, and Bruce A. Smith, An Analysis of the Deployment of Fire-Fighting Resources in Wilmington, Delaware, The New York City-Rand Institute, R-1566/5-HUD, July 1975, pp. 54, 70.

[2]See discussion of the basis for this conclusion in Appendix D. It relies on a comparison of empirical data with estimates made by the RAND Simulation approach in Denver.

extra loss--than would have occurred if officials had decided how to cut the budget without using the approaches. This cannot be determined with confidence because the city officials had not developed their own plan for cuts prior to use of the RAND approaches.

On the other hand, the plan that the city is pursuing is expected to result in only a .04 minute increase in average citywide travel time by first-due engines to structural fires. Moreover, the center city region, where added time is likely to mean the most extra loss, will have reduced travel times to structural fires by first-due ladders which should compensate somewhat for the increase in first-due engine travel times. Thus, the added loss from extra travel time is no longer likely to be enough by itself to exceed the value of the cost savings from the eliminated company. However, the full plan calls for relocation of three fire stations, of which one was scheduled to be moved anyway and one was clearly deteriorated and in need of replacement. That still leaves one station relocation whose cost may have to be charged to the plan, and that cost is large enough (about half a million dollars) to mean that it will probably be several years before the net financial impact can be said to be profitable. Documented information on what had been planned for these stations was very sketchy and very subject to change, though. The Wilmington case illustrates as well as any the difficulty of determining a fair context of baseline expectations within which the decisions made using analysis can be assessed.

In Yonkers (which used RAND's PAM and FSEM approaches), there were no direct cost savings as of the end of the case study, because the deployment plan selected changed only the locations of two companies. The average travel time of first-due engines to alarm boxes would have been expected to drop by 0.2 minutes in one region of the city and to remain unchanged in all other regions.[1] A crude calculation of the likely savings from this travel time reduction, using the same procedure as for Denver and Wilmington, indicated that several years would be required before those savings would have paid for the costs of using the RAND PAM and FSEM models, and that random errors in the calculation of travel times could easily have been large enough to wipe out most or all of those savings.[2] Moreover, the one relocation that lowered the travel times would have been made because of condemnation of the old station site for highway construction; thus, some version of that change should have been regarded as part of the baseline expectations (although the new site selected could have been different).[3] Therefore, this kind of use of the analytic approaches probably costs more than it is worth.

In Jersey City (which used RAND's PAM and FSEM approaches), no changes had been adopted as of the end of the case study.[4] If this continues to be true there will, of course, be a net loss to the city from use of the PAM and FSEM approaches.

Summary of Findings on Productivity Impact

The two cities—Trenton and Denver—whose end-of-case-study plans seemed most likely to produce net productivity improvement chose major deployment changes involving the elimination of more than one company and the relocation

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[1]Jack Hausner, Warren Walker, and Arthur Swersey, An Analysis of the Deployment of Fire-Fighting Resources in Yonkers, New York, The New York City-Rand Institute, R-1566/2-HUD/CY, October 1974, p. 42.

[2]As was true for Wilmington, this conclusion regarding the possible impact of errors in calculating travel times is based on a test carried out in Denver. See Appendix D.

[3]Hausner et al., Yonkers, p. 38.

[4]Walker, Guide to Models, p. 44.

of many others. The two cities--Jersey City and Yonkers--whose end-of-case-study plans did not seem likely to produce net productivity improvements chose very minor changes or no changes at all. The one city--Wilmington--whose plans were hardest to assess for net productivity impact either had a plan that involved major deployment changes and major costs that were previously unplanned (the plan Wilmington is pursuing) or seemed to be considering partial implementation of the recommendations (the company-cut-only option). Communities that do implement only a fraction of the recommended changes in a package may obtain a deployment that represents a net worsening of their situation. A revised plan--like the one now in Denver--should be analyzed in its own right using the PTI or RAND approaches.

The cities that planned major deployment changes had all reached the point where major changes were indicated. Trenton and Wilmington had several station houses that needed to be replaced because of dilapidation or age; therefore most capital costs of station relocation could be considered part of what would be done in any case and would not have to be included in any calculation of net savings from the use of the approaches. Denver's officials were trying to plan for future demand because they foresaw problems with busy companies being unable to respond to new alarms in the next five to ten years. (It was ultimately determined that this would not occur, whether or not the deployment was changed.) Their station houses did not clearly need to be moved, but the cost of moving them was expected to be more than compensated for by the projected cost savings because the planned change in the number of companies was so great—five companies to be eliminated. Wilmington had severe budget problems and had to cut personnel; thus, the increase in travel time included in their plan is not a pure cost of using the RAND approaches but may actually reflect an improvement over the travel time increase that would otherwise have occurred.

Brief references to three cities' experiences in PTI's manuals[1] plus unpublished information on the experiences of users of the PTI approach[2] seem to indicate that the kinds of changes planned by the RAND user cities and the costs and benefits they projected for themselves would apply fairly well to PTI user cities as well.

Some of the kinds of major deployment changes that were mentioned at the end of the section on costs were not selected in any of the cities with documented experience but could be selected by some users of the approaches. For example, major relocations leaving the number of companies unchanged could produce major travel time improvements, but the costs of relocating stations are so high that there would probably be a net loss in such a change unless the station houses needed replacing in any case. A city planning substantial expansion (addition of one or more companies) might be able to use the approaches to find much better locations (resulting in lower travel times) or to reduce the number of extra companies deemed necessary (resulting in a large cost avoidance), or both. Some unpublished data from PTI suggest these undocumented uses have occurred.[3]

The RAND and PTI approaches appear to have significant advantages over the methods now in use in most cities for deciding deployment issues. Several of the five case studies described what the city officials were planning prior

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[1]Public Technology, Inc., "Fire Station Location Package," Fire Chief's Report, pp. 3-4.

[2]Undated material sent to the U.S. Department of Housing and Urban Development in about 1975 by PTI.

[3]Ibid.

to their use of the RAND models, and it is clear that use of the models in those cities led to decisions different from those originally planned, although the exact nature of the differences was not always clear. Unpublished material on user experience with PTI's approaches indicates the PTI approach has also led to changed decisions.[1] But the RAND case studies and the PTI unpublished material indicate PTI's and RAND's approaches have also been used in some other cities that did not change their original plans to any great extent. (The approaches may still have one major "advantage" in these cases--the detailed support they provide for the deployment changes a fire department wishes to sell to top management and the public. But that is an "advantage" to the agency, and perhaps the city government, that would remain even if the information given by the approaches was misleading.)

The documented cases all involved cities that received technical assistance from RAND in use of the techniques, but RAND has indicated that other cities have successfully used their approaches without technical assistance and without a sophisticated analytical staff. PTI also has indicated that its approaches have been used by cities without sophisticated analysts; technical assistance is a normal part of the service provided by PTI to a user city.

C. Were There Any Effects on Employee Satisfaction or Labor-Management Relations Associated with Using the Approaches?

The changes in Wilmington and New York City resulted in strong union objections, including a lawsuit against the city and appeals to the public and the state legislature in New York City and rejection of a wage agreement that

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[1] Ibid.

included the company cut in Wilmington.[1] In the other cities that used the RAND approaches, no evidence on union reaction or employee satisfaction was cited.

All of the three cities with case studies that used the RAND approaches and cut or planned to cut companies made plans that involved no layoffs, possibly in anticipation of employee reaction: Denver, Trenton, and Wilmington used or planned to use attrition; Wilmington also reduced overtime.[2]

We found no information on union reactions or employee satisfaction in cities using the PTI approach.

In view of the Wilmington and New York City experiences, communities should probably anticipate union resistance to planned changes in deploying fire companies if they involve loss of jobs. A phased program using attrition may be acceptable where abrupt cuts would not be.

D. Are the Models Underlying the Approaches Sufficiently Accurate?

The first question is whether the appropriate measures of performance are examined by the approaches--or at least whether the measures examined provide information on all important aspects. In choosing among several new deployment options, fire officials would like to know how much and which way, the total loss (possibly including casualties) occurring during travel to alarms will change if the city moves to a new deployment. (Officials

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[1]Walker, Singleton, and Smith, Wilmington, pp. 67-70; and Edward J. Ignall et al., "Improving the Deployment of New York City Fire Companies," Paper presented at the 45th Joint National Meeting of the Operations Research Society of America and the Institute of Management Sciences, Boston, Mass., April 22-24, 1974, RAND Paper P-5280, pp. 22-23.

[2]Walker, Singleton, and Smith, Wilmington, p. 68; Hendrick et al., Denver, p. 113; letter from Jan Chaiken and Warren Walker, May 5, 1977.

will also want to make sure that no part of the city will have to bear a widely disproportionate share of any extra loss due to travel time increases. Both PTI and RAND check this by printing out separate figures for major neighborhoods.)

All the approaches use travel time as the principal measure of performance other than cost.[1] None of the approaches translate expected travel time changes into even rough estimates of expected changes in fire losses and fire casualties, and the current state-of-the-art for making such calculations is very poor. The principal accuracy questions thus concern summary statistics on travel times associated with deployment options. If all fires added dollars of loss at the same constant rate per minute, regardless of fire size, type of activity in the building, and the like, then clearly a minute less of travel time in responding to one fire would be perfectly balanced by a minute more of travel time in responding to another fire. This would mean that the citywide average travel time to all fires would be a perfect indicator of loss. But fires do not all add dollars of loss at the same constant rate. Therefore, the problem is how best to modify or supplement the basic statistic of average travel time to fires in order to reflect the differences that actually occur. One way used by both RAND and PTI is to group fires according to the degree of "hazard" of the fire-involved structure and report travel time figures separately for each hazard group. (Hazard classes distinguish major differences in the value of an extra minute of travel time that occur because of major differences in the number of people and/or amount of property at risk.) Another technique used by RAND is to provide separate figures for different types of alarms (such as structural

[1] RAND's PAM and Simulation approaches also provide estimates of workload to permit fire chiefs to consider workload balance in making location decisions. However, very few cities and counties will have alarm rates high enough for this to be a serious concern.

fires), with those groups reflecting different amounts of loss expected to occur if travel times become longer. (The PTI program provides figures for only one type of alarm at a time, but separate runs can be made using tallies of different types of incidents on each run.)

It is important to know whether any increases in travel times are being added on more to the above-average travel times than to the below-average travel times. This is because in general a minute added to an already long travel time (3-6 minutes in the cities studied) has a higher expected loss attached to it than a minute added to a short travel time--because fires tend to grow geometrically in size. (It should be noted, however, that travel time is usually a small fraction of the total time a fire has been burning before the fire fighters arrive. But it appears reasonable—for major hazard classes if not for the city as a whole--to assume that fires in buildings near the fire stations and fires in buildings far from the fire stations include approximately the same percentages of large and small fires at discovery. That assumption, plus the assumption that fires tend to grow geometrically, justifies the special concern to avoid increases in travel times that are already long.)

PTI and RAND handle the review of longer travel times (to see whether those will grow more than the shorter travel times if a new deployment is introduced) by printing out a frequency distribution of travel times to points in the community, but neither RAND nor PTI gives this distribution for alarms. Also, RAND's case-study users do not appear to have used this option; only "maximum" travel times to alarm boxes were documented.[1]

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[1]Changes in maximum travel times were generally expected to be small for all the principal options considered in all the cities but Wilmington; these maximum times do not appear to have played a large role in users' decisions. While more detailed information on the percentage of alarms not reached in a short enough time would have been desirable (and possible without any additional data or major programming changes), it does not appear that the additional information, if available, would have undercut the case for net productivity changes in the five cities. Nevertheless, this aspect could prove important in some communities and the calculation of maximum travel times or other travel time distribution measures is still recommended. (Note that this differs from RAND's FSEM option of distributions for alarm boxes; distributions for alarms are what is needed.)

