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16. Abstract

This report examines two major issues: (1) the impact of labor union work rules on bus transit operating costs and (2) the magnitude of cost savings that can be expected from the use of part-time drivers. These issues are examined within the context of finding ways to reduce transit deficits.

The work rules analyzed include restrictions on part-time labor, changes in spread premiums and limitations on maximum spread time for drivers. Labor costs were estimated using the RUCUS automated scheduling program which was applied to actual service schedules from five U.S. transit properties. The analysis yielded cost estimates for a total of 45 combinations of work rules and service schedules, and revealed that (1) paying spread time after 10 hours, rather than 12 boosts labor cost by 4% to 7%, with negligible effect on number of drivers required; (2) the effect of reducing the maximum spread time is highly sensitive to the peak/base ratio and the interval between the morning and evening peak; and (3) savings from the use of part-time labor, under favorable conditions, will be in the range of 3% to 8% but may be cancelled out by wage increases necessary to secure union approval of the change.

The report concludes that work rule changes are no panacea for transit deficits; the principal source of deficits is the decision to maintain low fares and low-patronage routes. Appendices include a glossary of scheduling terminology and tables and simplified methods which can be used to estimate the cost effects of work rule changes in a given transit property.

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Kathy Alberti typed numerous drafts, struggled with our spelling, and put up with our frequent demands for instant service.

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EXECUTIVE SUMMARY

THE QUESTION

What is the impact of labor union work rules on transit operating costs? What magnitude of cost saving can be expected from the use of part-time drivers? What magnitude of cost increase can be expected from additional restrictions on the driver's work day? We examine these questions within the general context of finding ways to reduce transit deficits. The work rules analyzed include restrictions on part-time labor, changes in spread premiums, and limitations on maximum spread time for drivers. We also provide tables, and simplified methods, which the reader may use to estimate the cost-effects of work rule changes for any given transit property.

THE CONTEXT: TRANSIT DEFICITS

In 1967, U.S. transit revenues paid 96% of costs; by 1977 transit revenues covered only 53% of costs. A number of demographic and social trends are responsible for this change. A) The movement of families to the suburbs produced lower population density, hence lower density transit routes and increased vehicle-deadheading. That is, it became physically difficult to structure an efficient route system. B) The increase in family income permitted an increase in auto ownership, which lowered transit demand in general, and concentrated the remaining demand on the journey to work; hence increasing the relative amount of peak-hour service needed. Such highly peaked demand is inherently expensive to serve since the buses and drivers hired to serve the peaks cannot be efficiently utilized during the rest of the day. We now have a situation where most transit resources are underutilized most of the time. C) Finally, the increase in public subsidy has, itself turned out to be a cause of decreased efficiency. Public subsidies were ultimately accompanied by demands that transit accept increased social responsiblities as well: we now ask that transit maintain extensive route structures and frequent service, regardless of demand; and we now ask it to keep fares extremely low regardless of costs. Such route structures and fare policies are, of course, inherently incompatible with sound financial management.

THE PROBLEM: SERVING THE PEAKS, EQUITY VS. EFFICIENCY

Highly peaked bus schedules pose a dilemma for transit systems: drivers are needed for the morning and evening rush, but not in-between. A full-time driver assigned to both peaks may face a total workday, or spread, of thirteen hours from start to finish, though only six hours of actual driving may be involved. Equity demands that drivers be compensated for, or protected from, such undesirable spreads. At most districts, work rules specify spread premiums: payment at time-and-a-half for work performed beyond a designated spread premium time; and/or maximum spread time, which no assignment may exceed. Shifts which cannot be paired within the maximum spread time must be assigned separately, each to a full-time driver who receives a guaranteed eight hours daily pay. Current trends toward more restrictive spread rules and more peaked service therefore boost both labor costs and the attractiveness of part-time drivers, for whom spread rules would not be applicable.

