1977

An evaluation of productivity and efficiency in work scheduling in a public works department

Kraig L. Gordon

AN EVALUATION OF PRODUCTIVITY AND EFFICIENCY IN WORK SCHEDULING IN A PUBLIC WORKS DEPARTMENT

BY

KRAIG L. GORDON, 1948

A THESIS

Presented to the Faculty of the Graduate School of the

UNIVERSITY OF MISSOURI-ROLLA

In Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE IN ENGINEERING MANAGEMENT

1977

Approved by

(Advisor)

ABSTRACT

Managers throughout the world frequently associate the meanings of productivity and efficiency with the capabilities and performance of employees. This approach is limited since productivity entails far more than the output of the labor force. The factors affecting productivity need evaluating to determine the significance they plan in the overall process.

Industry has attempted to improve its productivity posture by utilizing a multitude of concepts. Some of these concepts are time and motion studies and process planning. However, in the public sector, literature shows that little has been attempted to improve the productivity in public organizations.

The greatest portion of a public budget is delegated to the operation of a public works department. Therefore a need exists to bridge the gap between productivity and the operation of a public works department.

This thesis presents an evaluation of operation in a public works department. This evaluation reviews, in particular, the operation of a street department. This includes the street department organization, crew

performance on standard work projects and the work scheduling they employ.

After the review of the street department is completed and the results noted, a work scheduling technique is provided. This method attempts to provide long and short term planning through effective work scheduling.

ACKNOWLEDGEMENTS

The author expresses his deep appreciation to his advisor, Dr. Yildirim Omurtag for his advice and assistance in preparation of this thesis. Thanks are also extended to the members of his committee, Dr. John Eilers and Professor Vernon T. Loesing.

I would also like to extend my appreciation to the Mayor and City Council Members of Rolla for allowing me to survey a part of the city organization. Thanks are extended to Mr. Donald Loomis, Public Works Director/ City Engineer and Mr. William Carroll, Street Superintendent, for their valuable assistance in gathering information for this thesis.

Particular gratitude is expressed to my wife, Mrs. Joyce E. Gordon and daughter, Tara Lynn for their patience and understanding during our tenure at the University in Rolla. Also to my parents, Mr. and Mrs. Leo H. Gordon, I give my thanks for their guidance, counsel, and love throughout my life.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

I. INTRODUCTION

Since the end of World War II, the citizens of this nation have found their lives becoming more involved with a term known as "productivity". This simple term has become woven into the fabric of American life and style.

Many industries at the turn of the century became involved with the industrial management development of our country. Such people as Elton Mayo, Frederick Taylor and Frank and Lillian Gilbreath established the foundation on which this productivity movement was founded. The movement has grown in size, depth and levels of applicability since its founding. What this all basically means is that the roots of what we call productivity today, was started years ago through the development of industrial management.

The central concept in the management revolution is based upon the theme of increasing production output while expending the same or lesser amounts of resources (men, equipment and natural resources). Early practitioners of management established the work horse in measuring productivity, which is called "time and motion studies". From studying the body movements or motions of an employee in conjunction with time, management sought to increase the output of labor.

The emphasis placed upon the measurement of productivity has never really declined, but increased in industry at a moderate rate. However, in the last decade, productivity has become of major importance. This was caused by many factors with one of the most important being the recent developments concerning the availability of energy resources. Inflation has also cut deeply into the pockets of this nation's industries as well as damaging the individual consumer. This problem has resulted in a decrease in our earning and spending powers. Industry has recognized this problem and sought to improve its posture by increasing efficiency and productivity by decreasing its operating expenses and materials cost, and increasing the unit output. An example of this is broadcast quite frequently via the advertisements on television. U.S. Steel has taken measures to advertise how it is increasing its' productivity by showing how it is changing and improving its' operations.

The problems the public sector has experienced are no different from those that have beset industry. Unlike their private counterparts, public institutions have not been as concerned about productivity. Government can less afford to operate in an inefficient manner. Examples of how serious government views the need for efficiency, due to public pressure,

can be seen in the last presidential campaign. Both President Gerald Ford and our present President, Jimmy Carter, sought votes through appealing to the nation by advocating greater productivity and work efficiency in government operations. Since the election, President Carter has continued to push for greater output of government agencies.

These comments have been directed primarily at the national level, but similarities can be found at all levels of government, Federal, state and local. State and local officials have campaigned on the basis of bringing about greater productivity in government. There is a need for all levels of public service to be concerned about productivity in its work, but the problem is particularly significant at the grass roots level, or the local government units.

Why is this so significant? No citizen of this nation goes without being covered by a form of local government. Another reason is that the local funds, derived by taxation are used directly by the municipal government. A citizen can actually see where his money is being spent.

> "Over the past two decades, state and local spending, now at $221.5 billion, has grown faster than any other sector of the economy. State and local expenditures, exclusive of federal aid, use from 7.4% of the Gross National Product (G.N.P.) in 1954 to 11.6% last year". (1)

These simple facts clearly illustrate why local governments should attempt to perform at their greatest efficiency, just as industry has attempted in recent years. Since the greatest percent of local budgets are expended in the area of public works, it appears that this should be the logical starting point in evaluating the productivity of community government.

In subsequent chapters, material which has recently been published in the area of productivity will be examined. Factors relevant to why higher productivity is difficult to achieve in the industrial and public sectors will be discussed, with emphasis placed on the problems specifically existing in public works departments. In an attempt to document this problem the author conducted an evaluation of work scheduling through measurement of productivity in the Public Works Department of Rolla, Missouri. In specific, he evaluated its Street Department's performance in executing standard projects and compared these results with a standard work force performing the same given task. The evaluation is concerned with the work technique and employee performance. The results of this evaluation are presented, and a work scheduling technique that could be employed by communities to assist them in improving their productivity is proposed.

II. REVIEW OF LITERATURE

The "APWA Reporter", the monthly magazine of the American Public Works Association, defines Public Works as

> "the physical structures and facilities developed or acquired by public agencies to house governmental functions and provide water, waste disposal, power transportation, and similar services to facilitate achievement of common social and economic objectives". (2)

This is the typical definition that applies to medium and larger municipalities. They provide a multitude of diverse services established by the needs of the community. However, in recent years, Shell and Shupe state that,

> "... service cut-backs, layoffs, reduction in capital improvements and possible financial default -- these headlines evidence the growing plight of many cities across the nation. The typical municipality is being hard pressed to maintain its service oriented, labor intensive functions in the face of continuing inflation while on a relatively fixed income base". (3)

These authors also state:

> "The revenues of local government have not kept pace with spiraling expenditures. The bottom line result to date has been deeper budget deficits. To relieve this mounting deficit pressure, most cities must either cut services or improve productivity". (4)

The primary concern of municipal government should be to fulfill the collective needs and desires of its

citizens. Productivity improvements permit higher quality or additional service at the same or reduced cost as indicated by the following quotation from "Industrial Engineering" magazine.

> "Characteristically, municipal management has considerable experience and is willing to accomplish productivity improvements". (5)

Unfortunately, two conditions prevail that hinder this development: (1) Too often managers lack the necessary technical tools to analyze successfully and solve the problems that deter productivity growth, and (2) in the case of small communities not only do they lack the expertise, but also the financial capabilities to afford a consultant to assist in productivity growth.

These hinderances to productivity growth in municipal government are compounded by political barriers. Political barriers in this case refers to the freedom to act in a logical manner, in developing the growth of a community. The political barriers existing in municipal government are more complex than typically found in the private sector. They affect not only costs, but also restrain freedom of action in developing, implementing, and maintaining productivity programs.

Dr. Frank Cotton's quotation alludes to the importance of planning in the productivity process.

> "Although productivity improvement is by no means new to private business and industry, there now is a new surge of interest. Hopefully through effective planning, this surge will evolve into a continuous, intensive development and will permeate the public sector of the economy as well". (6)

The very purpose of planning is to obtain better results, to move effectively and efficiently toward achieving goals. Planning, itself, can be highly productive, as it increases the productivity of other functions and activities.

Henry Ford once said that if you need a piece of equipment but don't buy it, you pay for it even though you don't have to.

> "The same case with planning: you either invest in planning and improve your results or you pay for not planning through the lack of results". (7)

Professor Frank Cotton, Professor of Industrial Engineering at the Mississippi State University, emphasizes that productivity must be planned. He states that productivity planning, as a successful, long-term undertaking, involves three principal steps: (1) developing an effective planning process and structure in the organization; (2) preparation of productivity goals, permeating the planning process with scientific objectives based on these goals; (3) establishing productivity surveillance, assistance and coordination in a manner tailored to the organization's needs.