In Trenton, maximum travel times for engines were expected to decrease in all but two neighborhoods and those two neighborhoods would still have had only the third and fourth longest maximum travel times of the six neighborhoods. Maximum travel times for ladders in Trenton were expected to drop or stay the same in all neighborhoods. Maximum travel times in Wilmington were expected to rise by .16 minutes citywide for first-due engines and .46 minutes citywide for first-due ladders. Maximum travel time in the only neighborhood changed in Yonkers was expected to drop. In Denver, the rate of alarms reached in over 5 minutes was expected to rise from 5 per 1,000 alarms under the existing deployment and current alarm rate to about 16 per 1,000 under the new deployment and projected future alarm rate. (Retaining the old deployment would have been expected to result in a rate of 14 per 1,000 under the projected future alarm rate.) Page references for these statements are the same as those given for the statement on expected changes in average travel times, except for the Denver results which come from p. 89.

Both PTI and RAND could print out figures on, for example, the percentage of alarms not reached within "x" minutes, without needing any more data than they now collect.

This leaves the basic question of whether or not the travel time estimates produced by the models are accurate. We have drawn several conclusions based on published data on comparisons of (a) an estimate based on clocked travel times in Denver for a sample of incidents versus an estimate based on the RAND Simulation using Denver data, (b) clocked travel times in Denver and other cities versus PTI's suggested "round number" speeds, and (c) travel time estimates made by RAND's PAM and by RAND's FSEM in Wilmington. No other comparisons could be made with the documented data. (For more details on data and sources used in deriving these conclusions, see Appendix D.)

- The RAND Simulation approach and the RAND FSEM approach estimate average travel time accurately enough for most deployment decisions.
- The accuracy of the PTI approach in practice has not been documented, but a careful review of the procedures it uses to estimate travel times shows no reason to believe that it is substantially more or less accurate than the above two RAND approaches.
- The RAND PAM appears to produce significantly less accurate information (than the other two RAND approaches), and so is not recommended by RAND as a tool for making final decisions.

There is also little published evidence on other aspects of the accuracy of model estimates--such as the size of differences in the best formula for travel speed (expressed as a function of travel distance) between different neighborhoods of the community and different periods of the day. This evidence is briefly discussed in Appendix D. It generally suggests that time-of-day variations are not significant except in the morning rush hour (which is usually a period of low alarm frequency anyway) and that area-of-city variations in travel time as a function of travel distance are also small.

As to the importance of long travel times in practice, Jane Hogg's figures indicate there is very little importance for fires occurring in dwellings (i.e., detached houses or duplexes) but that the long times are very important for fires in other structures.[1] This suggests that communities may want to examine the frequency and magnitude of long travel times primarily in nonresidential and high population density areas.

E. Which of the Approaches is Best and Under What Conditions?

The published evidence is not sufficient for an assessment of which approach is most accurate under which conditions, except for three general statements that have been generally acknowledged by both PTI and RAND.[2]

1. RAND's formulas for calculating travel distance (from fire station to fire scene) by crow's-flight or rectilinear paths are likely to lead to unacceptable inaccuracies in a city with many barriers to travel (such as rivers) or with subareas having few roads connecting them (as is true in some urbanized counties). It is not known at what point this problem becomes serious, nor does this imply that RAND's formulas for converting distance to travel time become inaccurate in the same circumstances. (At least one city--San Jose, California--has used a hybrid approach with PTI-type directly measured travel distances and a RAND-type formula for converting distance to travel time.)[3]

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[1]See Appendix C for more details on Jane Hogg's calculations.

[2]One potentially important difference between the RAND and PTI approaches is the way they divide up the city into zones for modeling purposes. RAND tends to favor uniform grids in which every zone has the same area; PTI tends to concentrate its zones around major city hazards. This will lead to differences in the estimated travel time statistics that PTI's and RAND's approaches will compute for any given deployment, but the typical size of these differences is unknown.

[3]Conversation with Stan Phillips, San Jose Fire Department, January 12, 1977.

2. One of PTI's data options--speed-run based speed data on each link in the transportation network--will be too costly for some cities to accept. These cities could use (a) the RAND formulas for converting distance to travel time, which have proven fairly accurate, or (b) PTI's "round number" speeds, which have less evidence supporting them but appear to be consistent with actual speeds found by RAND and the Denver study team in the six cities with documentation.

3. Very few (probably only two or three) cities in the country will have first-due companies busy often enough to have to incorporate that aspect in their modelling. Therefore, the RAND Simulation approach's accuracy improvements are almost never sufficient to match its greatly increased cost over the FSEM cost.

All these approaches involve complex models and sophisticated assumptions that are very difficult to translate into readily understandable terms. In general, both PTI and RAND have provided instructional materials that seem likely to suffice for a city whose officials are willing to accept that the numbers generated are valid and accurate. A more skeptical user will need considerable sophistication in analysis to follow all the assumptions and may still be unsatisfied with the documentation.

PTI provides full technical assistance to each user, which probably gives their package an edge in overall ease of use, although none of the user surveys by RAND and PTI has documented user perceptions in enough depth to confirm or discomfirm the difference between the two approaches. Also, PTI is organized to treat users as buyers of a service, while RAND is not. Time spent by RAND researchers answering questions is time taken away from their principal activity of doing research, while PTI has people with time set aside for servicing user requests. Overall, this gives PTI an edge in ease of use which RAND appears to acknowledge.[1]

On understandability of written instructional materials, we have no direct evidence from users. However, PTI's step-by-step format appears likely to make the steps it presents easier to understand. RAND's materials, on the other hand, have more backup on the reasons why certain steps are to be done in a certain way and have material on the limitations of each approach; this information would be of value to those users who wish to understand in depth what they are doing and may permit those users to provide judgmental inputs to the approaches that better reflect their true values. (Here again, the user surveys do not indicate whether these differences actually exist.)

Both PTI's and RAND's materials omit needed guidance on some steps (e.g., PTI does not indicate in detail how the differences in specific response time requirements for different hazard classes should be set; RAND's PAM approach does not specify how the differences in weight given to response times for different hazard levels should be set).

The PTI and RAND approaches could each benefit from some features of the other. PTI's printouts would be more useful if they included figures on average travel times to alarms. RAND's instructional manuals could benefit from the more easily understood and more detailed (in some places) step-by-step format used by PTI.

Both RAND and PTI leave gaps in describing how to decide which areas need shorter travel times because of hazards in their areas and how much shorter those times need to be. This is a particular concern with the PTI approach and the RAND PAM because these approaches use the relative degree of hazard in guiding the user to a "solution."

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[1]Conversations with Warren Walker, formerly Rand Corporation, on January 6, 1977, and Jan Chaiken on February 17, 1977.

Neither RAND nor PTI provides much guidance to users on how to trade off possible cost savings due to changes in deployment against the travel time increases usually associated with those changes. Some users will not have to worry about this problem because they will be able to obtain cost savings <u>and</u> reduced travel times. But most users will have to trade off decreases in either costs or travel times against increases in the other. In the absence of guidance they will probably use rules-of-thumb such as "travel time increases up to a certain size are small and therefore acceptable." Under some circumstances, though, small changes in average citywide travel time or other summary statistics can mean large changes in annual fire loss--for example, if the fire rate is high enough and the neighborhoods hit by the changes have a lot of valuable property.

To summarize, the factors discussed above should be considered by communities considering use of these approaches. Neither RAND nor PTI has a clear advantage on all relevant considerations.

PART THREE:

RECOMMENDATIONS FOR FUTURE RESEARCH AND DEMONSTRATION EFFORTS

Three types of recommendations for future research and demonstration efforts, based on findings discussed in the first two parts of this report, are presented below:

- Research on the "Four City" and Related Efforts
- Research on the RAND and PTI Fire Deployment and Related Approaches
- Evaluation of Pilot and Demonstration Productivity Improvement Efforts.

Research on the "Four-City" and Related Efforts

1. We recommend that further analysis focus on other governments which have already tried three approaches tested in these demonstrations--work planning, scheduling and reporting procedures; the 4-10 workweek; and evaluation systems linked with photographic standards. This is probably more important than further research on the Honolulu, Hartford and Dallas demonstrations. We particularly recommend more study of work planning, scheduling and reporting procedures. Of greater interest would be those governments with at least a year's experience (and preferably more) and, if possible, those that have introduced one type of change with no significant confounding effects (such as new work scheduling procedures without the simultaneous introduction of a 4-10 workweek).

2. The activities mentioned in (1) above are viewed as only a first step because of difficulties in reconstructing baseline data on productivity and employee attitudes against which to compare data for periods after changes were made. Therefore, we recommend that the federal government support or sponsor planned variations of productivity improvement efforts, such as

work planning, scheduling and reporting procedures, with governments just planning to implement such changes. Such efforts should be planned to contain adequate procedures for collecting the types of evaluation information described in recommendation (13) below (and presented in Appendix A). Time will need to be provided for initial introduction, "settling-in" of the new procedures, and an adequate operational period (generally at least one full year)--before the assessment can be completed.

3. We recommend that a jurisdiction undertake an initial diagnostic study, using such techniques as work sampling, before it chooses new work planning, scheduling or reporting procedures. Such a study would be aimed at identifying and measuring the approximate magnitude of problems (such as causes of idle employee time) and giving indications of activities (such as particular types of repair crews) with the greatest potential for generating productivity improvement.[1] Better procedures for scheduling work are not, for example, likely to generate significant productivity improvements in street cleaning if the crucial problem causing idle employee time is equipment downtime. Such a study can also provide baseline data for comparison with information for periods after new procedures have been introduced. Information on how initial diagnostic studies were undertaken, as well as their results, should be included in reports on the new procedures as guides for other service areas or jursidictions.

4. We recommend that the federal government support the preparation and publication of a compendium on alternative approaches to work planning, scheduling and reporting. The compendium should include major options and cover

[1]The work sampling study undertaken at the beginning of the Honolulu street repair demonstration (discussed on p. 1-8) illustrates how such a study can enhance the probability that changes introduced will actually lead to productivitiy improvements.

various degrees of sophistication. Numerous local and state government services, such as maintenance service (vehicle, parks, streets, facility or other) and many, if not most, other services (such as health and welfare) have made use of more systematic approaches in recent years. The proposed document would describe such approaches as daily work scheduling (such as for street repair crews), weekly maintenance scheduling (such as for parks), annual or seasonal estimation of staffing requirements (for a service or department), weekly reporting on "productive" hours for maintenance workers, and the use of work standards. This report should indicate what types of data and data collection procedures are currently available, what each can (and cannot) do, and the likely costs and staffing requirements (including any special skills and training likely to be required). It should also list particular jurisdictions which are known to be using the approaches described (and in which service areas).

5. We recommend that the federal government support the preparation and publication of a collection of work (time) standards which have been calculated for tasks which local and state governments perform. We emphasize that such a publication would need to take great care to define the task elements (including specific work methods used and time allowances) covered by each of the standards, as well as to identify any special local conditions (such as terrain, employee skill level) assumed in calculating the standards. Preferably, provision should be made for periodic (perhaps annual) updating. Such a collection would permit individual governments to have a basis for comparison of their own times, and, in some cases, would prevent individual governments from having to "reinvent the wheel."

6. We suggest some further (but not extensive) assessment of the Honolulu parks and streets approaches to ascertain whether there were any actual cost savings or changes in the level or quality of service associated with the procedures introduced in these demonstrations (and according to later reports continued beyond the demonstration period). The availability of relevant data is unknown at this point. It is, however, not likely to be possible to isolate the effects of each of the multiple actions that were introduced. In Honolulu's parks and streets agencies, there was some evidence that some aspects of productivity improved during the demonstration period. Appearance ratings improved for parks in District III and materials used per employee-day increased for three street repair crews.

7. It appears from the draft report that very little was actually done during the Hartford demonstration--primarily a work control system for a 6-person operation for 3 winter (low workload) months. However, some additional study is probably warranted to ascertain how much of the system was continued beyond the demonstration, how effectively the system operated during summer (peak workload) months, how "productive" hours information varied and was used in later months, and whether continued real efficiency or effectiveness gains have resulted.