METHODOLOGY

Our goal was to quantify the cost-effects of changes in spread rules, part-time labor provisions, and the ratio of peak-hour service to base (midday) service. Labor costs were estimated using computerized simulation of driver assignments, scheduling them so as to meet given work-rules at minimum cost. The resulting run cut, or assignment roster, determines the precise payroll cost. Using the RUCUS scheduling program, we applied three different part-time provisions and three sets of spread rules to a spectrum of actual service-schedules from five transit districts, yielding cost estimates for a total of forty-five combinations of work-rules and service-schedules. Spread rules considered include maximum spreads of 12 and 13 hours in combination with spread premium time after 10 hours; and 13 hours maximum spread combined with 12 hours spread premium time. Part-time scenarios posit maximum part-time forces at 0%, 10%, and 20% of full-time staff, each part-timer working only one peak. Peak/base ratios ranged from 1.5 to 3.9.

ANALYSIS

Spread premium time. Paying spread premium after 10 hours, rather than 12, boosts labor cost by 4% to 7%, with negligible effect on number of drivers required.

Maximum spread time. The effect of reducing the maximum spread time is highly sensitive to the peak base/ratio and to the interval between the start of the morning peak and the end of the evening peak. As maximum spread time is reduced toward that interval, it becomes difficult to assign both peaks to the same driver, and staffing requirements increase. The higher the peak/base ratio, the larger the proportion of runs affected. Thus a district with a peak/base ratio of 3.9 experienced a 23% increase in labor costs following a reduction in maximum spread from 13 hours to 12 hours. But for a district with peak/base = 1.5, a similar reduction had virtually no effect.

Part-time labor. The impact of part-time labor is also highly context-sensitive. The returns to part-time labor are greater where peak/base is high and maximum spread is low. Given a maximum spread of 13 hours for all drivers, introduction of a part-time force equal to 20% of full-time drivers, each working one peak, will save from 3% to 8% of labor costs, under a number of favorable assumptions: full implementation of the part-time quota, no increase in supervisory costs, no decrease in driver reliability, and no countervailing wage concessions. In fact the current negotiating climate suggests that the wage increases (necessary to win union approval of the change) could easily cancel out savings from use of part-time labor.

Other. Preliminary results indicate some possibility of savings from reform of absenteeism policies, and from better extraboard management.

CONCLUSIONS AND RECOMMENDATIONS

Work-rule changes are no panacea; the principal source of transit deficits is the decision to maintain low fares and low-patronage routes. In some cases, work-rule changes can produce modest savings; but a careful analysis of the context is necessary to determine whether a particular change is worthwhile. (We illustrate ways for doing these analyses for the reader's own transit district: both a simple, rough estimation procedure; and a more complex, accurate procedure.) Joint computerized scheduling experiments may allow union and management to find mutually preferred sets of work rules.

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CHAPTER 1
INTRODUCTION

Improving Transit's Financial Status

No transit administrator needs to be told that it is important to find ways of improving transit's financial status. An industry which had been essentially self-supporting now suffers multibillion dollar losses and is placing a very considerable strain on state and local governments, which pay for three-fourths of the operating deficit. Two solutions come to mind immediately as ways of dealing with the problem: raise revenues or cut operating costs.

The revenue-oriented solution involves increasing fares and reducing low patronage routes. Although such actions are probably the most effective way of dealing with transit's financial problems, they are also the most difficult to implement. There are simply too many political constituencies committed to low-priced transit service as a necessary element in solving their favorite problem--curing poverty, saving the cities, saving the environment, or getting even with the automobile--and these constituencies all seem to believe the myth that low fares are the key factor in attracting transit patronage.