A representation of Mr. Cotton's idea is found on Fig. 1. This figure attempts to bring the three concepts together into a graphical representation of a planning productivity process.

In relationship to process productivity, attention is often focused only on employee productivity. This is a limited view and yields limited results. Productivity attention should focus on the total process, rather than on just the people for they comprise only one of the cost inputs in the process. This relationship is significant in a small community, since manpower costs comprise the greatest portion of overall costs.

Discussion up to this point has focused primarily on the public sector. Politicians, academicians, and even the local citizen have started to review the importance of productivity in the public sector. Due to this recent trend, little has been published or produced in an effort to review productivity in governmental bodies. Therefore, I would like to direct attention to the industrial scene in an attempt to measure their progress.

The question which confronted Frederick Taylor and Frank and Lillian Gilbreath in the early 1900's was "How to raise the efficiency of the individual laborer". Taylor sought a "fair day's work for a fair day's pay" by the time study technique (8). Gilbreath searched

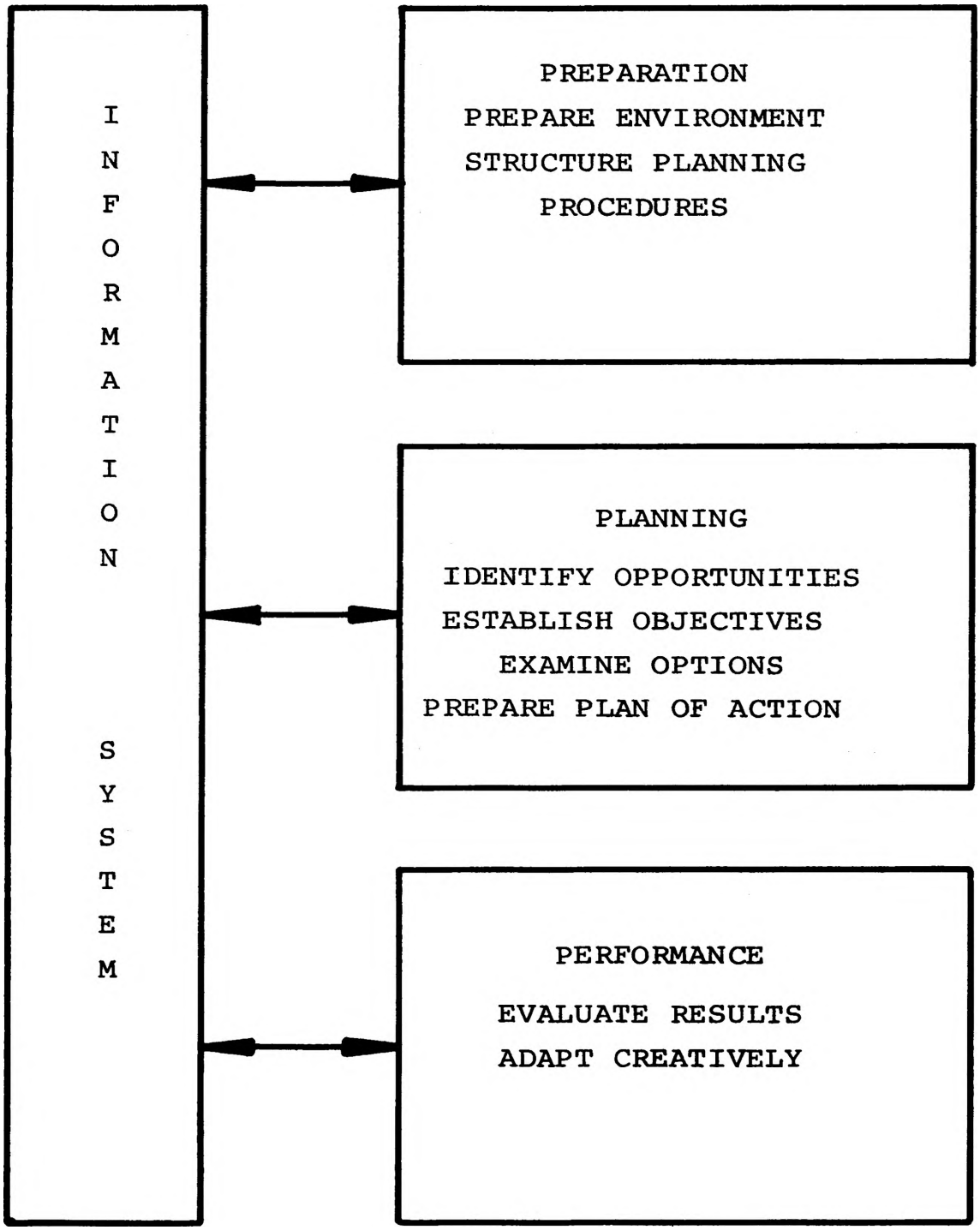

Fig. 1. Planning Process Model

for "the one best way" in techniques of motion study (9). "Dr. Ralph M. Barnes was largely responsible for bringing the separated techniques of time and motion study into the concept of work measurement" (10). The approach to efficiency in the early 1900's, and to a large extent still used today, was to develop techniques for measuring the output of goods and services as they are related to the manpower effort.

The National Bureau of Standards has adopted the definition of productivity to be "real output per hour of work" (11). Productivity in this sense is a rough measure of the effectiveness with which we use our labor resource.

Peter Drucker advised that, "Productivity means that balance of all factors of production that will give the greatest output for the smallest effort" (12). This statement is in basic contrast to the classical meaning of productivity per worker developed through time and motion methodology.

Measurement of productivity involves two basic concepts. It relates the current performance index against that of a standard or base performance index. This could also mean current performance evaluation of inputs against outputs over a standard base period. This is then compared to the base performance and multiplied by 100 percent to establish the level of

performance against the standard. This is represented by the following formula.

$$\text{Productivity or Performance} = \frac{\text{Current Performance}}{\text{Standard Performance}} \times 100\%$$

According to Drucker,

> "A productivity measurement is the only yardstick that can actually engage the competence of management and allow comparison between managements of units within the enterprise, and of different enterprises". (13)

As a different view, Frank DeWitt indicates,

> "...that if productivity is to be measured in terms of all resources it must be measured in terms of the total output of the enterprise. Hence, management capabilities are included in the resource factor. It also seems to indicate that enterprise productivity would appear to be the indicator by which quality of management can be evaluated". (14).

These comments have been a review of prominent individual's views and opinions on both public and private sector productivity. Each has its own merit and application.

To understand better how efficiency and productivity in a public works department can be increased, we must survey one of the most important elements of planning that contributes directly to the success or failure of the operation -- work scheduling. An organization can have the best trained and motivated personnel and equipment, and an abundance of materials, as well as a

comprehensive plan but without an effective work schedule program little efficiency will ever be achieved.

A. SELECTED METHODS OF WORK SCHEDULING

One of the most important items to consider is that similarity is found among many work scheduling techniques. Many organizations adopt only parts of a total concept, obviously only those that are relevant to them. This situation is widely found in the field of public works. Communities adopt only those parts of concepts that can work in their environment, thus creating a hybrid system. One that matches the needs of the community.

Experience indicates that there are three predominent schools of thought in the field of work scheduling in public works departments. Each method is developed with respect to complexity in relationship to the needs and size of the community.

1. "U.S. Army Corps of Engineers, Facility Engineering Work Scheduling" (15). The essential point of this concept evolves around the actual project. Prior to review of the project by the Facility Engineer, a preliminary estimate of the work to be performed is completed. This not only entails materials and equipment, but a breakdown of work disciplines necessary to complete the project. Also

included in the estimate process is a scale of factors to be used in accordance with the distance of the project from the central shop facility. This simply includes a travel time for the workers to go to and return from a project. If the project is approved, a final estimate is completed and the materials placed on order. When the work coordinator recognizes that 100% of the materials needed to complete a project is accomplished, the coordinator places the project on a standing list. When it has worked up on the list it will be started and each discipline will work until its area is completed.

This system provides for a deliberate process to be followed. It utilizes absolute control and permits good planning. Fig. 2 shows a schematic of how this process is followed. This scheme is also followed for all normal maintenance programs when total cost of the project exceeds $200.

2. Medium and Large City Programs. These in some ways have characteristics similar to that used by the Corps of Engineers. The central figure is a work coordinator who essentially "directs traffic". He forwards projects to the estimator for time and materials evaluation. Once the estimate is completed, he coordinates the project with relationship to the section that will perform the work and assists in planning the project into the work schedule.