8. We do not recommend further study of the Dallas 4-10 project. Additional study appears to hold small prospects for obtaining meaningful information as compared to study of other locations using the 4-10 workweek. We recommend further study concentrate on those other sites (see recommendation 1 above). The Dallas project has already been the subject of considerable study, with another case study sponsored by the National Center for Productivity and Quality of Working Life in addition to the project report and this review. It is, however, difficult to separate out the 4-10 from other changes introduced during the demonstrations

(the extent and timing of these changes is not clear from existing information). The limited before-and-after information also makes it difficult to tell whether any significant productivity improvements were made.

Research on the RAND and PTI Fire Deployment and Related Approaches

None of the options for further research presented here has been worked out in detail. A more thorough examination of likely costs and benefits (in terms of added information) should precede any decisions to undertake such research.

9. Research is needed to establish user guidelines--even rough ones--on the implications of travel time changes of particular magnitudes. Crude techniques for estimating the monetary impact (in terms of added or reduced loss and casualties) of travel time increases could be useful, possibly even if they could only be trusted within a factor of three or four.[1] Development of these techniques would involve a special study since there are no generally accepted methods for making such conversions at present. (One technique that does not provide impact estimates directly but may make it easier to judge whether the impacts are likely to exceed the changes in costs is outlined in Appendix E.)

10. Additional tests of the accuracy of the estimates of average travel time used by RAND's FSEM approach would probably cost more than they would be worth. However, tests of the accuracy of RAND's FSEM in producing estimates of maximum travel times and estimates of the percentage of travel times over "x" minutes would be useful, as would tests of the accuracy of PTI's approach in producing estimates of those two measures and of average travel times. The

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[1]Our calculations of benefits (costs) from travel time decreases (increases), as described on pages 55 and 56 and in Appendix C, indicated that at least in the cases examined, accuracy could be this poor without reversing the basic conclusion that benefits exceeded costs. Clearly, in some cases, greater accuracy would be needed for the conclusions to remain insensitive.

comparison of model estimates to clocked-time estimates done in the Denver test of the RAND Simulation would be a good way to proceed, except that variability in the clocked-time-based estimates should be calculated as we attempted to do in this assessment (See Appendix D). If these tests were done for both PTI and RAND in the same cities, comparisons of their relative accuracies might be possible, although the heuristic and subjective features (such as PTI's calibration of travel times) of all the models would have to be handled in ways that assured a fair test.

These tests would be useful, but they could also be expensive in light of the substantial costs incurred by RAND and PTI in obtaining the current information on accuracy and the probability that greater accuracy will be needed to determine whether and in what situations either model is more accurate. A month or so of actual companies' runs would probably be needed as a minimum if the test looked only at citywide averages, maximums, and other indicators.[1] A few years ago, RAND estimated the cost per city for tests of this kind at $55,000; the current cost would probably be about $65,000 per city. A more ambitious test might cost more, and a more ingenious test might cost less. An expert panel should review the possibilities and set the objectives of the test before it is concluded that useful results could be obtained at reasonable cost.

11. A full assessment of the different approaches would need to test more than just the underlying mathematical models. This wider testing could be done in several ways. One way would be to have an evaluation of the different aspects of each approach (understandability, cost, accuracy) done by a panel of professionals (say, under the auspices of the National Fire Protection Association

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[1]It would also be interesting to examine statistics for each major neighborhood in each city, but this would be likely to require clocked company-run data for 1-1/2 to 3 years (assuming 4 to 6 neighborhoods) in order to maintain the same precision in the test.

and/or the U.S. National Fire Prevention and Control Administration). Such a panel should obtain information from past users and could conduct further tests as they saw fit. One such test could investigate whether the different approaches tend to lead to different results in practice, possibly because the models give different kinds of information and different values for the same measures, possibly because the approaches differ in ease of use, or possibly because of other reasons. If outputs from RAND's FSEM and PTI's approach could be prepared for all the deployment choices in several cities, at least a partial test could be made. Two groups of fire officials could each be given output statements for each of the cities, with each group getting some RAND-FSEM output statements and some PTI statements. Each group would select a "best" deployment for each city. Then, the results would tend to indicate whether differences were occurring and whether they were due more to differences in the output statements or differences among the groups of officials.

We estimate very roughly that such a test could cost from $250,000 to $1 million.[1] The cost cannot be estimated more precisely at this point, because it would depend greatly on the extent to which existing data bases (particularly for use in the PTI approach) could be used.[2]

12. Two hybrid approaches might be worth exploring as potentially more attractive to users than any of the RAND or PTI approaches. One such hybrid approach used in San Jose employs PTI's travel distance estimation techniques.

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[1]The reason this is so expensive is that it requires as input the equivalent of a full deployment analysis by each of the approaches being studied in each of the cities used in the test. So assuming a cost of $30,000 to $40,000 per city for deployment analysis by both approaches (the cost figures suggested by our limited information on typical user costs), a minimal test using 6-8 cities would cost $250,000 and a test with good statistical confidence using 25-30 cities would cost $1 million.

[2]Some reviewers of this report believed the incremental value of the results of this kind of test would not be worth the high cost.

(That is, actual paths from fire houses to points in the city are measured on a map, thereby removing the danger that barriers to travel may make RAND's estimated distances inaccurate.) Then, travel times based on distances are calculated from a RAND speed formula, removing one of the most expensive parts of PTI's data collection requirements.

Another interesting hybrid possibility would be a hybrid of one of the cheaper approaches (RAND's PAM) and the informal, nonanalytical methods most departments now use to make deployment decisions. In this version, one would first decide how many companies the city and each of its major areas should have used the RAND PAM approach. These numbers would not be round numbers, but the practical equivalent of having a company split between two neighborhoods would be achieved by giving that company a first-due area split by the boundary between the neighborhoods. Second, one would decide on the locations of the stations without using any additional help from formal models but making use of information already generated by the PAM approach and the same list of potential site locations that would have been needed as input for the RAND FSEM or the PTI approach. This would probably be a low-cost decision-making technique that would still generate some data on expected impacts of proposed changes. There is potential for data inaccuracies that should be examined, but none of the tests to date have directly addressed the accuracy of this kind of approach. (RAND did a recent study in Tacoma, Washington, that followed this procedure, but no other approaches were applied to check whether the conclusions would have been the same with more extended analysis. Furthermore, the deployment change recommended was one the city had already concluded was desirable and so the persuasive power of this more limited analysis was not seriously tested.)[1]

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[1]Chaiken, "Classification and Catalog."

Evaluation of Pilot/Demonstration Productivity Improvement Efforts

Recommendations to federal agencies

13. In order to maximize the usefulness to state and local officials of pilot experiences, federal project officials should undertake a pre-project assessment to determine to what extent evaluation of the project can and should be undertaken and to establish an adequate evaluation plan, schedule, and budget. Such evaluations should incorporate procedures for collecting comprehensive information on costs, quantity of output, quality of the output, and employee satisfaction. The information collected should, whenever possible, obtain such information both before and after the changes have been introduced in order to permit an assessment of the extent to which productivity improvements actually occurred. Detailed records should be kept on what changes are made and how they are implemented so that other governments will have a clear picture as to what was implemented and how. These points may sound trivial, but in fact we found it surprisingly difficult in some projects to answer important questions regarding the details of what was tried and its effects on efficiency, effectiveness, and employee satisfaction. A more complete discussion of the types of information that should be sought as part of pilot/demonstration projects is presented in Appendix A.[1]

14. The amount of calendar time allotted to a pilot/demonstration effort should provide sufficient time for an adequate assessment and reporting of the effort. Time is needed for (a) preliminary planning of the project; (b) gathering of baseline information before the new procedures are introduced,

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[1]Earlier sections of this report have discussed limitations in the evaluative information provided for particular HUD-sponsored projects. Our past experience indicates that the problems we have identified are not unique to these particular demonstrations nor to HUD. For example, the Urban Institute had similar difficulties in assessing the productivity and related impacts of activities for a number of monetary incentive and work standard programs. See Greiner et al., Monetary Incentives and Work Standards in Five Cities.

(c) introduction and stabilization of the new procedures (often in the face of resistance or at least minimum enthusiasm), (d) testing of the procedures for a sufficient period (in most cases, at least one year) in order to permit conclusions on probably productivity and related impacts (such as on employee satisfaction), and (e) analysis of the results and documentation of the project findings. Failure to provide adequate time for the introduction and testing of new approaches appears to be more the rule than the exception at present. "Unexpected" delays are inevitable and should be allowed for when scheduling and budgeting test efforts. Appendix G discusses this and a number of related evaluation issues.

Recommendations to local and state governments

15. Local and state governments that undertake productivity improvement efforts should themselves provide for follow-up evaluations of the impacts (on efficiency, effectiveness, employee satisfaction, etc.) stemming from productivity improvement efforts. The findings of such evaluations should help local and state government officials make sound decisions on continuation, modification, expansion, or curtailment of their pilot efforts. Many of the jurisdictions involved in the pilot studies discussed in this report made little if any provision for substantive follow-up evaluation, perhaps prefering to rely on federal agency evaluations. Moreover, our knowledge of other pilot projects indicates that such provision is rarely made by local and state governments. For these reasons, the suggestions in Appendix A (and to a lesser extent, Appendix G) apply to local and state governments as well as federal agencies.

16. Jurisdictions testing new approaches should attempt to limit the introduction of other changes during the pilot period. This will make the assessment of the impacts of the pilot effort considerably easier.

An additional recommendation to HUD

17. Finally, we suggest that HUD sponsor the development of a handbook for state and local governments that would provide examples of specific procedures for these governments to use in developing evaluative information on productivity and related impacts. These examples should take into account general problems of data availability and resource limitations which state and local agencies will encounter. Information on the process of designing, collecting and interpreting baseline and test period information would be helpful. Specific examples from a number of past and on-going efforts would be very useful. These examples should include procedures for evaluating efforts in different functional areas and on different approaches (such as new work scheduling procedures and organizational changes).

APPENDICES

APPENDIX A

CHECKLIST OF TYPES OF INFORMATION NEEDED FOR A COMPREHENSIVE EVALUATION OF INDIVIDUAL PRODUCTIVITY IMPROVEMENT EFFORTS

INTRODUCTION

To improve the productivity of government services, each level of government (federal, state and local) on occasion either supports or actually undertakes projects aimed at such improvements.

In order to gain the most utility from such efforts, it is highly desirable that those governments provide for a comprehensive, and objective, evaluation of the efforts so as to identify the degree of their success and, to the extent possible, the reasons for success, or lack of it. Such information seems vital both for the governments testing these projects (in order to determine whether they should continue, expand, modify, or terminate them), and for other governments to help them determine whether it is in their best interest to implement, or encourage others to implement, a program begun elsewhere.

The attached checklist is intended to provide suggestions as to the information that seems needed for a comprehensive, objective, evaluation of productivity improvement efforts. The checklist provides only general guidance as to specific procedures that a government should use for such evaluations. There are numerous publications on program evaluation which can provide some additional guidance. However, ultimately, the evaluation of each particular productivity program will need to be hand-tailored to the particular local circumstances and will have to be planned carefully by the sponsoring agency.

CHECKLIST OF TYPES OF INFORMATION NEEDED FOR A COMPREHENSIVE EVALUATION OF INDIVIDUAL PRODUCTIVITY IMPROVEMENT EFFORTS[1]

I. Identification of the Specific Nature of the Productivity Improvement Effort:

The productivity improvement that was actually tested should be described. All changes introduced during the trial period that could have a significant effect on the productivity changes observed should be identified, even though they are not part of the productivity improvement effort as originally defined. A project as finally implemented is often quite different from the project as originally envisioned.

In addition to documenting the salient characteristics of the productivity improvement effort, an evaluation should also document how the changes were introduced. This should include such factors as: (a) the major steps undertaken to introduce the changes to employees, (b) the major problems encountered, and (c) the steps undertaken to alleviate these problems.