This leaves us with only the second approach to the problem: improving operating effiency. The transit industry and UMTA have worked diligently to improve efficiency, and a variety of cost cutting techniques have been tried: improved scheduling of bus maintenance, management by objectives, better fare collection systems, etc. Unfortunately, none of these innovations has made a significant impact on the cost problem. To understand why this is necessarily so, the analyst must understand a generalization which we call The Law of Large Proportions. In its briefest form, this law states: The Biggest Components Matter Most. The most effective way to change something (like operating costs) inside a system is to concentrate on its largest components because a small improvement in a major component makes more difference than a large improvement in a minor component. The application of this law in transit is particularly striking because of the enormous difference in the relative size of the cost components: labor costs amount to 80% of the total budget, while the remaining 20% is split among expenses such as fuel, tires, and depreciation.[1]

Cost-cutting efforts have often ignored this law, and have been ineffective as a result. Ten years ago mini-buses were justified, at least in part, as a way of cutting costs; but what they do is economize on the smallest component in the system, depreciation cost, while totally ignoring the major component, labor cost. Likewise when planners decided to build a new generation of "economical" rail systems they ignored the fact that capital investment is the overwhelming cost component, while operator labor is only a small fraction of the overall cost. Rather than concentrating on decreasing the size of the capital component they actually increased it by adding automatic train control systems and fare collection machines in a misguided effort to economize on the tiny labor component.

Reducing Labor Costs: The Problem of Peaking

The principal barrier to efficient utilization of labor is the peaked nature of transit demand; two-thirds of daily trips are carried during the rush hours. Since transit systems must employ enough labor and purchase enough vehicles to handle this brief peak load, and since the labor and vehicles must then remain underutilized for the major part of the day, transit systems are being forced to operate in an <u>inherently uneconomic</u> manner.

This point can be clarified with a simple example. Figure 1-1 shows the daily vehicle schedule of a typical transit property. The horizontal axis is the time of day, and the vertical axis shows the number of buses in service during each hour of that day. Note that there are twice as many buses in service during the morning and evening peaks as there are during the central part of the day (a peak/base ratio of 2:1, which is about average for the U.S.).

Now imagine that you have been given the job of assigning work shifts to the drivers in this district. Your goal is to assign drivers to buses in a

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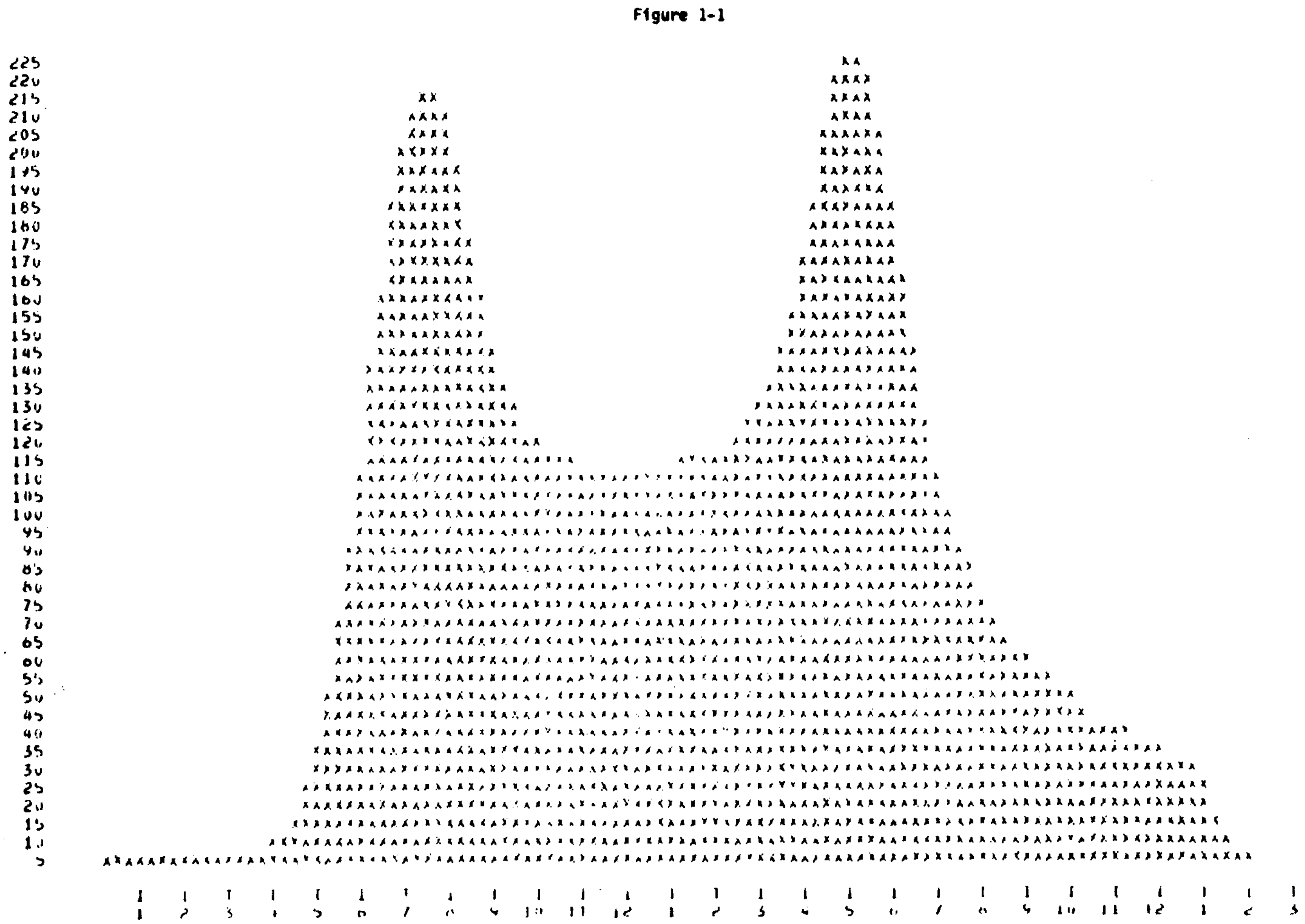
[1] William C. Sproull, <u>A method for evaluating the relationship of research, development and demonstration programs to operator labor cost components in bus transit systems</u>. (Doctoral dissertation, American University, 1973), Chapter 2.