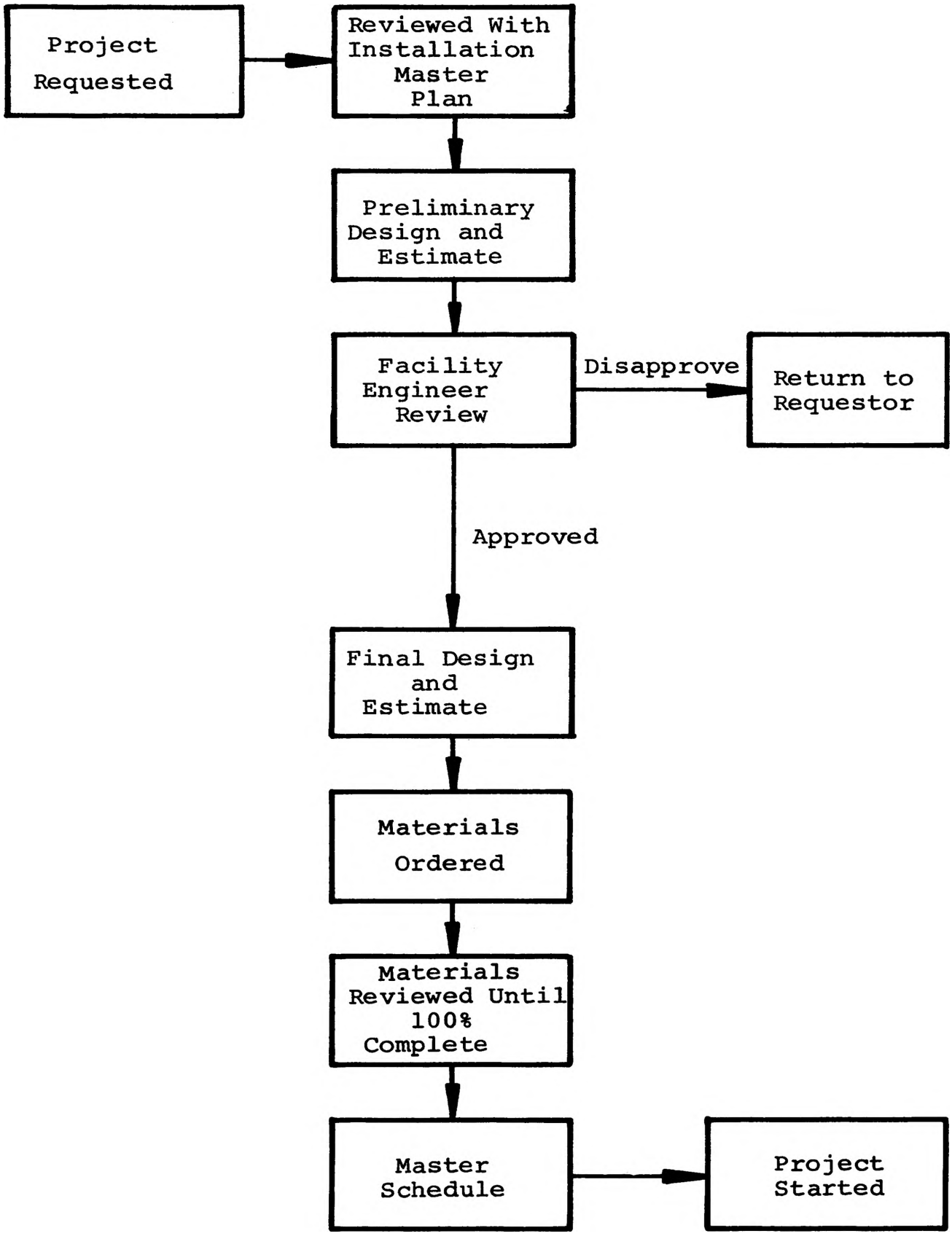

Fig. 2. Facility Engineers' Work Scheduling Model

The work schedule is made through coordination between the Section Superintendent and the Public Works Director on a standard interval of time.

This system provides a reasonable amount of planning and coordination. If initiated properly, it can assist in maximum utilization of personnel and still allow for flexibility necessary in an emergency. The major disadvantage of this plan stems from the additional cost for manpower in the estimate and work coordination section.

3. Informal Technique (Hey-You). This type of work scheduling is widely utilized in small communities. They lack sufficient funds to hire a full-time scheduler and estimator. Hence the public works official is left not only to run the department, but plan and coordinate the projects.

The essence of this system is simplicity. The technique utilizes a relatively small amount of planning. Employees report to work daily for job assignment. The individual in charge will in simplicity say, "Hey you, take your equipment out to Route B and do a certain type of work".

B. CONCLUSION

All of these various methods have their merits, from simplicity to good engineering management and planning. Unfortunately, the cost of a good program is appreciable.

However, the loss of efficiency can offset the cost of a satisfactory program.

What this all means is that productivity involves many factors -- each contributing to the whole. No single item is more important than the other, but effective work scheduling can most improve any situation. If one element is left out of the system, the system will simply cease to work effectively. A good example is the case of a small city (a city with a population of less than 30,000 people). Here all of these factors come together and render themselves for best review.

III. EVALUATION OF PRODUCTIVITY IN A STREET DEPARTMENT

Substantiation of this problem can be found through evaluation of a section within a public works department. By evaluating the project coordinator in a department, an individual can compare the department performance with a standard and establish a measure of productivity. To illustrate this idea, an attempt was made to evaluate a public works operation in a small community. Here all the factors that effect efficiency were examined and evaluated.

A. BACKGROUND

The city chosen for analysis of efficiency in work scheduling is Rolla, Missouri. Rolla is a small city located in the rolling hills in the Ozark Region of south central Missouri. The population of this community is approximately 13,000 permanent residents. These people fill the work force of five major institutions. They are the United States Geological Survey, Mark Twain National Forest Headquarters, the University of Missouri at Rolla, government employees working at Fort Leonard Wood, and the local businessmen.

Rolla is organized under the Council-Administrator form of government. This is a recent development (within the last year) and has brought a level of professionalism to the government operation that appears to have never been achieved previously. The council is made up of

two council members from each of the six wards encompassing the total city. The Mayor is elected by a majority on an "at-large" basis.

The City Administrator is directly responsible for the day-to-day operations of the city government. Fig. 3 shows the basic schematic structure of the city organization and the chain of command. This figure shows that the public works director (City Engineer) is directly responsible for the operation of his department to the city administrator. This type of situation can provide the best interface with the respective departments and the administrator. Also the administrator is in a position to provide the necessary leadership and supervision of city operations.

Perhaps one of the most important advantages of this form of government is that all key line officers (P.W. Director, etc.) are out of the direct political fire of the Mayor and Council. The City Administrator is capable of advising the council on any given situation. In return, he takes their directives, with their priorities, and places the project responsibility on the proper department. This keeps the departments out of the political "pressure cooker" and enables them to perform their mission efficiently.

Prior to this form of government, the Mayor and council could exert direct influence on city officials