It is generally impossible to isolate the effects of the implementation process from the effects of the programmatic changes. Nevertheless, it still remains highly desirable to identify the characteristics of the implementation effort so that judgments can be made as to the degree to which the implementation steps would also be necessary if the same productivity improvement changes were introduced by another jurisdiction. How the innovation was introduced would include such factors as the nature and extent of participation in planning and introducing the new program by such groups as line employees, first line supervisors, middle management, union officials, and legislators.

The information obtained under (I) will permit users of the evaluation to identify what had actually been implemented and evaluated. The evaluators in the final report should summarize any available evidence indicating the likely contribution to the observed changes in productivity of each of the major elements of the new program.

II. Findings as to Changes in Productivity

This is the "bottom line" for productivity improvement efforts. There are two major classes of productivity impacts that should be estimated:

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[1] This checklist was prepared for the Office of Policy Development and Research of the U.S. Department of Housing and Urban Development.

1. Effectiveness/quality of service/level of service

This category is concerned with those service effects that will be of direct concern to the clients of the service. Intentional changes in effectiveness should be documented as well as unintended and detrimental effects that may have occurred (such as added pollution from capital improvement projects or increased delay times to citizens if employee time is cut back as part of the productivity improvement effort).

The term "client" may refer to the general citizens of a jurisdiction (for such services as solid waste collection, police, and fire protection), or it may refer to some specific recipient group (such as for public assistance programs). For projects aimed at improving internal support services (such as data processing, purchasing, and personnel) it may refer to persons in other parts of the government that receive these support services. In cases where the general public is the client, consideration should be given to techniques, such as citizen surveys, to measure the public reaction to the quality of service provided, before and after the changes are introduced.

In general, each government service will have its own set of appropriate indicators of the effectiveness and quality of the service.[1]

Note that tracking the quality and level of service is also a necessary ingredient to assessing efficiency (#2 below). That is, if output per unit of input increases but at the expense of the quality of the output or the level of service, this should not be considered a real efficiency improvement. (For example, a speedup of work activity such as for road maintenance, waste collection, eligibility determination, or any government activity can be accomplished by reducing the quality of that effort.)

2. Efficiency, including total cost

Efficiency is generally defined as the ratio of the amount of output obtained per unit of input such as the number of employee-hours or number of dollars expended. Appropriate outputs and their associated inputs should be identified and changes in their values tracked.

It is also important to track changes in the total costs expended. Changes in actual costs are, of course, a major concern in improvement efforts. Efficiency ratios do not always cover all relevant costs and cannot be assumed to provide information equivalent to total costs.

It is important to distinguish between (a) actual, realized, cost reductions, (b) those cost reductions that are projected but not yet actually realized, and (c) those costs that are believed to have been avoided because of the new program. Each of these represents significantly different evidence problems. Ultimately, of course, a jurisdiction wants to have real cost reduction or real cost avoidance; evidence that the productivity improvement effort has actually reduced the total

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[1] An illustrative compendium of such indicators is included in: "How Effective Are Your Community Services: Procedures for Monitoring the Effectiveness of Municipal Services," The Urban Institute and the International City Management Association, Washington, D.C., 1977.

cost to the jurisdiction is important evidence of productivity improvement impacts. Cost savings that are not yet realized for the future, need documentation as to the realism of the estimated savings. Future cost savings are often overestimated by not adequately considering difficulties in implementing the cost savings. For example, improvements in efficiency may not actually lead to immediate cost reductions because the jurisdiction has decided to reduce staffing by attrition rather than by layoffs. This may considerably delay the cost savings. If the government does not in the meantime increase the effectiveness, quality, or level of service, real productivity improvements may not actually occur at least until attrition has occurred and real cost reductions have been achieved.

The initial startup costs for implementing the productivity improvement effort should be identified--for example, purchase of new equipment required for the effort, initial training of employees in the new procedures, and installation of any added recordkeeping that may be needed (such as for new work standards programs).

Costs that are associated with the particular trial or demonstration effort that are not likely to be required by other jurisdictions (such as special evaluation or procedure development activities that would not be needed in the future) should be distinguished so that they can be deleted from estimated startup costs for other jurisdictions.

Costs, or services, which may have been paid for or subsidized by another level of government, but which would likely have to be incurred by another government in implementing the productivity improvement effort, should be identified.

III. Findings as to Effects on Employees and Labor-Management Relations

The impact of a productivity improvement effort on the jurisdiction's employees and its labor-management implications can be an important side effect and should be assessed--both because governments are concerned about the welfare of their employees and because employee problems can cause a government numerous short term difficulties as well as possibly leading to counter-productive results over the long run (even though this is not immediately observable during the early stages of the introduction of the productivity improvement effort).

The following effects on employees should be examined:

1. Changes in morale and job satisfaction. Surveys of employees, can be used to generate this information. Preferably, employee surveys would be undertaken both before the new project is introduced and after it had been in existence for a number of months.

2. Changes in various indicators of "counter-productive" behavior such as: rates of absenteeism, injuries, disciplinary actions, and tardiness.

Effects on employees should be considered not only for non-supervisory employees but also first-line supervisors and higher level management. Some projects, or at least the way they are implemented, may cause problems for supervisors and add to later difficulties.

To assess the change in quality of labor-management relations from before the project's introduction, changes in such factors as the following should be considered:

1. The number and character of the grievances.

2. The number and character of incidents of strikes, work stoppages, or disruptions.

3. The extent of employee organization.

4. The "healthiness" and amiability of labor-management relations as perceived by management officials and employee leaders.

IV. Degree of Satisfaction of the Jurisdiction with the Productivity Improvement Effort

Principal indicators of a jurisdiction's satisfaction would come from such sources as the following:

1. Evidence that the jurisdiction is continuing to use the productivity improvement effort. Expansion of the usage of the new procedure, perhaps to other parts of the organization not covered in the original productivity improvement effort, would be a particularly strong indication.

2. Expression of satisfaction by the jurisdiction officials. Such information should be obtained in a systematic way through interviews of public officials in the jurisdiction. Special care needs to be applied here both to:

   (a) Cover a representative section of management (including various levels of management) and not only those who have the greatest self interest in the project.

   (b) Undertake the interviews using procedures that maximize the likelihood that the opinions expressed represent the real viewpoints of the respondents (rather than, for example, presenting a public-relations image).

Such evidence of a jurisdiction's satisfaction should, in general, be considered as a less satisfactory indicator of productivity improvement than the direct indicators of productivity changes. Without evidence of improvements in service effectiveness or efficiency, expressed satisfaction may well be based on factors other than improved productivity. If there has not been significant evidence of improved effectiveness or efficiency, but the jurisdiction is continuing the project, public officials should be questioned for reasons for the retention. This may identify side-benefits that have occurred or at least indicate that the project's retention is based on a subjective feeling that productivity improvement will result in the future.

Non-continuation of, or dissatisfaction with, the productivity improvement effort, accompanied by evidence of negligible or negative effects on productivity, would add to the evidence that the productivity improvement effort has not succeeded. Non-continuation or dissatisfaction with the effort, even though productivity appears to have improved, would suggest the existence of other factors; the evaluators should attempt to probe public officials for the reasons for discontinuation (in the face of apparent productivity improvement) to uncover possible negative side effects of the effort. (A government might not continue a project--even though there was evidence of substantial improvement in productivity--for a variety of reasons, perhaps "political" in nature, which might or might not also be a problem for other jurisdictions.)

In general, however, project continuation or stated satisfaction by public officials should not be considered sufficient evidence by themselves that a productivity improvement effort had indeed led to improved productivity.

V. Comparison of Achievements Against Project Objectives/Targets

At the beginning of a productivity improvement effort, specific objectives with specific targets may be set by the sponsoring government. If so, an additional evaluation task is the comparison of actual achievements against those targets.

Such targets should be as specific as possible. They should cover efficiency, effectiveness (quality-of-service), and impacts on employee and labor-management relations.

However, setting targets in innovative projects can be precarious, and target selection depends on such factors as the perspectives and personalities of the target setters at the time they are set. Viewpoints as to what is "adequate" improvement may also change by the time the results are in. Therefore, the comparison of actual performance versus targeted performance should probably be considered as secondary to the assessment of actual levels of performance (as discussed in II and III). Ultimately, public officials will probably want to focus on the extent to which the improvements that are actually achievable are worth the cost, regardless of any earlier established targets.

VI. Identification of Special Conditions that May be Associated with the Project Effects

There are many factors that can substantially affect the impacts of a productivity improvement effort and its transferability to other governments. These should be identified and, to the extent possible, their effects on the observed productivity impacts estimated.

The following is a list of some of the factors that could make it significantly more or less difficult for another jurisdiction to duplicate the success of the trial jurisdiction:

1. Differences, or changes, in the magnitude or character of the incoming workload. These can cause costs and efficiency to increase or decrease, perhaps because of economies-of-scale effects or because the workload has become more difficult (or easier) than in the baseline period. Because of such possibilities, it is important to compare the magnitude and character of the workload in the baseline period to that of the demonstration period.

2. Unusual characteristics of the period before introduction of the productivity improvement effort such as:

   (a) A prior level of performance (on either efficiency, effectiveness, or employee morale) which was unusually high or low. (If the starting position is extremely inefficient, almost any change might improve productivity. Conversely, if the starting position of the service happends to be very efficient or very effective, it may be very difficult to make substantial further improvements.)

   (b) The existence of previous actions which substantially reduce the costs or other problems to the jurisdiction undertaking the productivity improvement effort. For example, a government with a substantial computerized management information system might be able to avoid added data collection costs associated with a productivity improvement project requiring computerized management information procedures.

3. Unusually good or poor environment for making changes.

4. Unusual physical characteristics of the jurisdiction such as particularly bad weather or narrow streets.

5. State or local legal constraints to implementation.

VII. Considerations in Assessing the Validity of the Findings

The previous sections have identified the major items of information that are needed to make the assessment. Here are enumerated a number of factors that evaluators should consider both when planning the evaluation (at the beginning of a productivity improvement effort) and which they should examine at the end of the trial effort to obtain a proper perspective on the quality of the evaluation information that is obtained:

1. Has a comprehensive and relevant set of criteria for evaluating the innovation been identified:

   (a) Are all essential criteria included? Are data being collected on all possible major impacts--both detrimental as well as beneficial effects (such as changes in the error rate accompanying an effort to increase the output for a certain activity)?

(b) Are inappropriate criteria excluded?

(c) Are both efficiency and effectiveness (including quality of service/level of service) indicators considered?

2. Are all significant and relevant costs included in the cost estimates (e.g., capital costs, planning and scheduling costs, associated materials costs, operating and maintenance costs, necessary special training of personnel, variable overhead costs)?

3. Are the data collection procedures and resulting data of acceptable quality? For instance:

(a) Does the data come from reasonably reliable sources?

(b) If samples are used, have they been appropriately selected?

(c) If survey questionnaires were used, have they been adequately pre-tested to minimize biases and ambiguities? Are the questions used unbiased?

(d) Have consistent definitions of cost and effectiveness data elements been used between the baseline period and the trial period?

4. Has sufficient time been allowed for a reasonable test of the impacts of the productivity improvement effort? Generally, at least a few months are needed before an effort can be assumed to have shaken down sufficiently that subsequent months can be assumed to represent a real test of the changes. If there has not been sufficient time to represent the long-term impacts, the evaluation should at least attempt to identify the likely consequences of the overly short evaluation period.

5. Can the findings found be attributed with confidence to the changes being tested? For example:

(a) To what extent could other internal (governmental) factors or programs have been responsible for the results (e.g., other procedural changes introduced during the test period)?

(b) To what extent could external (non-governmental) factors have been responsible for the results (e.g., see section VI)?

It is important for the evaluation to attempt to assess, if only by judgment, the extent to which such external factors rather than the productivity improvement effort might have affected the observed impacts. Unless some type of formal experimental design (using control and experimental groups) is used, the evaluators will often need to be very restrained in their claims as to the cause of the observed productivity changes.