Figure 1-1

NUMBER OF BUSES IN SERVICE (VERTICAL AXIS) BY TIME OF DAY (HORIZONTAL AXIS)



manner that minimizes the number of slack hours. But looking at the height of the peaks and how far apart they are, it is obvious that you must have many drivers who will put in a very long shift between the time they "clock-on" in the morning and the time they "clock-out" in the evening, roughly twelve hours. But despite the inordinately long work-shift, these driver are only going to be useful to you for about 5 hours per day. Nonetheless, you are going to have to pay them for at least eight hours work. They have given a piece of their lives to you and they rightfully demand a regular wage in return. Furthermore, they deserve, and receive, additional compensatory pay for working an extremely long shift.

For a driver schedule like this, a typical district will end up paying an operator nine hours pay for 5 hours work. This demonstrates the high cost of transit peaks: in a peaky system you are hiring enough labor to take care of the extremes, and then leaving them idle for most of the day. Overall, most transit resources are underutilized most of the time, and this is a major reason why we have transit deficits.

There are two principal approaches to lowering the labor-costs associated with transit demand peaking:

1. The peak/base ratio can be decreased by load-shedding, or reducing the number of peak hour transit passengers carried on conventional transit systems and making greater use of paratransit modes like shared-ride taxis, van pools, subscription bus services, car pools, etc.
2. Contracts can be changed to permit the use of part-time labor. Management hires part-time drivers to cover the extra service needed during peak hours.

There is little enthusiasm for the first approach because it substitutes paratransit for conventional service, hence there will be fewer driving jobs (and fewer management jobs) in the existing districts. Furthermore, some managers believe that the peak hour is their most profitable time of day and that loss of any peak hour transit service would cost money rather than save it. As a result, management has turned to the second solution, the use of part time labor, as a way of cutting cost. One goal of this report is to quantify the possible savings which might result from part-time labor and from other changes in work rules.