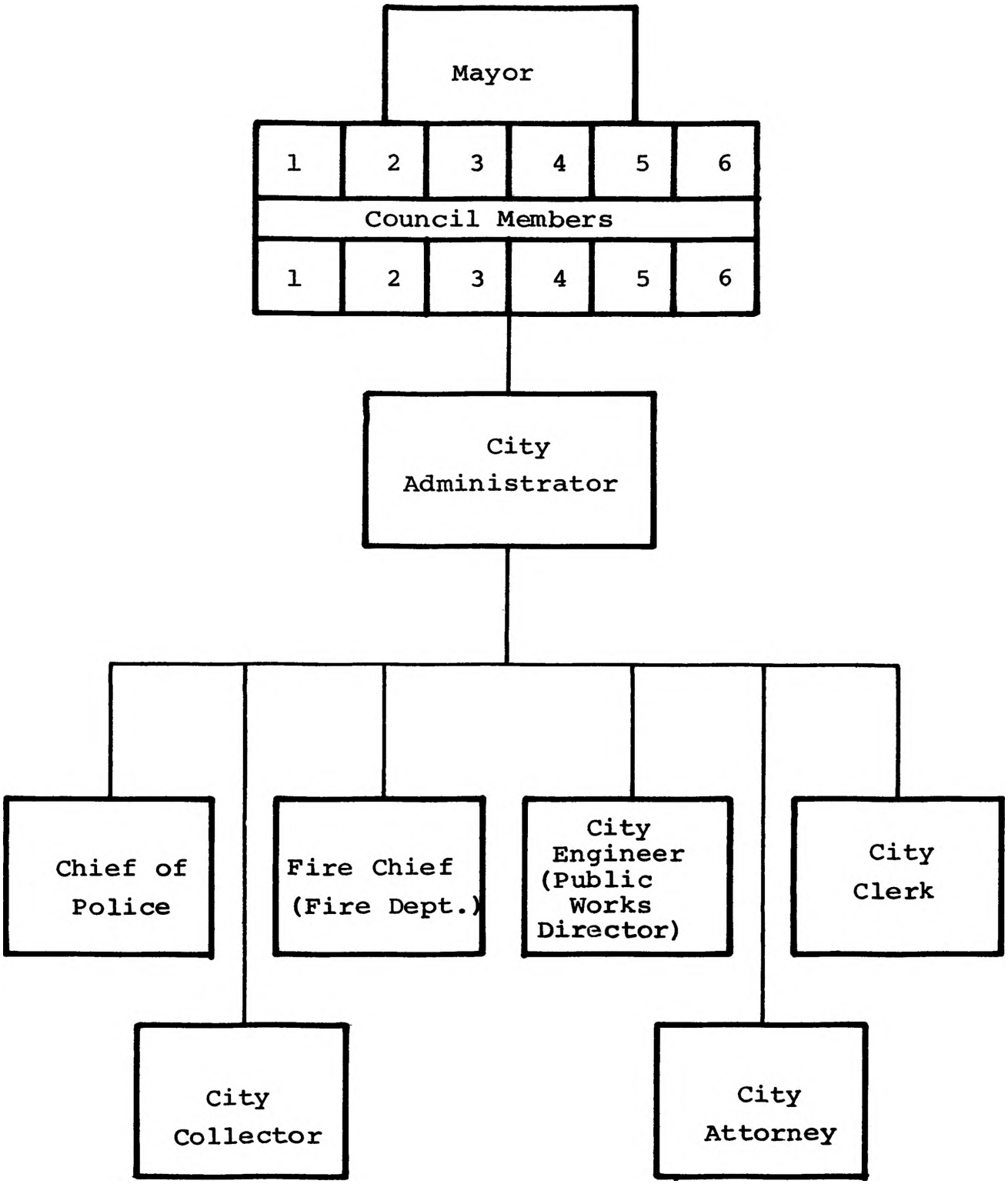

Fig. 3. City of Rolla Organization Structure

and put them under great scrutiny and political pressure.

B. THE PUBLIC WORKS DEPARTMENT (CITY ENGINEER OFFICE).

Before discussing this community's public works department further, we should examine the public works function in greater detail.

One of the first items of interest needing development is that no public works department is the same. There are several reasons for this: (1) Public works departments responsibilities and functions vary to the needs of its people. (2) The basic city charter stipulates the organization of the city. This includes all departments from structure, job description and number of employees. (3) The needs of each city vary with location, climate and geography. A city in Maine needs snow and ice removal equipment, but in Florida this equipment would be worthless.

After a random sample of public works departments is made, these are a few of the items a city public works department might be responsible for: (1) Sanitation - solid waste, sanitary landfill operation and sewage treatment. (2) Engineering - engineering design for highways and structures. (3) Building code inspection, construction licensing or permitting, inspection of current buildings to insure they are within city maintenance guidelines, and overall zoning

responsibilities. (4) Street department - highway maintenance, traffic signals, snow and ice removal, new construction, sewer maintenance, street sweeping. (5) Garage operations - maintenance of city vehicle and equipment fleet, bus lines operations. (6) Forestry - grass cutting and leaf raking on city property, tree planting and pruning, and entomology services. (7) Building maintenance - maintenance of all city owned property and janitorial services.

As mentioned previously, these are just the major areas of responsibility. Cities take on a combination of these items, pertinent to their needs.

Fig. 4 shows the basic organization of structure for the city of Rolla's City Engineers Office. The street department is organized under the direction of the city engineer (public works director) with a supervisor directly responsible for its operation. Fig. 5 graphically displays the basic organization structure of the city street department.

The mission of this department is to maintain the 80 miles of streets and alleys within the city limits. This includes incidental patching, grading of road side berms and ditches, new paving and overlays to old pavements. The department is responsible for all snow and ice removal in the winter months. In the summer, the street department crews keep all the streets clean