6. Could a simpler and less expensive variation of the productivity improvement effort have been used that would likely achieve most of the productivity improvements? The evaluation should provide an assessment of whether simpler, less expensive, procedures might have achieved most of the gains identified. Conversely, it should also consider whether significantly greater productivity gains may be possible if other steps, not undertaken in the trial, were undertaken by other jurisdictions.

APPENDIX B

DETAILED INFORMATION ON PROCEDURES AND DATA INVOLVED IN USING THE RAND AND PTI FIRE DEPLOYMENT APPROACHES

B-1. RAND Parametric Allocation Method (PAM)

B-2. RAND Firehouse Site Evaluation Method (FSEM)

B-3. RAND Simulation Approach

B-4. PTI Fire Station Location Package

EXHIBIT B-1

RAND PARAMETRIC ALLOCATION METHOD (PAM)

When Should It Be Used

RAND recommends that the PAM be used only for the initial stages of a study leading into use of the Firehouse Site Evaluation Model (FSEM) or the Simulation model. The PAM is used to get a rough idea of how many engine and ladder companies are needed in total and how they should be divided up among major regions of the city.

Simplified Description of Steps Required[1]

(1) Arrange to obtain the model from the time-sharing computer service that handles it or obtain the program details for the batch processing version from RAND.

(2) Identify major regions of the city so that each one is roughly homogeneous in the hazards it contains and has its past alarms and current fire companies (by type) fairly evenly distributed throughout the region. (Yonkers used a total of four regions, while New York City used twenty-one.)

Characteristics of Model[1]

1) Data Required

- For each region, alarm rates by type (total, false, serious fire, non-serious fire), size in square miles, current numbers of companies, a hazard factor (defined roughly as how much extra time in this region is worth in losses and casualties divided by the worth of the same extra time in the other regions), and work time per alarm (by type of incident) as a function of dispatch policy.
- Coefficients of the exponential function that best converts distance to time for that city.
- Trade-off parameter that indicates the relative emphasis to be given to coverage of potential alarms in high hazard regions vs. coverage of areas that have had the most alarms in the past.

2) Output Provided

- Average travel time to points in the area (unweighted by alarm rate) and percent of time companies are busy--overall and by region--when the allocation of companies by region is already set.
- "Best" allocation of companies to regions, given a certain total number of companies to allocate and values of the trade-off parameters and hazard factors. Also travel times to points in the area and percent of time companies are busy, overall and by region, if that allocation is used.

3) Special Properties

- Estimates of the number of companies assigned to a region under the "best" allocation generally are not whole number
- Estimates average travel distance from station to potential fire site for each region by a standard formula linking distance to areal size of region, number of companies in region, and average number of busy companies in region.
- Also takes account of busy companies by requiring that the number of companies allocated to each region must be at least as large as the average number of busy companies in that region.

1 Adapted from Kenneth Lloyd Rider, A Parametric Model for the Allocation of Fire Companies: User's Manual, The New York City-Rand Institute, R-1646/2-HUD, August 1975.

EXHIBIT B-2

RAND FIREHOUSE SITE EVALUATION METHOD (FSEM)

When Should It Be Used

RAND states that this model should be used and should be sufficient for most problems involving identification of the desired number of companies and the desired locations of stations and companies.

Simplified Description of Steps Required[1]

(1) Obtain from RAND the report that contains details of the computer program.

(2) Divide the city into a fine, relatively uniform grid, with a "phantom box" address assigned to each segment of the grid to represent for modeling purposes the source of all alarms from any addresses in that segment. Identify those phantom boxes with unusual hazards as "target hazards" and identify major regions of the city by the phantom boxes assigned to them.

(3) Use the model.

Characteristics of Model[1]

(1) Data Required

- (X,Y) coordinates for each phantom box and each possible station location.
- Annual alarm rates by type of alarm (false, non-serious, serious) for each phantom box.
- Formula to be used in estimating travel distance between 2 points--either a constant times the crow's-flight distance or the right-angle distance appropriate to a city whose streets form a rectangular grid.
- Formula to be used in estimating travel speed--generally a curve that varies as the square-root of distance over short distances and linearly with distance over long distances.

(2) Output Provided

- Average travel times to structural fires and to points in the area for whole city, major regions, and zones surrounding "target hazard" boxes.

(3) Special Properties

- Cannot take account of busy companies.

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[1] Adapted from Peter Dormont, Jack Hausner, and Warren Walker, Firehouse Site Evaluation Model: Description and User's Manual, The New York City-RAND Institute, R-1618/2-HUD, June 1975.

EXHIBIT B-3

RAND SIMULATION APPROACH

When Should It Be Used

RAND's guidelines recommend use of this model rather than one of their simpler models only if there is a busy company problem, which means that there are sizeable portions of the day when companies are busy an average of at least 10% of the time. Or, if users are interested in planning for demand in the future, when alarm rates are projected to be higher and it is considered possible that a busy company problem will result, this model should be used. Or, if users are interested in examining policies deemed capable of creating a busy company problem (e.g., increasing the number of units assigned to respond to alarms) or policies intended to deal with a busy company problem (e.g., rules for temporary relocation of idle companies into areas with several incidents in progress), this model should be used.

Simplified Description of Steps Required[1]

(1) Obtain the report with the program description from RAND and keypunch the programs. Some components may be dropped or modified at this stage to reflect local policy (e.g., local dispatch policy).

(2) Divide the city into a fine, relatively uniform grid, with a "phantom box" address assigned to each segment of the grid to represent for modeling purposes the source of all alarms from any addresses in that segment. (Denver used 458 phantom boxes.) Assign (x,y) coordinates to each phantom box and each station location. Use random selection techniques to identify a model sequence of incidents to be used in any further calculations. (Denver used 1000 incidents.) Model the timing of the occurrence of the incidents using several different citywide alarm rates if desired.

Characteristics of the Model[1]

(1) Data Required

- For each type of incident to be used in the data base, the number of pieces of each type of equipment needed at that kind of incident, the dispatch policy that determines how they are called in, and how long each piece of equipment works on the average. (The 18,000 incidents of 1972 were used in Denver.)
- Proportion of incidents at each phantom box that are of each type and the proportion of incidents in the city that are at each phantom box, both calculated from the above data base of incidents.
- Travel distance and travel speed formulas like those used in the FSEM, or speeds between station locations and alarm boxes based on speed runs.

(2) Output Produced

- Average travel times to incidents at an alarm box or a group of alarm boxes, by type of incident (where types reflect amount of equipment needed and time each will have to spend at the scene).
- "Percent of time available" by company, to show how much of a busy-company problem there was.

(3) Special Properties

- Takes account of busy companies by sending next assigned unit if first-due unit is shown to be busy at the time an alarm comes in. Also provides for some companies being unavailable due to equipment needing repair.
- Response times to high-hazard alarm boxes as a group can be obtained if desired.

1 Adapted from Grace Carter, Edward Ignall, and Warren Walker, A Simulation Model of the New York City Fire Department: Its Use in Deployment Analysis, The New York City-Rand Institute, P-5110-1, July 1975, and Grace Carter, Jan Chaiken, and Edward Ignall, Simulation Model of Fire Department Operations: Executive Summary, The New York City-Rand Institute, R-1188/1-HUD, December 1974.

EXHIBIT B-4

PTI FIRE STATION LOCATION PACKAGE

Simplified Description of Steps Required[1]

(1) Obtain manuals and programs from PTI. Have PTI provide training to staff and other initial technical assistance as needed.

(2) Identify classes of property types deemed to pose similar fire hazards and therefore to have similar strategic importance. For each hazard class, indicate whether travel times must be shorter (high hazard) or can be longer (low hazard) to such properties and by how much.

(3) Divide the city into a set of "fire demand zones," each about the size of several city blocks, by grouping together properties of the same hazard class. Begin with the properties having the most strategic importance. Each fire demand zone should be assigned a "focal point"--usually a centrally-located intersection of two streets--that will be used to represent the site of any fire occurring in that zone. Each zone is also assigned a "response time requirement"--defined as the maximum allowable travel time to that zone if it is to be considered covered. Each zone's requirement is computed as the standard response time requirement for the city plus or minus the adjustment that was defined in step (2) for properties of the hazard class contained in that zone. In addition to a response time requirement, each zone is assigned a "safety margin," set so as to reflect the fact that particular locations in the zone may be slightly closer to or slightly farther from the station than the zone's focal point. Some computer runs may be made with the safety margins added to or subtracted from the response time requirements.

(4) Set up a road network of nodes and links with each focal point and each potential station site assigned a node and with other nodes assigned so that the resulting links all represent stretches of fairly constant speed. Provide speed and distance data for each link. Calibrate the data by comparing actual travel times on some station-to-site paths to travel times estimated by the model using the data.

(5) Select the company locations to be studied and use the model.

Characteristics of Model[1]

(1) Data Required:

- Distance and speed data required for each link in the transportation network to be used in modeling the city. Obtain distance estimates from measurement on a detailed city map (e.g., by using calipers). Obtain speed estimates from one of several procedures, depending on how much accuracy is desired and how much cost is acceptable. Procedures include (1) estimating speeds from sample runs over each link on each route, and (2) using some PTI-suggested speed value for all links of a certain type (e.g., 20 miles per hour on all segments of arterial road located in the central business district).
- Historical alarm rate for each fire demand zone.
- Assigned hazard level and corresponding response time requirement for each fire demand zone. Also, response time safety margin for each fire demand zone.
- Locations where fire stations may be placed.

(2) Outputs Provided:

- List of each fire demand zone that cannot be reached from any station within that zone's response time requirement and the historic alarm rate for those zones.
- Frequency distribution of travel times to the fire demand zones, plus average travel times (not weighted by alarm rate) for (a) all zones and (b) all zones that can be reached within their response time requirements.
- Same information provided for second-due and third-due responses.

(3) Special Properties:

- Cannot take account of busy companies.

[1]Adapted from Public Technology, Inc., "Fire Station Location Package," 4 reports, Washington, D.C.: U.S. Department of Housing and Urban Development, no date.

APPENDIX C

JANE HOGG'S ESTIMATES ON THE MONETARY VALUE OF CHANGES IN FIRE COMPANY TRAVEL TIME

The estimates developed by Jane Hogg were used in two different ways in this report. First, they were used in the rough calculations of the monetary value of net travel time increases in Denver and Wilmington and of a net travel time decrease in Yonkers. The figures shown in Column 2 below were converted to U.S. dollars and updated to reflect inflation. Then, the figures in the "dwelling" and "other buildings" columns were combined according to our best guess on the mix of dwelling versus other-building fires in the areas of the city affected by the change. The combined figure based on an old-deployment average travel time of 2 minutes was used because all the cities had average travel times very close to 2 minutes. Finally, that dollar figure was multiplied by the projected change in average travel time to get an estimate of the impact of the planned deployment change on losses and casualties.

The second use of Jane Hogg's estimates was as a basis for assessing the importance of separately examining the changes in long travel times. As column 2 shows the expected cost of extra time in dwelling fires varies little as a function of the old travel time. The expected cost of extra time in non-dwelling fires varies considerably, however, with extra time applied to a 5-minute travel time costing nearly twice as much in losses and casualties as extra time applied to a travel time near 0 minutes.

Column 1	Column 2	
Travel time prior to change (mins.)	Average monetary cost in extra losses and expected casualties of an extra minute of travel time[1]	
	Dwellings[2]	Other buildings
0	57	241
1	58	286
2	59	333
3	61	380
4	63	428
5	64	480

[1] The cost figures are in British pounds and are based on 1967 United Kingdom fire data. The figures include the expected value of lost life with a life valued at 30,000 English pounds. Data computed from Table 2 of Jane M. Hogg, "A Distribution Model for an Emergency Service," Imperial College of Science and Technology, University of London, September 1970.

[2] Dwellings are detached houses and duplexes.