Work Rules: The Historical Context

When transit managers talk about work rules they generally do so in a negative way: work rules hinder operations and prevent the most efficient utilization of the labor force. However, we must remember that the work rules, which are so bothersome today, arose in a historical context where they were genuinely needed by labor. All of us would agree that they have functioned to protect labor against what were quite exploitive working conditions: fourteen or sixteen hour shifts with unreliable amounts of work time at low pay rates. It seems obvious that the motivation for work rules in the early days was one that we all would have shared. The current problem, though, is the impact of work rules under today's conditions of highly peaked transit demand, and the resultant situation where some drivers must be paid for far more hours than they can actually be utilized.

Work rules typically concern such issues as: the total amount of time that an operator may be required to serve on a split shift; premium pay after a certain number of hours on split shifts to compensate for this form of work; and restrictions on the total number of labor shifts that may be split into two pieces. Work rules are continuing to evolve, and as Transport Canada notes, "transit labour's demands are not out of line with improved social benefits generally gained by labour as a whole throughout the 60's and early 70's."[2]

Nonetheless, it must be realized that the combination of reasonably motivated work rules and increased demand for transit during peak hours has led to increases in costs and decreases in productivity. The labor which is hired to provide service during the peaks cannot be efficiently used during other times. Even worse, the restrictions on maximum allowable spread time (for split shifts) produce a situation in which a single driver cannot even serve both the peaks. For example, when the maximum spread time was decreased from 13 hours to 11.5 hours in San Diego, the number of operators required increased by 15%. Cost increases of this same order of magnitude have also been reported from computer simulations of spread time reductions

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[2]Sage Management Consultants, Labour in urban transit operations: Profile and prospects. Working Paper #TP 1430. (Montreal, Quebec, Canada: Transport Canada, Surface Transportation Administration, Urban Transportation Research Branch, March 1978) p. 85.

for a number of other transit agencies.[3,4] Thus, labor's desire for a reasonable work day produces very substantial cost increases.

The national trend toward increased peak/base ratios will accentuate this problem. If work rules are not changed, then an ever-increasing number of operators will find themselves on very long spreads in order to service the increasing peak demands. This will, in turn, increase the union pressure for reductions in maximum allowable spread. On the other hand, if maximum spread time is reduced, then the increased peaking will produce an ever-growing number of operators who can only be efficiently used during a small part of their working day.

One obvious solution to the peaking problem is to match the labor workday with the demand for transit service by using part-time labor. If additional peak-hour service is needed, then an operator is hired to serve that peak and paid for that time only. We might have one person cover the morning, one person cover the evening, and no one forced to work an especially onerous workday. In fact, operators can then go to other jobs, they can use part-time driving as moonlighting activity.

The use of part-time labor seems to offer something for everyone: management obtains lower costs, and labor obtains a better working day--it gets rid of very long shifts and allows the people who want to be full-time bus drivers to work straight eight hour shifts. The people who want extra part-time work can do that. No one is in danger of losing a job since UMTA is expanding bus service; the additional drivers hired are part-time, and as the bus fleet gradually expands, more and more people work a regular, eight hour day. Unions have perceived a number of problems with these claims, however, and they have generally opposed the change.

The whole topic of part-time labor has in fact generated an immense amount of emotional debate within the labor community and the transit community, with people taking fairly extreme views on both sides. We decided to examine the real consequences of part-time labor. To do this, we examined the effects of potential work rule changes at actual transit districts,

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[3]John R. Meyer & Jose A. Gomez-Ibanez, <u>Improving urban mass transportation productivity</u>. Final report #UMTA-MA-11-0026. (Cambridge, Mass.: Harvard University, February 1977), p. 18.

[4]Sage Management Consultants, <u>Labour in urban transit operations</u>, p. 92.

using real schedules. For each schedule, we devised appropriate driver assignments for several different sets of work rules. Computing the implied labor costs, we were able to measure the consequences of a variety of work rule changes.

Such a research task would have been impossible ten years ago: the amount of effort necessary to "cut" a bus service-schedule into a set of driver runs is truely enormous. The research task only becomes possible today because of a computer program called RUCUS, a run-cutting and scheduling program developed under sponsorship of the Urban Mass Transportation Administration. (See Appendix A for a general description of the program and its use.)