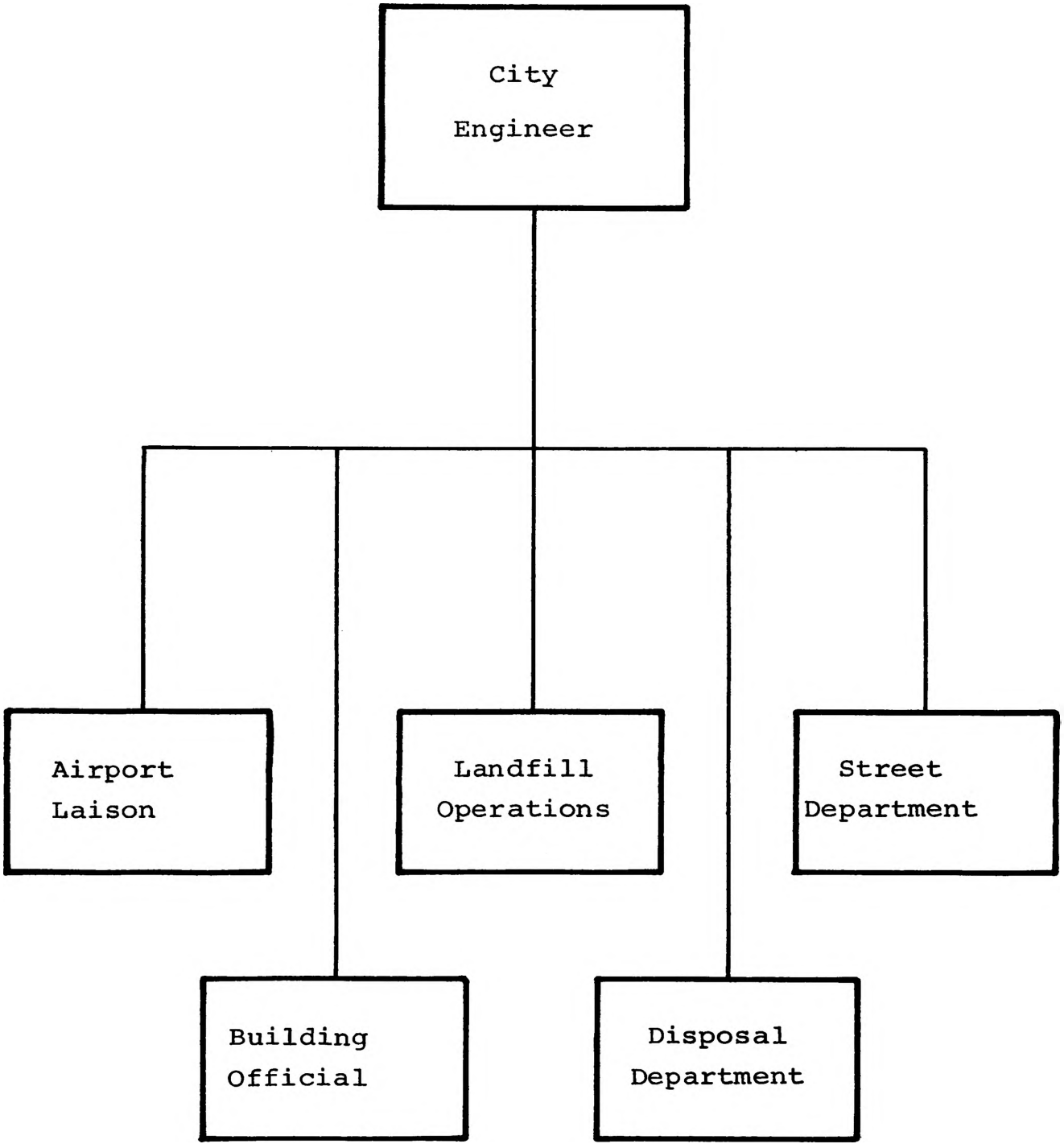

Fig. 4. City of Rolla City Engineers' Organization

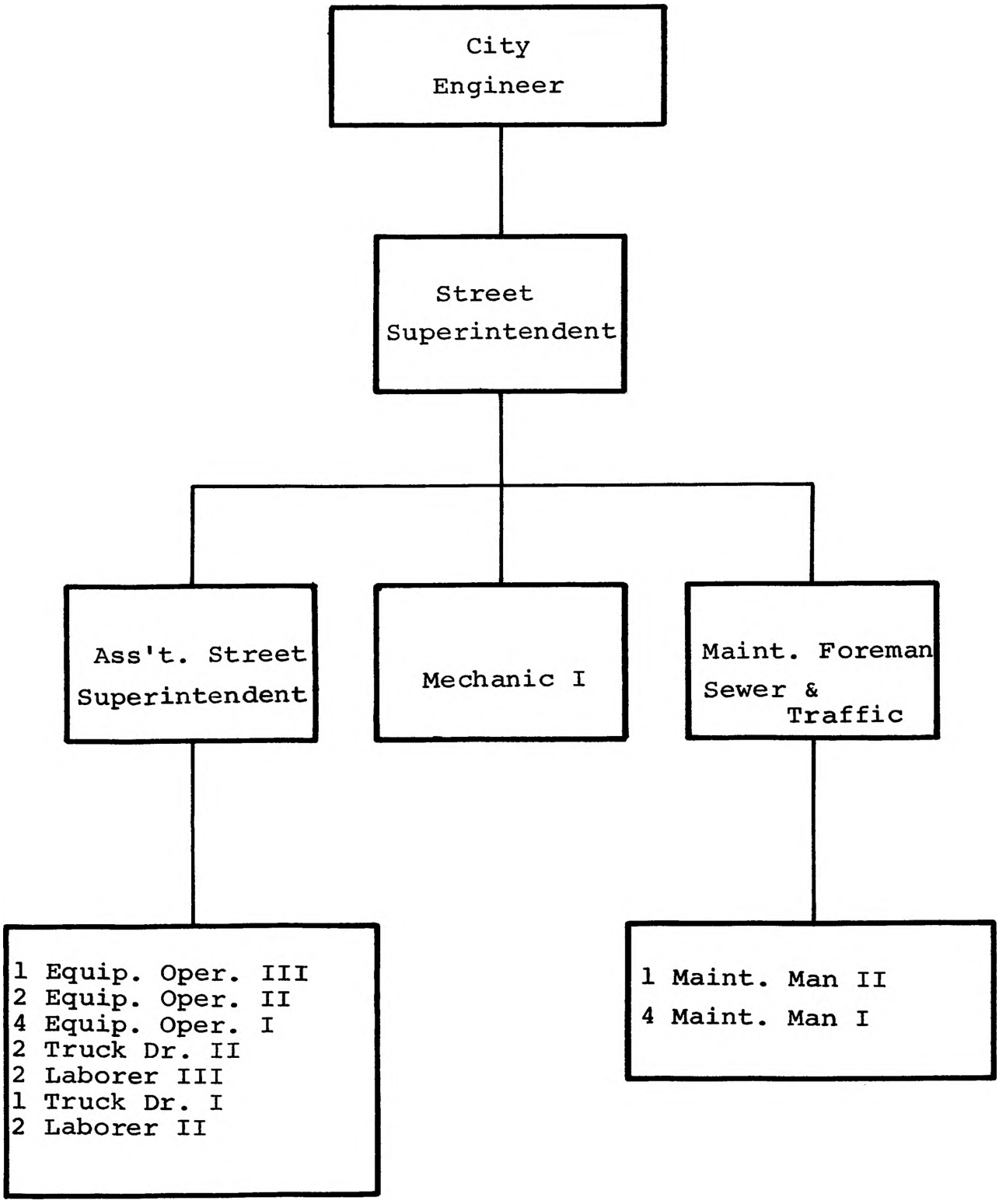

Fig. 5. City of Rolla Street Department Organization

by street vacuuming and sweeping. They are responsible for all appertences found on city streets (i.e., highway signs, street markings, etc.), and maintenance of all storm drains and gutters.

Overall, this department accounts for 65% of the total amount of effort expended within the city engineers office.

C. AN INVESTIGATION

It was the intent of the author to find the productivity levels of the Street Department of Rolla's Engineers Office. To be able to ascertain its efficiency, it was essential to conduct a review of the engineer departments operations. This was performed in two ways. The first was through discussions with the City Engineer and the Street Department Superintendent. Also included in this area was casual observations of the entire operation. The second way was through analysis of actual work completed on projects. This included a wide variety of projects to ascertain the departments productivity.

The general planning operation of the street department is informal. The City Engineer establishes a general work schedule on a monthly basis through communication with the street supervisor. They review the objectives of the department, discuss the means of

achieving it and establish a general time schedule to complete these projects.

The street supervisor in turn takes this guidance and attempts to plan the months' activities. At the close of each week, the supervisor reviews the progress and informally plans the following weeks' work. Each work day he either goes to the project site and directly supervises it or checks on it throughout the day. A depiction of this process is seen in Fig. 6.

Evaluation of a system of this type is extremely difficult. Retrieval of substantiative productivity data is a major problem in almost all environments. The industrial engineer is faced with this problem every time he makes a time motion study or tries to gather any related performance data on an employee of a firm. This problem is not dissimilar to the one the author faced in gathering data.

Rolla has characteristics common to other communities of its size and nature. Through the years of development and growth, communities may become factionalized into groups, primarily dependent upon their employment. People who have not been residents of that community all their lives may be somewhat viewed as outsiders. With this in mind, methods for collecting work performance data were developed.

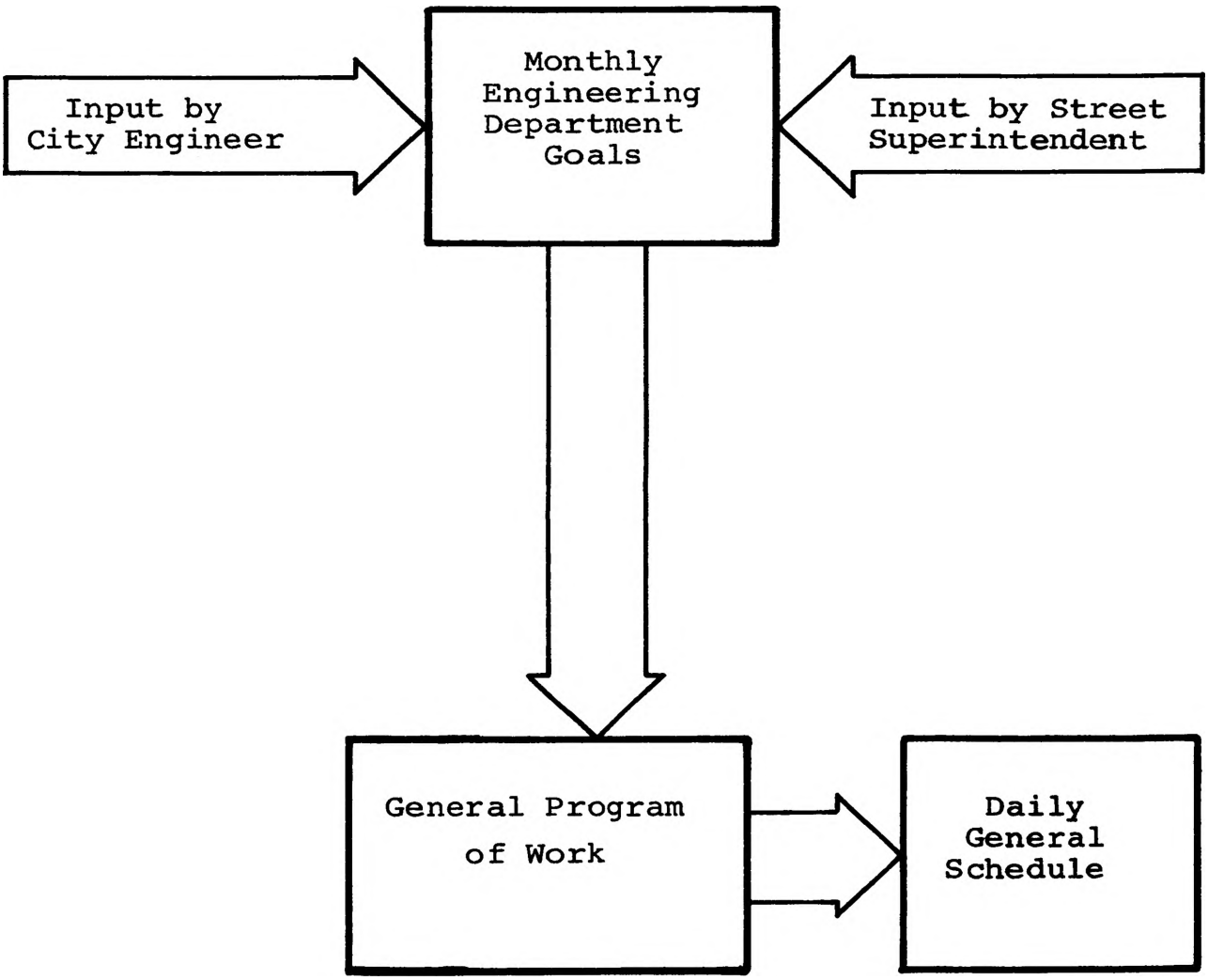

Fig. 6. Rolla's Work Scheduling Program

After discussion on how to gather the data, with the city engineer and the city administrator, several ideas were rejected and one accepted.