APPENDIX D

DETAILED REVIEW OF INFORMATION ON THE ACCURACY OF TRAVEL TIME ESTIMATES PRODUCED BY USE OF THE RAND AND PTI MODELS

The only published data on the overall accuracy of RAND's or PTI's travel time estimates came in the Denver study. An estimate of the average travel time to alarms from the RAND Simulation was compared to an estimate of the average travel time to alarms based on clocked travel times. The estimate from the RAND Simulation was about 1.93 minutes[1] and was based on 1,000 simulated incidents and the 1973 average alarm rate; the estimate from clocked travel times was 2.01 minutes and was based on 1,575 runs during 1973 (about 8 percent of the year's total alarms).[2] The difference of .08 minutes, or about 4 percent, was considered small by both the Denver study team and RAND. Also, the estimate of average travel time based on the clocked runs was probably accurate only to within .05 to .07 minutes;[3] so, the actual modeling error may have been very small.

If (a) the model estimates of travel time are inaccurate by up to 4 percent of the estimated average travel time--which would make the model's estimate of the difference in travel times inaccurate by up to 6 percent (or about .12 minutes)--and (b) the projected change in average travel time in each of the four cities that selected deployment changes with the approach is thereby lowered by .12 minutes citywide, then Trenton and Denver would still be projected to achieve net productivity improvements, but Wilmington and Yonkers might not be. In Wilmington's case the cost of the higher travel times (based on Jane Hogg's figures, updated) could then be large enough to overwhelm the cost savings. In the case of Yonkers, an apparent small improvement in travel time in the neighborhood would be converted to a worsening in travel time.

The RAND FSEM can be considered proven accurate to the same degree as the RAND Simulation because the two approaches give the same estimates when the average percent-of-time-busy of companies is as low as it was found to be in Denver.[4]

There is no published evidence yet on the accuracy of the PTI approach, but there seems to be no clear reason to expect it to be much more or less accurate than RAND's FSEM approach in estimating average travel times. PTI's "round number" speeds, based on federal guidelines for desired road capacities,[5] appear to be consistent with the data on actual speeds being

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[1] Hendrick et al., Denver, p. 106.
[2] Ibid.
[3] This assumes a statistical standard error for single-run fire company travel times roughly equal to 50 to 100 percent of that found in RAND's New York City tests, as calculated from data shown in Table 5 of Peter Kolesar and Warren Walker, Measuring the Travel Characteristics of New York City's Fire Companies, New York City RAND Institute, R-1449-NYC, April, 1974.
[4] Hendrick et al., Denver, p. 125.
[5] Public Technology, Inc., "Fire Station Location Package," Project Leader's Guide, p. 20.

achieved by fire companies in five cities whose documented experience, as measured by RAND, permitted such a comparison (see Exhibit D-1). PTI's manuals call for calibration of the travel times, but the manuals do not specify how this calibration is done so its impact on accuracy cannot be assessed.[1]

The only published evidence on the accuracy of RAND's PAM approach is a comparison of its estimates with those of RAND's FSEM package in Wilmington. If RAND's FSEM's accuracy is accepted on the basis of the Denver test, then the PAM-FSEM comparisons can be used to judge the accuracy of the PAM. RAND's PAM estimates (not weighted by alarm rates) differed from the FSEM alarm rate estimates (weighted by alarm rates) by about .10 to .15 minutes citywide and by about .1 to .4 minutes in major service areas.[2] These differences are a cause for concern. RAND does not recommend use of the PAM without subsequent use of the FSEM to pick particular sites.

Much less published evidence exists on the accuracy of model estimates other than estimates of citywide average travel times. The following is a capsule description of a few other points:

- Comparisons in several of the six cities between the RAND speed formula curve (the curve that translates travel distance into travel time) and the clocked travel time data used to derive the curve indicate that maximum times from the formulas tended to understate actual maximum times by up to 10 to 15 percent.[3] This is the only evidence on the model's accuracies in estimating the frequency of longer travel times. Much if not all of this apparent inaccuracy could instead be due to the substantial variability in travel times over the same path, which the Denver project showed to exist and which none of the RAND or PTI approaches capture.

- A study in New York City developed speed formulas for each of 13 ladder companies. This is the only published evidence on the size of inaccuracies caused by using a single citywide speed formula instead of speed formulas separately derived for each area of the city. The differences found using about 1,800 clocked runs[4] were barely statistically significant, and the neighborhoods whose speed formulas differed most from the citywide formula would have had their estimated travel speeds at any travel distance changed by no more than 10 percent if they had switched from using the citywide formula to using their neighborhood formulas.[5]

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[1]Analysts in San Jose compared RAND's and PTI's speed formulas, but the results of that comparison have not yet been published.

[2]Walker, Singleton, and Smith, Wilmington, pp. 45, 54, 63.

[3]See the data plots in the Yonkers, Jersey City, Wilmington and Trenton case studies and in Kolesar and Walker, Travel Characteristics.

[4]Kolesar and Walker, Travel Characteristics, Table 5 and Figures 2-15. The same report says on p. 1 that there were over 2,000 observations taken, but some were dropped as data errors and others were runs by battalion chiefs that were not analyzed in detail.

[5]Computed from Kolesar and Walker, Travel Characteristics, Figures 2-15, for a range of travel distances.

EXHIBIT D-1

COMPARISON OF PTI'S ROUND NUMBER SPEEDS AND ACTUAL SPEEDS IN THE FIVE CITIES WITH DOCUMENTED RESULTS[1]

PTI SPEEDS[2] (Miles per hour)

Type of Road	Central Business District[3]	Rest of City[3]
Local	10	15
Collector	15	20
Arterial	20	25
Expressway	30	30
Freeway	40	40

SPEEDS IN FIVE CITIES (Miles per hour)

City	Average speed over all alarms	Speed range for short distances[9] (Company travel speeds over these distances will probably be dominated by speeds on local and collector roads.)	Speed range for long distances[9] (Company travel speeds over these distances will probably be dominated by speeds on arterials, expressways, and freeways.)
Jersey City[4]	20	11-23	33-40
New York City[5]	18	8-12	25-30
Trenton[6]	25	15-20	30-34
Wilmington[7]	24	14-17	27-36
Yonkers[8]	26	5-21	23-40

[1] The Denver report's travel time data displays did not provide the kind of information shown here.

[2] Public Technology, Inc., "Fire Station Location Package." Project Leader's Guide, p. 20.

[3] PTI also has suggested speeds for suburban and rural areas.

[4] Rider et al., Jersey City, p. 36.

[5] Computed from data in Kolesar and Walker, Travel Characteristics, pp. 29, 31.

[6] Hausner and Walker, Trenton, p. 31.

[7] Walker, Singleton, and Smith, Wilmington, p. 35.

[8] Hausner et al., Yonkers, p. 31.

[9] Short distances are 0.1 to 0.3 miles; long distances are 2.0 miles and over. The range shown is for the average speed of all clocked runs over a particular distance. For example, the range for short distances goes from the average speed for all runs of 0.1 mile to the average speed for all runs of 0.3 miles.

- Studies of variations in speed by time of day were made in all of the six cities. These studies showed very little variation except in the morning rush hour, where speeds were lower by about 5 to 25 percent and possibly more because RAND's tests tended to understate the deviation by lumping weekday and weekend alarms together.[1] Lower speeds in rush hour, if they were about the same around the city, could be handled fairly easily; a user could simply add a fixed percentage to any estimates of travel time given by the model. If rush hour lowered speeds to different degrees in different areas of the city, this could be handled only by collecting speed run data during the rush hour period and using only that data for an analysis. Since the morning rush hour is generally a period with a low alarm rate, it would probably take over a year of data to permit an analysis with acceptable accuracy.

[1] Ibid., pp. 30-31. Also, p. 32 of the Trenton study; p. 37 of the Jersey City study; p. 37 of the Wilmington study; and p. 33 of the Yonkers study.

APPENDIX E
A TECHNIQUE FOR COMPARING COST AND TRAVEL TIME IMPACTS OF
FIRE DEPLOYMENT CHANGES USING READILY AVAILABLE DATA

If estimating the additional loss likely to occur as travel time increases is deemed too difficult or too uncertain, the feasibility and utility of another procedure could be studied. In this procedure, if the changes being considered involve a net reduction in the number of companies planned and a rise in the average travel time, then fire officials would convert the expected annual dollar savings from that reduction to a savings rate per incident or per additional minute of delay allowed.[1] Fire officials would then decide whether that savings rate was likely, in their judgment, to be greater or less than the value of the average additional dollar loss per incident or per additional minute of delay that would be expected to occur because of the expected increase in travel time.[2] If the changes being considered involved additional annual costs--added companies or relocated stations—and a decrease in average travel time, the same type of comparison would be carried out but with the dollar cost per incident (or per minute of delay) being judged as to whether it was greater or less than an expected savings (from reduced loss and casualties) per incident or per minute of delay removed. It might be preferable to use only the number of building fire incidents in this comparison because most loss is concentrated there and it is somewhat easier to estimate what the loss was at such incidents.

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[1]"Dollar savings per minute of delay allowed" could be calculated by dividing the "dollar savings per incident" by the expected increase in average citywide travel time. (As noted above, only building fire incidents might be used.)

[2]Note that the "average additional loss from a minute's delay" is not the same thing as the "loss from a minute's delay at an 'average' or typical fire." The latter number will be much smaller because the former number will be dominated by a few cases of very large loss. Because of the potential confusion between these two concepts, the particular measures suggested here may not be the most helpful. This should be explored through further research that might identify other ways for users to be aided in making the trade-off of savings versus loss.

APPENDIX F

MATERIAL REVIEWED FOR ASSESSMENT OF PTI AND RAND
FIRE DEPLOYMENT ANALYSIS APPROACHES
--AND WHERE TO GET IT

The materials reviewed are organized by where you can write to order them. Documents with an ordering number consisting of "PB" followed by a six-digit number can also be ordered from:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

For further information on deployment analysis studies supported by the U.S. Department of Housing and Urban Development, write to:

Ms. Hartley Campbell Fitts
Chief, Community Management and
Productivity Improvement Research Staff
Division of Community Development and
Management Research, Room 8162
U.S. Department of Housing and Urban Development
451 Seventh Street, S.W.
Washington, D.C. 20410

Material available from: Denver Urban Observatory
University Center
Box 2483
Denver, Colorado 80220

Hendrick, Thomas E. et al., "Denver Fire Services Research Project Report: Feasibility Test of Applying Emergency Service Deployment and Facility Location Methods to Assist in Municipal Budget Decisions in the Fire Service," Denver Urban Observatory, 1974, PB 239 666.

"Policy Analysis for Urban Fire Stations: How Many and Where," Denver Urban Observatory, November 1974, PB 239 711.

Material available from: Public Technology, Inc.
1140 Connecticut Avenue, N.W.
Washington, D.C. 20036

Fire Station Location Package, Public Technology, Inc., undated but first produced in about 1974. Full four-volume package--PB 239 900.
"Chief Executive's Report" only--PB 239 901.
"Fire Chief's Report" only--PB 239 902.
"Project Leader's Guide" only--PB 239 903.
"Project Operations Guide" only--PB 239 904.
PATH computer program (not included in four-volume package).
LOCATION computer program (not included in four-volume package).

"The PTI Fire Station Location Package: Effectiveness Survey Analysis," Draft Paper, Public Technology, Inc., May 25, 1977.

Material available from: The Rand Corporation
1700 Main Street
Santa Monica, California 90406

Carter, Grace, "Simulation Model of Fire Department Operations: Program Description," The New York City-Rand Institute, R-1188/2-HUD, December 1974, PB 242 400.

Carter, Grace, and Ignall, Edward, "A Simulation Model of Fire Department Operations: Design and Preliminary Results," The New York City-Rand Institute, R-632-NYC, December 1970, PB 258 377.

Carter, Grace; Chaiken, Jan; and Ignall, Edward, "Simulation Model of Fire Department Operations: Executive Summary," The New York City-Rand Institute, R-1188/1-HUD, December 1974, PB 242 401.

Carter, Grace; Ignall, Edward; and Walker, Warren, "A Simulation Model of the New York City Fire Department: Its Use in Deployment Analysis," The New York City-Rand Institute, P-5110-1, July 1975, PB 258 334.