It was found to be impractical for personal visits to the work sites to gather data. This was rejected for two reasons. (1) The researcher would probably not be well received by the employees due to being an outsider to their group. Nothing could be said that would bolster their faith and provide a source of true data. (2) The researcher could be viewed as an outgrowth of the city administrator's office. This would put the administrator in an undesirable position in trying to develop trust in an organization he had just joined.

Another method which was considered, but rejected, was for the Engineering Inspector to gather the data. This was impractical since he didn't spend a great percentage of his time on any given project.

The selected system was one where the street superintendent would gather the data daily. He spent the majority of his time on the projects and could evaluate how the time was spent. He would fill out a data sheet, Fig. 7, with that days' information. This form was developed especially for this application.

This data was gathered during the summer and fall of 1977 for a two month period of actual work time.

DATE: _____

SIZE OF CREW: _____

TYPE OF PROJECT: _____

LOCATION OF PROJECT: _____

DISTANCE FROM SHOP: _____

ACTUAL WORK PERFORMED: _____

_____

_____

TIME SPENT IN TRAVEL: _____

_____

TIME SPENT AWAITING OR RECEIVING MATERIALS: _____

_____

TIME ON COFFEE BREAKS: _____

TIME SPENT IN ACTUAL WORK: _____

Fig. 7. Work Data Collection Form

Records were collected on projects which required two or more hours time span for completion. All types of work projects were included in this study since all tasks performed by a street department are funded through budgeting and are attributed to the department's activities.

IV. ANALYSIS OF RESULTS

A. IDENTIFICATION OF PROBLEMS

As is the case in most studies of this nature, results are affected by many variables. This study is representative of this fact.

One of the most critical problems the street department faces is related to ineffective time management. Crews report directly to the street department office to get their daily assignments. Upon receiving the assignment, they check out their equipment and drive to the job site. This process can take up to 45 minutes. At 15 to 30 minutes prior to lunch, the crews stop work and return to the department for lunch. After lunch they return to the work site taking another period of time. At the end of the work day, they again stop work to make sure they return to the office by quitting time. Variation of their time usage varies daily. However, if totaled, this could accumulate to as much as two hours of non-functional time daily. This would automatically mean that they are working at a 75% productivity rate (six of eight hours).

Another problem that the department faces is performing new construction with out-moded equipment and techniques. One example is an asphalt plant that the city owns. It is old and works at a low percentage of its prescribed capacity. Due to its low output,

the plant provides an appreciably lower amount than the crews can place. The crews could easily place in excess of 30 tons per hour, but the plant, if operating, processes roughly half that amount.

The next problem is an out-moded truck fleet. The department operates six each, 10-ton, single-axle trucks. This style of truck hauls only about one-half of the capacity of a 20-ton, twin-axle truck. This means that they would have to make twice the number of trips with their present vehicles as with larger equipment and at basically the same operating cost.

They also use a spreader box form of asphalt paver. This fits onto the back of dump trucks. This is obviously one of several asphalt paving techniques. This style is 65-75 percent as efficient as using a motorized paving machine. A motorized paving machine would pave more roads in a given time span and at a better quality of paved surface.

The author found that the street department superintendent assigned the proper number and skill type of his employees to various projects. After review of all the assigned jobs, a personnel assigned deviation of just over 1% was found. This relates the number and type of personnel required in accordance to "Means Standard Construction Estimator's Guide", to that of what the superintendent actually assigned.

B. FINDINGS

The exact results of the review are found in Tables I, II, and III. These tables depict the type of work performed and a measure of the performance on that particular project. The standard data for each project is then compared with the results of Rolla for that same project. This, in turn, gives a percentage figure for the departments productivity rating.

The results are the best possible way of analyzing the productivity of the department. These figures should not be over-emphasized. Many factors influence these results. As mentioned previously, on the job performance by employees contributes to the efficiency of the department but not as dramatically as one might expect. Men will generally perform a fair days labor under most conditions. The factor of using out-dated equipment and techniques and inadequate time management has a tendency to degradate the street department crews performance more than any other single factor.

Another factor which affects the operation of the department is the work scheduling, or the lack thereof. If a system was adopted with more short and long term planning emphasized, greater productivity could be realized.

TABLE I

ASPHALT WORK DATA

Job Number	Type of Work Performed	Actual Performance				Standard Performance			Productivity		
		Crew Size	Total Hours	Actual Hours	Actual Output	Crew Size	Hours Worked	Standard Output	Actual	Standard	Percent
1	Asphalt Paving	8	8	5-1/2	100 cyd	8	8	148 cyd	100%	148	67%
2	Asphalt Paving	7	4	3	30 cyd	4	4	74 cyd	30%	74	40%
3	Asphalt Paving	4	4	2	20 cyd	4	4	74 cyd	20%	74	27%
4	Asphalt Paving	3	2	1-1/2	10 cyd	4	2	37 cyd	10%	37	27%
5	Asphalt Paving	8	8	6-1/4	125 cyd	8	8	148 cyd	125%	148	85%
6	Asphalt Paving	8	8	6	115 cyd	8	8	148 cyd	115%	148	78%
7	Asphalt Paving	9	8	6-1/2	165 cyd	8	8	148 cyd	165%	148	115%
8	Asphalt Paving	8	8	6-1/2	111 cyd	8	8	148 cyd	111%	148	75%
9	Asphalt Paving	8	8	6-1/2	70 cyd	8	8	148 cyd	70%	148	47%
10	Asphalt Paving	8	8	6-1/2	75 cyd	8	8	148 cyd	75%	148	51%

TABLE I (continued)

Job Number	Type of Work Performed	Actual Performance				Standard Performance			Productivity		
		Crew Size	Total Hours	Actual Hours	Actual Output	Crew Size	Hours Worked	Stan-dard Output	Actual	Standard	Percent
11	Asphalt Paving	8	8	6-1/2	111 cyd	8	8	148 cyd	111%	148	75%
12	Asphalt Paving	8	5	4-1/4	69 cyd	8	5	92 cyd	69%	92	75%
13	Asphalt Paving	8	4	3-3/4	33 cyd	8	4	74 cyd	33%	74	45%
14	Asphalt Paving	7	4	4	55 cyd	8	4	74 cyd	55%	74	75%
15	Asphalt Paving	7	8	6-1/2	88 cyd	8	8	148 cyd	88%	148	60%
16	Asphalt Paving	8	8	6-1/2	83 cyd	8	8	148 cyd	83%	148	57%
Total Hours			103	81.75					81.75%	103	79% (Over-all Time Utiliza-tion)

TABLE II

CONSTRUCTION WORK DATA

Job Number	Type of Work Performed	Actual Performance				Standard Performance			Productivity		
		Crew Size	Total Hours	Actual Hours	Actual Output	Crew Size	Total Hours	Stan-dard Output	Actual U.S. Standard		%
1	Loading & hauling materials	6	6	5-1/3	100 loads	6	6	110 loads	100%	110	91%
2	Loading & hauling materials	4	3-1/2	3-1/2	40 loads	4	3-1/2	44 loads	40%	44	91%
1	Laying base materials	3	2	1-1/2	20 cyd	3	2	187	20%	187	11%
2	Laying base materials	5	8	7-1/4	200 cyd	5	8	500	200%	500	40%
3	Laying base materials	5	8	6-1/4	150 cyd	5	8	500	150%	150	30%

TABLE II (continued)

Job Number	Type of Work Performed	Actual Performance				Standard Performance			Productivity		
		Crew Size	Total Hours	Actual Hours	Actual Output	Crew Size	Total Hours	Stan-dard Output	Actual U.S. Standard		%
1	Gradework	2	3	2-1/2	500 sq. yd.	2	3	600 sq. yd.	500%	600	83%
2	Gradework	2	8	7-1/2	1300 sq. yd.	2	8	1600 sq. yd.	1300%	1600	81%
3	Gradework	4	8	7-1/4	1400 sq. yd.	4	8	1600 sq. yd.	1400%	1600	87%
4	Gradework	3	7	5	1800 sq. yd.	3	7	1400 sq. yd.	1000%	1400	71%
5	Gradework	2	3-1/2	3	600 sq. yd.	2	3-1/2	700 sq. yd.	600%	700	86%
6	Gradework	2	4-1/2	4	700 sq. yd.	2	4-1/2	900 sq. yd.	700%	908	77%
7	Gradework	2	4	3-1/2	600 sq. yd.	2	4	800 sq. yd.	600%	800	75%

TABLE II (continued)

Job Number	Type of Work Performed	Actual Performance				Standard Performance			Productivity		
		Crew Size	Total Hours	Actual Hours	Actual Output	Crew Size	Total Hours	Stan-dard Output	Actual U.S. Standard		%
1	Chipwork	6	4	3-1/2	900 sq. yd.	6	4	1400 sq. yd.	900%	1400	65%
2	Chipwork	5	4-1/4	3-1/4	500 sq. yd.	5	4-1/4	1487 sq. yd.	500%	1487	34%
3	Chipwork	4	5-1/2	4-1/2	1666 sq. yd.	5	5-1/2	1950 sq. yd.	1666%	1950	86%
4	Chipwork	7	8	6	2400 sq. yd.	7	8	2800 sq. yd.	2400%	2800	85%
Total Hours			95.5	73.83					73.83%	95.5	77% (Over-all Time Utiliza-tion)

TABLE III

NON-STANDARD WORK DATA

Job Number	Type of work Performed	Crew Size	Actual Performance: Total Hours	Actual Performance: Actual Hours	Actual Performance: Actual Output	Productivity: Actual %	Productivity: Total	Productivity: Percent
1	Cleaning Ditches	2	2-1/2	2	300 L.F.	2%	2-1/2	80%
2	Patchwork (asphalt)	2	3-1/4	3	4 cyd	3%	3-1/4	92%
3	Raising Man Holes	2	4	3-1/4	4 M.H.	3-1/4%	4	81%
4	Excavation Repair	5	7	5	30 L.F.	3%	7	71%
5	Cleaning Grass from curb	4	2	1-1/2	400 L.F.	1-1/2%	2	75%
6	Cleaning Grass from curb	5	5-1/4	4-1/2	1200 L.F.	4-1/2%	5-1/4	86%
7	Yardwork	6	6-3/4	6	--	6%	6-3/4	88%
8	Cutting Base	5	4	3-1/4	400 L.F.	3-1/4%	4	81%
Total Hours			34.75	28.5		28.5%	34.75	82%

NOTE: Since these projects were non-standard, they are evaluated only with respect to actual hours working on the project versus the total time.

V. CONCLUSIONS

A. A SMALL CITY WORK SCHEDULING MODEL

The most important features of any method of management in a public works department should be that the method be simple and easy to use, flexible, give accurate results, and practical. My method of work scheduling and planning can provide this and reduce some of the political pressure.

To establish this method of scheduling, both the city government and the public works director, independently compile a list of capital improvements they would like to see completed over the next five years. This would give each council member the opportunity to consult with his constituents and find out what they consider important in the council members political area. The public works director could review the maintenance and capital improvements requirements for the city to aid in deriving his list.

After a satisfactory time span has been completed that affords both parties the opportunity to complete an improvements list, a meeting is held. The parties compare their lists and assign a flexible priority to the projects. The public works director then takes these projects to his department for estimation of project cost and time. These estimations would elicit

the cost, manpower according to discipline, and the equipment necessary to complete the project.

These estimates could be completed through the use of a standard estimator's guide such as Means, Richardson, or Dodge estimating manuals.

The council and the public works director will hold another meeting after the completion of the estimates. At this meeting, they will establish a five year comprehensive public works budget including maintenance and capital improvements. Each following year both parties would simply review, change if necessary, and adopt the next year's public works program as previously put together. At the same time, they would again develop another years' program to place in the year five slot, since all have slid forward one year. This process is represented by Fig. 8.

Once the public works budget has been completed, the public works director would review it to ascertain which projects, if any, the members of his various departments could perform with regards to type, size and scale of the projects. The public works director tabulates these projects into two listings, those that he is going to perform, and those that he is going to contract out.

The next step is to prepare the projects the department will complete within a calendar year. Each

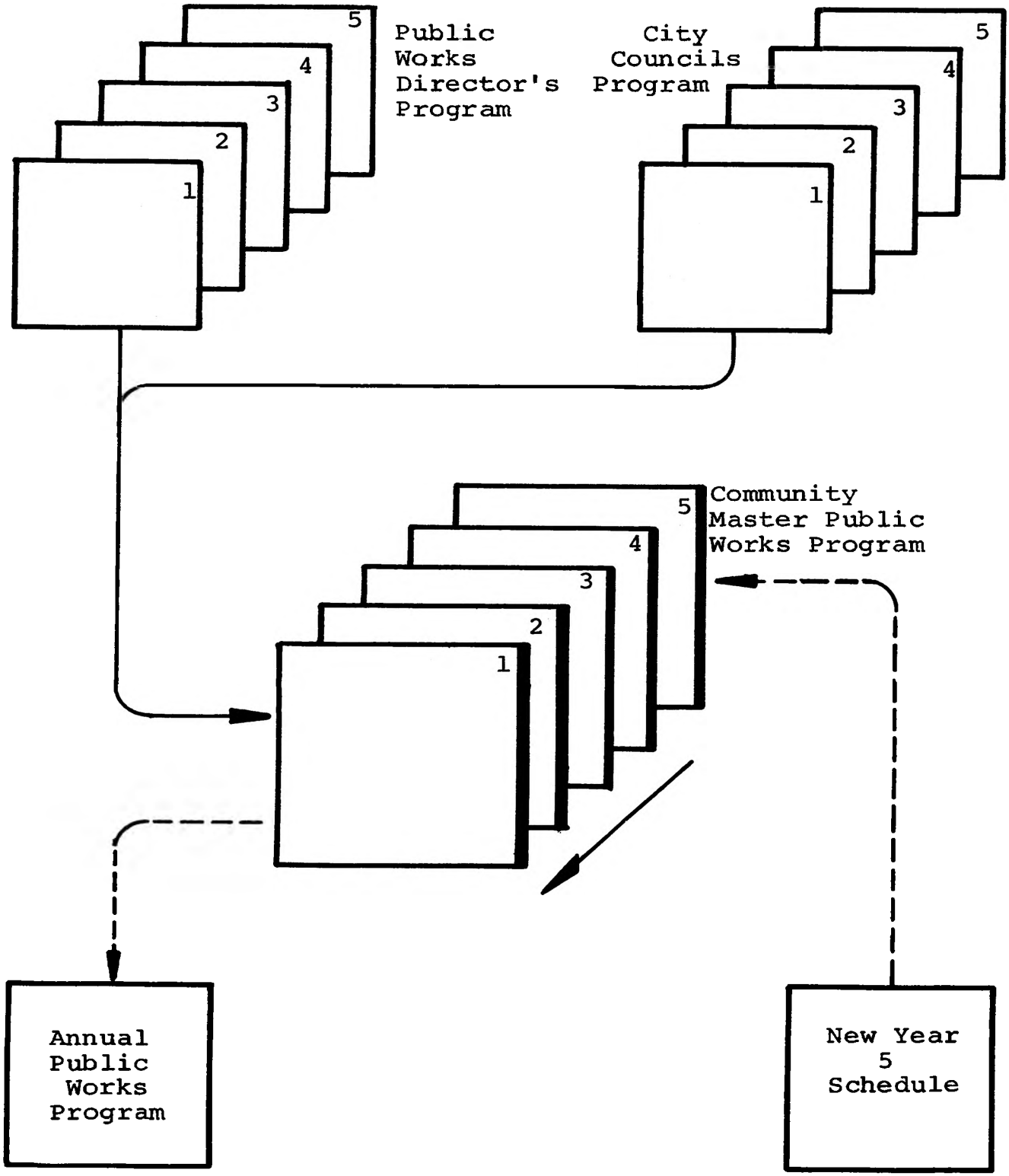

Fig. 8. Small City Work Scheduling Process

month of the year, his department will have an established number of hours available to contribute on new work projects, an amount to spend on standard projects, and one for spending on sick leave and vacation. Standard time is that time spent on certain standard projects. Examples of this might be 400 hours in January for snow and ice removal, or 100 hours in May for repairs to storm drains due to winter thaw and spring rains. When the director subtracts the standard time and the sick leave and vacation time from the total monthly man hours, he arrives at an amount

Project Dev. Time=Total Monthly Manhours - Sick Time - Vacation - Std. Time

he can use for project development. The more information provided in this equation, the better tool for planning it can be.