Chaiken, Jan M., "Classification and Catalog of Local Government Experience in Adopting Six Emergency Service Deployment Models," Unpublished RAND report to HUD, May 1977.

Chaiken, Jan M., "Implementation of Emergency Service Deployment Models in Operating Agencies," Rand Corporation, P-5870, May 1977.

Chaiken, Jan; Ignall, Edward; and Walker, Warren, "Deployment Methodology for Fire Departments: How Station Locations and Dispatching Practices Can Be Analyzed and Improved," The New York City-Rand Institute, R-1853-HUD, September 1975, PB 253 394.

Chaiken, Jan; Ignall, Edward; and Walker, Warren, "A Training Course in Deployment of Emergency Services: Instructor's Manual," The New York City-Rand Institute, R-1784/1-HUD, September 1975, PB 250 462.

Chaiken, Jan; Ignall, Edward; and Walker, Warren, "A Training Course in Deployment of Emergency Services: Student's Manual," The New York City-Rand Institute, R-1784/2-HUD, September 1975, PB 250 463.

Dormont, Peter; Hausner, Jack; and Walker, Warren, "Firehouse Site Evaluation Model: Description and User's Manual," The New York City-Rand Institute, R-1618/2-HUD, June 1975, PB 250 438.

Hausner, Jack, "Determining the Travel Characteristics of Emergency Service Vehicles," The New York City-Rand Institute, R-1687-HUD, April 1975, PB 250 460.

Hausner, Jack, and Walker, Warren, "An Analysis of the Deployment of Fire-Fighting Resources in Trenton, New Jersey," The New York City-Rand Institute, R-1566/1-TRNTN, February 1975, PB 241 481.

Hausner, Jack; Walker, Warren; and Swersey, Arthur, "An Analysis of the Deployment of Fire-Fighting Resources in Yonkers, New York," The New York City-Rand Institute, R-1566/2-HUD/CY, October 1974, PB 241 482.

Hendrick, Thomas E. et al., "An Analysis of the Deployment of Fire-Fighting Resources in Denver, Colorado," The New York City-Rand Institute, R-1566/3-HUD, May 1975, PB 246 906.

Ignall, Edward; Kolesar, Peter; and Walker, Warren, "Using Simulation to Develop and Validate Analytical Emergency Service Deployment Models," The New York City-Rand Institute, P-5463, August 1975.

Ignall, Edward J. et al., "Improving the Deployment of New York City Fire Companies," The New York City-Rand Institute, P-5280, July 1974, PB 241 832.

Kolesar, Peter, and Blum, Edward H., "Square Root Laws for Fire Company Travel Distances," The New York City-Rand Institute, R-895-NYC, June 1975, PB 258 452.

Kolesar, Peter, and Walker, Warren, "Measuring the Travel Characteristics of New York City's Fire Companies," The New York City-Rand Institute, R-1449-NYC, April 1974, PB 258 325.

"A Model for Predicting Average Fire Company Travel Times," The Rand Corporation, R-1624-NYC, June 1975, PB 258 378.

"An On-Line Program for Relocating Fire-Fighting Resources," The Rand Corporation, R-1506-NYC, June 1975, PB 258 299.

"Reducing Fire Engine Dispatching Delays," The Rand Corporation, R-1458-NYC, December 1973, PB 258 370.

Rider, Ken, "A Parametric Model for the Allocation of Fire Companies: Executive Summary," The New York City-Rand Institute, R-1646/1-HUD, August 1975, PB 250 443.

Rider, Kenneth, "A Parametric Model for the Allocation of Fire Companies: User's Manual," The New York City-Rand Institute, R-1646/2-HUD, August 1975, PB 250 444.

Rider, Kenneth, "A Parametric Model for the Allocation of Fire Companies," The New York City-Rand Institute, R-1615-NYC/HUD, April 1975, PB 250 442.

Rider, Kenneth et al., "An Analysis of the Deployment of Fire-Fighting Resources in Jersey City," The New York City-Rand Institute, R-1566/4-HUD, August 1975, PB 250 464.

Swersey, Arthur J. et al., Fire Protection and Local Government: An Evaluation of Policy-Related Research, The New York City-Rand Institute, R-1813-NSF, September 1975.

Walker, Warren E.; Singleton, David W.; and Smith, Bruce, "An Analysis of the Deployment of Fire-Fighting Resources in Wilmington, Delaware," The New York City-Rand Institute, R-1566/5-HUD, July 1975, PB 250 465.

Walker, Warren E., "The Deployment of Emergency Services: A Guide to Selected Methods and Models," Rand Corporation, R-1867-HUD, September 1975, PB 253 395.

Walker, Warren E., "Firehouse Site Evaluation Model: Executive Summary," The New York City-Rand Institute, R-1618/1-HUD, June 1975, PB 250 437.

Three books on the RAND approaches are due out soon. Information on them can be obtained from: Warren Walker
Urbatronics, Inc.
713 Salem Street
Teaneck, New Jersey 07666

Chaiken, Jan M., Improving Station Location and Dispatching Practices in Fire Departments: A Guide for Fire Chiefs and Municipal Executives.

Rand Fire Project, Fire Department Deployment Analysis.

Walker, Warren, Analyzing Firehouse Locations: Case Studies in Five Cities.

Other Material Examined

"Ambulance Location System," Fire Chief, November 1977, p. 43 (on an extension of PTI's approach).

Applying Systems Analysis in Urban Government: Three Case Studies, International City Management Association, March 1972 (covered development of a forerunner of the PTI approach).

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Chaiken, Jan, and Walker, Warren, Letter to Harry Hatry and John Hall, May 5, 1977.

Fales, James M., "Fire Station Location," Public Management, International City Management Association, August 1973, p. 9 (on PTI approach).

Fyffe, David E., and Rardin, Ronald R., An Evaluation of Policy-Related Research in Fire Protection Service Management: Final Report, Georgia Institute of Technology, October 1974.

Hall, Ev, and Toregas, Costis, "A New Tool to Select Fire Station Sites," Fire Chief, November 1976, pp. 36-38 (on PTI approach).

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APPENDIX G

SOME EVALUATION ISSUES FACING FEDERAL AGENCIES THAT CONDUCT APPLIED RESEARCH, DEVELOPMENT, DEMONSTRATION OR TESTING OF PROGRAMS AIMED AT HELPING STATE AND LOCAL GOVERNMENTS[1]

When HUD or any other federal agency sponsors a project, such as a productivity improvement project that is aimed at helping state or local governments, that agency also should explicitly provide for adequate evaluation of that project. It is important to obtain information on the results of projects so that federal, state, and local governments can assess those results and decide whether transference to other governments of the procedures tested is warranted.

In Appendix A, specific items of needed information were listed and discussed. Here, we discuss some crucial issues in the process of selecting and administering project evaluations. An adequate evaluation will cost different amounts for different projects and may be very difficult to obtain at any reasonable cost for some projects. Thus, it is necessary to decide how much evaluation one wishes to pay for. And since evaluation requires some activities (e.g., obtaining baseline data) that should precede the introduction of the new improvement, it is important that adequate evaluation planning be undertaken prior to the project's start in order to increase the value of the project to other governments as well as those participating.

The discussion that follows applies to a variety of projects, including productivity improvement projects, public finance projects, technological improvement projects, and many others. The following questions are discussed below: (1) Which evaluation objectives are appropriate at each stage of development of the product? (2) Which projects should be evaluated and what type of evaluation should be used on each type of project? (3) Who should undertake the evaluation? (4) What resources are needed for the evaluation and what should the timing be?

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[1] These suggestions are by no means intended to be a comprehensive examination of evaluation issues. Rather they represent issues that arose out of our review of the productivity efforts discussed in the body of the report. Some of the information deficiencies noted in the body of this report have been noted by others. For example, Ken Kraemer and John King (in "A Critique of Federal Involvement in City Information: Part II" in Government Data Systems, July-August, 1977.) stated ". . . there has been great reluctance at the local level to document or proclaim anything but positive statements about the experiences. Information about failures and mistakes and why they happened which would be of tremendous value to others considering entering into similar efforts, is rare . . . there has been a reluctance to allow critical analysis in documentation of the projects." Their final recommendations include " . . . federal agencies should conceive of all future efforts as formal experiments and should therefore include pre-project, mid-project, and post-project studies of every program to show what has been learned, at what cost, and what might be done with the result."

Question 1: Which evaluation objectives are appropriate at each stage of development of the product?

The development of an innovation typically progresses through a number of stages of development. The stage an innovation is in can significantly affect the evaluation objectives and thus, the type of evaluation that is needed. It is important to distinguish (a) projects that are in the developmental stage, (b) projects that are ready for actual implementation testing of developed procedures and (c) projects aimed at promulgating products (preferably tested products showing substantial evidence of utility). Failure to distinguish these three phases can lead to considerable confusion, unreasonable expectations for evaluation, and wasted evaluation resources. Sometimes these phases overlap, making it more difficult to select the appropriate evaluation objectives. Even when this occurs, recognition of the existence of these three phases is likely to help sort out realistic evaluation objectives and provide an appropriate evaluation strategy. Exhibit G-1 summarizes some principal features of these three stages.

Projects in the developmental stage will usually have important special characteristics, such as close attention from special personnel and frequent changes in procedures. These projects probably need two types of evaluation. First, it is appropriate for contractors to undertake their own, internal, evaluations in order to aid them in developing the best possible product. Questions such as the accuracy of any technical procedures involved should be considered by the organization trying to develop the innovation. At the point at which the innovation is claimed to be ready for actual full-scale field trials beyond the developmental stage, it is desirable for an independent agency to evaluate the "validity" of the proposed procedures and their readiness for full-scale field trials. Such an evaluation should also include a preliminary user's assessment of the likely utility and feasibility of the innovation. In general, such an evaluation does not need complex evaluation designs (such as the use of experimental and control groups). It can still be expensive, however, depending upon such factors as the complexity of the technical procedures in the innovation.

In the implementation testing stage, more formal types of evaluation designs should be considered so that the new product's impacts on governmental efficiency, effectiveness, employee satisfaction, etc., can be determined under real conditions with relative confidence.

In the product promulgation stage, evaluation is also appropriate, although most projects to date have done this evaluation at a nominal level (such as collecting testimonials submitted by users at the users' own instigation). Projects in this stage should be assessed for their effectiveness in achieving audience awareness of the product; their success in providing useful, complete, understandable information on the product; and most important their success in stimulating widespread, successful use of the product by governments. For the purpose of this paper, which is not directly concerned with the dissemination stage, the principal points are (a) the choice of products to be disseminated should be based on the findings of the previous evaluations, and (b) the findings of those evaluations should be a major part of the information disseminated.

Exhibit G-1

Illustrative Stages of Product Development and Associated Evaluation Characteristics

	←Developmental Stage→		←Implementation Testing Stage→	←Promulgation Stage→
	Development of Product	When Purported to be Ready for Implementation Trials		
Evaluation Purpose	To develop the best possible product	To assess worthiness for field trials	To assess impacts in real-life situations	To assess effectiveness of dissemination
Focus of Evaluation	"Technical" characteristics	Potential for effective future use, apparent validity	Utility, costs, ease of use, transferability	Breadth of audience, awareness of and use of the product, degree of audience understanding of the product
Preferred Evaluator	Developer	Independent agency	Independent agency	Independent agency

Question 2: Which projects should be evaluated and what type of evaluation should be used on each type of project?

Because some projects require substantial funding to be adequately evaluated or are very difficult to evaluate at any cost, an assessment of the evaluation potential is needed at the beginning of the implementation testing stage for each candidate project to determine what type of evaluation, if any, it should have and what resources will be needed for that evaluation. An illustrative list of criteria for assessing the evaluation potential of a project is presented in Exhibit G-2.