The public works director and street department superintendent can then sit down with a standard monthly calendar and fill in some valuable planning information. They can write in the first work day of each week the total number of employable hours available. This is derived by subtracting out the vacation, and other related items. Then by working in the project duration, the director has laid out a monthly schedule on a yearly basis.

This annual schedule is given to the respective supervisors. At the beginning of each month the public works director and supervisors review this schedule and make the necessary corrections.

B. AN EXAMPLE

A public works department has 25 employees and a foreman in its street department. During this month, a total of six hours of storm damage repair is normally experienced. In addition, three men are going on vacation, one man 9-13 July and two men 16-20 July.

During this time the public works director has planned two major projects and one small project. The large projects are two bituminous street resurfacings and the small is a concrete sidewalk and curb job. The larger projects take 2,240 hours and 1600 hours respectively. The concrete job takes 160 hours. This calendar then depicts what the work schedule for the month of July would appear. An example of this is seen in Table IV.

C. ADVANTAGES

The advantages to this scheduling work program are listed below.

1. It gives a planned schedule on an annual basis giving best use of total resources.

TABLE IV

MONTHLY WORK SCHEDULE

July

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Note
1	2 1000 hrs. Proj. A	3 A	4 A	5 A	6 A	7	
8	9 960 hrs. Proj. A	10 A	11 A	12 A	13 A	14	
15	16 920 hrs. Proj. A	17 A	18 B	19 B	20 B	21	
22	23 960 hrs. Proj. B	24 B	25 B	26 B	27 B	28	
29	30 1000 hrs. Proj. C (160 hrs)	31	Aug. 1	2	3	4	

2. It can measure efficiency of the respective departments. If they consistently exceed or under-shoot the planned project duration, it can afford officials the opportunity to take remedial actions.
3. It is flexible enough that if a series of emergencies arise, it will show the repercussion of making a change in scheduling. Such as the logic in the Critical Path Method of planning.
4. It assists in the planning of all employees for an entire year.
5. It reflects what happens when a decision changing the schedule is made.
6. The schedule is not difficult to make and maintain.
7. It will provide a data base to assist in long range planning.

D. DISADVANTAGES

Listed below are some disadvantages to the scheduling work program.

1. The schedule is only as good as the people using it.
2. It is only as good as the estimates.

E. RECOMMENDATIONS

It is the opinion of the author that Rolla should consider making several changes in the operations.

First, they should implement a program that provides the benefits of the author's "Small City Work Scheduling Model". This could assist them dramatically in not only planning for the development and growth of the city through long range planning for improvements but also increase the productivity of city street department operation.

Updating of the equipment fleet would increase productivity and also improve the quality of work. These items go hand-in-hand to benefit the community. Rolla will continue to receive benefits from its employees based directly upon how they are equipped.

Another recommendation focuses upon time management. It is suggested that the practice of returning to the central shop facility for lunch be prohibited except on those days when incliment weather would prohibit them from eating on the job site. This touches upon only half of the problem. If a good planning and work scheduling system was adopted, the truck drivers could take the departments trucks home at night. The next day they would pick up work crew members on the way to the job site. They would report to the job site at starting time.

This would alleviate the time that is non-productive in the morning awaiting assignment. At quitting time, they return to the shop in time to check out the

equipment, refuel and to depart with the next days assignment. This would assist in building morale in the employees since they wouldn't have to worry about transportation to and from work. Overall, less non-productive time is realized.

The adverse benefits could be the cost of insurance and public ridicule. If the council supported such measures, the ridicule could be reduced since the council represents the grass roots of the community.

The last area needing review is that of the Street Superintendent Assistant. The present street superintendent is approaching the age of retirement. Upon his retirement, a critical wealth of knowledge and experience will depart the scene. Every effort should be made to improve the managerial and technical (engineering) knowledge of the assistant. This should include courses in asphalt paving operation, snow removal and many more related areas. Essential to the successful operation of the department is his training in manpower management. If remedial actions are not taken soon, tremendous problems could arise in the future for the street department.

Rolla is one of the growing communities in the state of Missouri. They have many physical benefits that offer a continuing growth pattern. They have a good developing work force that will assist in this

development. Over the last year, giant strides have been taken in the community through the development of a large shopping center. This will only assist in substantiating their claim as the regional trading and shopping center.

The student population at the University of Missouri-Rolla is expanding. The community is also viewing a boom period of new housing starts and upgrading of existing houses. The population of the community has grown by ten percent since 1970. In general, all factors point to growth and development.

With the growth and development of the community, a greater demand will in turn be placed on the public works department. Some of this can be met by adding more personnel to the city work force. Unfortunately, if something is not done to improve city operations, the increased work force will not be able to meet the demand. Therefore it is essential to the growth of the community that it review its operations and develop a critically needed planning system.

BIBLIOGRAPHY

1. "Borrowing Too Much To Keep Running", Business Week, Sept. 22, 1975, p. 84.

2. "Public Works Defined", APWA Reporter, August 1977, p. 2.

3. Shell, R. L. and Shupe, D. S., "Improving Productivity of Solid Waste Through Wage Incentives", Proceedings, Twenty-Seventh Annual Conference, AIIE, 1976.

4. Shell, R. L. and Shupe, D. S., "Productivity: Hope for City Woes", Industrial Engineering, Vol. 8, No. 12, December 1976, page 26.

5. Shell, R. L. and Shupe, D. S., "Productivity: Hope for City Woes", Industrial Engineering, Vol. 8, No. 12, December 1976, page 26.

6. Cotton, Frank E., "In Productivity, "Planning is Everything"", Industrial Engineering, Vol. 8, No. 11, November 1976, page 28.

7. Cotton, Frank E., "In Productivity, "Planning is Everything"", Industrial Engineering, Vol. 8, No. 11, November 1976, page 28.

8. Scientific Management, Harper Brothers, New York, New York, 1947.

9. Gilbreath, Frank and Gilbreath, Lillian, "Science in Management for the One Best Way To Do Work", The American Management Association book on Classics in Management, Edited by H. F. Merrill, 1960.

10. Barnes, Ralph M., Motion and Time Study: Design and Measurement of Work, John Wiley and Sons, New York, New York, Fifth Edition, 1963.

11. Stein, Hubert, "The Meaning and Measurement of Productivity", Bureau of Labor Statistics, U. S. Department of Labor, Bulletin 1714, September 1971.

12. Drucker, Peter, The Practice of Management, Harper and Brothers, New York, New York, 1954.

13. Brucker, Peter, The Practice of Management, Harper and Brothers, New York, New York, 1954.

14. DeWitt, Frank, "A Technique for Measuring Management Productivity", Management Review, June 1970.

15. Headquarters, Department of the Army, The Work Management System. D. A. Pamphlet, No. 420-6, January 1968.

VITA

Kraig L. Gordon was born October 21, 1948, in Huntington, Pennsylvania. He received his primary and secondary education through the Southern Huntington County School System, Three Springs, Pennsylvania. He attended the University of Pittsburgh in Johnstown, Pennsylvania where he studied civil engineering. He worked with the Pennsylvania Department of Highways as a Construction Engineer for one year prior to entering the U. S. Army.

Captain Gordon received his commission through completion of the U. S. Army Officers Candidate School at Fort Belvoir, Virginia on November 26, 1969. He spent his career in the military either working as a construction engineer or as a logistics officer. Captain Gordon spent significant periods of his military development working on all facets of construction and construction management. He had numerous tours throughout the United States and a tour in Seoul, Korea. He completed the Engineer Officers Advanced Course at Fort Belvoir in December, 1974. Upon completion, he commanded Company C, Third Battalion, Fourth Brigade at Fort Leonard Wood, Missouri.

In September, 1975 he returned to school and completed a Bachelor of Science in Engineering Management (Civil Engineering) in December, 1976.