Projects that tend to be quite difficult to evaluate for impacts include those involving organizational changes or improvements to such "support" functions as general management, management information, financial control, and budgeting. Ultimately, their impacts of interest are changes in government efficiency and effectiveness, but the connection between these impacts and those kinds of changes tends to be very indirect and vague. This forces evaluators to use measures of intermediate impacts (such as speed of processing forms), including some that may be quite nebulous and subjective (such as perceptions of agency managers as to changes in the quality of support services). Meaningful evaluations of these kinds of projects are likely to be more difficult, therefore, except perhaps in those cases where the innovations are primarily intended to reduce costs, say, by reducing paperwork.

Using the HUD-sponsored projects reviewed in this report as examples, the "Four-City" projects' innovations could be fully implemented much more rapidly than deployment changes based on the PTI-RAND project procedures. The latter changes require several years to be fully implemented. Thus, a considerably longer period would be needed to evaluate the latters' impacts. This also means that it would likely be considerably more difficult to separate out impacts due to other factors that could occur over the lengthy time period.

The 1976 Innovative Productivity Projects Program (IPP) provides another example of the wide differences in evaluation potential among projects (in this case, among the ten governments participating). For example, the Iron Range, Minnesota effort involved service organization changes that are likely to require local or state legislation; this means full implementation is likely to take a number of years.

In those cases where evaluation of impacts does not seem feasible, there are various fall-back positions such as (a) relying on indirect measures of effects or measures of intermediate effects such as response times to fire or police calls (substituted for fire losses averted or crimes prevented), (b) evaluating the "process" and not its effects, or (c) determining whether the process appears to be in place and then using users' assessments[1] of the utility of the product.

[1]Considerable care should be taken to obtain representative feedback and not just testimonials. The basic principles of good evaluation still apply. An independent evaluator should establish a set of unbiased questions, and there should be representative coverage of those persons affected by the product. Feedback should come not only from the officials responsible for introducing the innovation but also from a wide spectrum of personnel directly involved in or affected by its use. The feedback should preferably be confidential and anonymous and should be obtained long enough after the product has been introduced so as to reflect characteristics of "normal" use (as opposed to "test-condition" use).

EXHIBIT G-2

Illustrative Criteria for Assessing the Evaluation Potential of State and Local Government Improvement Projects

1. Are the nature and purposes of the innovation sufficiently defined including both what the innovation is and its purposes? Note that it is not necessary that everything about the project be spelled out completely in advance, but there should be sufficient specificity that evaluators could know whether the innovation had actually been implemented and could determine evaluation criteria.

2. Does the timing of the evaluation permit action to be taken based on the evaluation findings? If the evaluation would not be completed before minds were already made up and decisions were already set, it would be a waste to do an evaluation. Similarly, are the desired impacts of the innovation likely to take so long to appear that the data on those impacts are likely to be greatly influenced by factors other than the innovation?

3. Is it possible to obtain reasonably reliable, valid data on the impacts of the project?

4. Do the projected costs of the evaluation fit within the limits of the resources that will be available? If not, there is no use undertaking the evaluation.

These fall-back approaches generally are less expensive, but they also provide much less information--and much less believable information--as to the effects of the project being evaluated. Inevitably governments are tempted in their assessments to focus on those aspects of the new product that are easiest and cheapest to measure. The federal government should recognize that such evaluations are not in general sufficient to determine the impact of the product --information vitally needed by other potential users in making informed judgments. For most federally supported projects, potential users will want to know how the innovation affects costs, efficiency, and effectiveness, and not just feasibility.

These cautions against fall-back approaches are not meant to suggest that "controlled experiments" must be used. Although this type of evaluation design gives the best impact information, it is also the most expensive and most difficult. For many types of innovations, the requirements of such experiments--such as random assignment of the target population to experimental and control groups--are likely to be infeasible. Nevertheless, evaluation planning for major innovations should consider all experimental designs before falling back on less rigorous designs.[1]

Question 3: Who should undertake the evaluation?

The choice of evaluators can be as important to evaluation strategy as the timing and the evaluation design. The general principle is that the persons or organizations whose work is being evaluated should not undertake the evaluation themselves. Thus, evaluations generally should be done by independent parties, both to obtain an objective evaluation and to maintain the evaluation's credibility. In practice, evaluation responsibility for projects involving tests by local or state jurisdictions will often need to be shared with the jurisdiction undertaking the innovation, since much of the key data will involve government records and government personnel. Nevertheless, the evaluation should be overseen and coordinated by an independent agency. By contrast, in the "Four City" study and the RAND and PTI fire deployment projects, the federal government appears to have left the major responsibility for evaluation with the developers of the innovations being tested. It is certainly appropriate for the federal government to provide funds to its innovation developers in the developmental stage to undertake the kind of evaluation that help with their product development efforts. Nor should this preclude the federal government from encouraging a local government to participate in. or undertake, its own evaluation of innovations tested within its jurisdiction. But an independent evaluation should still be provided to ascertain whether the items developed seem technically sound and transferable.

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[1]More opportunities for "controlled-experiment" designs may be identified if it is recognized that the units of evaluation may be something other than persons--such as small geographical units within a jurisdiction or service districts within a local government.

Question 4: What resources are needed for the evaluation and what should the timing be?

The pressure to get demonstration projects funded as soon as possible, and later to get them disseminated quickly, is a major obstacle to meaningful evaluation. A major pressure can be that of having to show results as quickly as possible to meet short-term demands. The federal government should identify the evaluative information it wants from a demonstration before the project is implemented, require an evaluation plan, and provide the necessary time and resources to fulfill the plan and obtain the specified information.

Early evaluation planning is also needed to provide for adequate baseline data, i.e., data on conditions before the innovation is introduced which can be compared with data on conditions after the innovation has been fully implemented. Early planning is essential for evaluations using controlled-experiment designs, but it is also highly desirable, if not essential, for other types of evaluation as well. Plans for collecting baseline data can be dispensed with only when the jurisdiction's existing data files are known to provide reliable information of the kinds and amounts required. (Even then, this fact should be determined before implementation of the new program begins.) Unfortunately, evaluators almost invariably find that existing data fall short of what is needed for the evaluation. (This is true even for supposedly routine data such as unit-cost data, where the form and reliability of the data are often inadequate.)

If evaluation planning is begun prior to beginning implementation testing, many later problems can be avoided. For example, specific understandings can be obtained as to needed cooperation and data collection by the sites, and in some cases, site selection itself will be an important part of evaluation planning, e.g., to obtain a set of representative sites.

In setting the length of the field-test period, sufficient time should be provided to permit meaningful evaluation information. The short time horizons of some projects barely permit initial introduction of the innovations and shakedown periods. A year or less may be adequate for projects that are narrow in scope, such as those that introduce a new type of vehicle or a new paperwork procedure, but periods that short are seldom adequate if major revisions in work procedures or processes are involved. Generally, at least one year and preferably two (or more) are needed after shakedown in order to account for seasonal events and cover a sizeable period of "normal" use. A six-month implementation period followed by a 12-month trial with an additional 6 months for completing the evaluation would be a minimum for many projects. The federal government should recognize that problems inevitably arise in a state or local government, delaying full implementation of an innovation. Such contingencies should be provided for when establishing realistic timing for test and evaluation efforts.

Enough resources should be provided to undertake meaningful evaluations. Dilution of the evaluation activity by combining it with other tasks in a single contract should generally be avoided; experience shows that evaluation usually suffers in the competition for resources. The evaluations of the "Four City" projects appear to have been under-funded through this kind of dilution. (At most, $25,000-$50,000 seems to have been spent on evaluation activities for all four sites, with most funds having gone to help develop and implement the innovations.)

Another problem with underfunded and diluted evaluation contracts is that organizations with the needed evaluation expertise are likely to be dissuaded from the bidding. The problems of contracting can be major ones for federal agencies; some agencies (such as LEAA and HEW) have been trying the use of umbrella evaluation contracts that cover a number of related projects so as to minimize duplication of effort and to attract high-quality expertise.

Summary of Recommendations

1. Each project should have its stage of development identified and its appropriate evaluation objectives determined. The evaluation of projects in the developmental stage by the developer should focus on "internal" and technical issues with an independent assessment as to the product's technical quality and likely utility to users after the major development work has been completed. Full-scale field trials, in general, should then be undertaken for those products that appear to have potential, with an accompanying comprehensive evaluation by an independent agency (not the developer). The focus of that evaluation should be the product's impact, cost, feasibility, overall utility and likely transferability to other jurisdictions. The choice of products to receive significant dissemination assistance by the federal government should be based on the findings of significant evidence of utility and transferability. The evaluation information obtained should be part of the information disseminated.

2. Government supported projects should each be carefully assessed as to the ability to undertake an adequate evaluation, including the likely meaningfulness timeliness, and usefulness of the information likely to be forthcoming from the evaluation. This should be done in the context of the amount of resources that can be made available to undertake the evaluation. Projects found to have substantial evaluation difficulties should either be modified to increase their evaluability or should not be allocated significant evaluation resources. A set of pre-established evaluation criteria such as illustrated in Exhibit G-2 seems essential in order to systematically undertake such evaluability assessments. Governments, including the federal government, can avoid much frustration and wasted resources by following this practice, and by subsequently following through in their allocation of project resources.

The evaluability assessment should be used to screen out projects that do not merit large evaluation efforts so that HUD can concentrate its evaluation efforts on those projects that are both reasonably evaluable and deemed of national importance. For the latter, in-depth evaluations would generally be appropriate. For the less evaluable projects, simpler and less costly (but also less informative) approaches could be used, but less useful information should be expected.

3. Evaluation, in general, should be undertaken by an independent organization, not the one responsible for development of the new product. (In addition, product developers should be encouraged to evaluate their own work to help in improving the product.) Local governments participating in federally sponsored pilot projects should be encouraged to cooperate in evaluation and to develop their own on-going evaluation capabilities.

4. HUD and other federal agencies should pre-plan so as to provide timely (and comprehensive) evaluations. Evaluation planning should be undertaken before tests of innovations begin--and, preferably, help in test site selection. The consequences otherwise are those of providing inadequate information. Federal agencies should press hard to have the evaluation organization in place and the evaluation plan developed prior to the implementation of the innovation. And enough time should be allowed for shakedown of the new innovative procedures on the sites plus a long enough testing period to provide a test under reasonable realistic, stable field conditions. Combining evaluation with other tasks (such as helping sites implement the product) should be avoided both to avoid diluting the evaluation effort and to avoid discouraging potential quality evaluation contractors. Such dilutions can compromise the quality and credibility of the evaluations.

Government Capacity Sharing Program

There are five overview booklets available from HUD that tell about this and other ideas developed and tested in the eighteen HUD-funded projects aimed at improving productivity in state and local government:

- **Practical Ideas for Small Governments Facing Big Problems** tells how local governments have designed energy conservation programs, personnel management and purchasing systems, have introduced performance menasurement and cost accounting, have improved permit application and licensing, and have devised a way to plan for large street and road projects.
- **Practical Ideas for the Government That Has Everything—Including Productivity Problems** describes ideas for solving problems affecting service efficiency or effectiveness, or employee morale. Street repairs, park maintenance, street and alley cleaning, and permits and licenses are some of the subjects.
- **Practical Ideas on Ways for Governments to Work Together** describes four intergovernmental projects and one public-private project. Subjects include joint provision of services, a successful environmental review team, energy conservation, personnel management, purchasing, developing cost accounting and performance measures, and drawing on the management experience available in the private sector.
- **Practical Ideas for Governments Facing Planning and Scheduling Problems** describes ways of coordinating public services and citizen responsibilities to improve services to a neighborhood, a method for planning large public works projects, a way of instituting quality control in parks maintenance, an information system designed for parks, methods for scheduling shift work equitably, and ways of locating emergency and leisure service facilities.
- **Summary of Productivity Improvement Projects** describes each of the eighteen projects carried out and lists over eighty of the documents produced on the projects.

A free copy of each can be obtained by writing to Division of Product Dissemination and Transfer, Assistant Secretary for Policy Development and Research, Department of Housing and Urban Development, Room 8124, 451 7th Street, S.W., Washington, D.C. 20410.