Purpose of this Research

We are interested in estimating the actual dollar effects of work rule changes, e.g. how much might a transit district expect to save from the right to use part-time labor, or what will happen to labor costs if the maximum permissible spread time is reduced by an hour. The answer to such questions is obviously context specific: it depends on the amount of demand peaking at a property (the peak/base ratio), the time spread between peaks, and the existing work rules. And even for a given specific context the answers are still difficult to compute because one must reschedule all the runs at the property and then cost out the resultant run-cut in order to make any comparisons. Except for the few transit districts which have computerized run-cutting systems, and very experienced computer scheduling personnel, such calculations are prohibitively expensive and time consuming.

Hence this report is intended to provide two kinds of help for estimating the costs and benefits of work rule changes. First, we have calculated the estimated cost effects of the most typical work rule changes (adoption of part-time labor, changing spread rules, etc.) for a variety of different transit systems and tabulated these results in systematic form. Our intent was to produce a set of tables which both union and management might use to estimate the effects of some given work rule change on a transit system similar to their own. Second, we hope that our methodology can serve as a guide for systems which have the resources to undertake their own experimental runcuts.

Before beginning our detailed examination of the effects of work rule changes, it is worth putting the problem into historical perspective and examining the overall situation with respect to transit's financial problems. The source of these financial problems is much broader than the work rule limitations, themselves, and it is useful to have an overall view of the situation. Chapter Two provides such an examination.

CHAPTER 2

HISTORICAL TRENDS IN DEFICITS AND PRODUCTIVITY

In 1967 the U.S. transit industry, as a whole, earned revenues sufficient to pay 96% of its costs; by 1977 this figure had fallen to 53%, and the operating deficit was $2.03 billion.[1] In addition to this operating deficit there was also a capital deficit, made up from UMTA funds, of $1.3 billion.[2] When this capital subsidy is taken into account, the industry earned significantly less than half its expenses in 1977. The operating deficit is expected to grow to about $3 billion, in 1977 dollars, by 1982;[3] and there have been recent proposals to make large increases in the capital subsidy as well.

The picture in Britain is similar: operating deficits went from £13 million in 1972 to £150 million in 1975 , and it is projected that subsidies at least five times that large will be needed to maintain the British system at current ridership levels in 1985.[4]

Cost Trends

Using the ten-year period from 1967 to 1976: U.S. transit operating costs increased by 148%, while revenues increased by only 39%.[5] That is, costs grew about four times faster than revenues. Table 2-1 examines the factors behind the cost increase. Looking at the top of the table, we see that about half of the total increase is produced by the general inflation in the economy over this period of time. Transit service did expand over

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[1]American Public Transit Association, <u>Transit fact book</u> (1977-1978 ed). (Washington, D.C.: 1978), p. 20.

[2]Ibid., p. 40.

[3]Public Technology Inc., <u>Proceedings of the First National Conference on Transit Performance</u> (#UMTA-DC-06-0184-77-1). (Washington, D.C.: January 1978), p. 43.

[4]Richard L. Oram, Peak period supplements: The contemporary economics of urban bus transport in the U.K. and U.S.A. <u>Progress in Planning</u>, 1978, <u>12(2)</u>, pp. 89-103.

[5]APTA, <u>Transit fact book</u>, pp. 20, 21.

TABLE 2-1

COST INCREASE TRENDS 1967-1976

In Current Dollar Amounts, Cost Grew by 148%[6]

Inflation (measured by the GNP deflator)		71%	148%
Service expansion (1.4% increase in VMT)	1%	77%	
Increase in wages and benefits (above the inflation rate)	41%		
Increase in employees (above the number required by the service expansion)	13%		
Increase in fuel costs (above the rate of inflation and service expansion)	4%		
Insurance, electricity, parts, taxes, and a small unexplained portion	16%		

Breakdown of Components of the Increase

Constant Dollar Amounts

Service expansion (1.4% increase in VMT)	2%	100%
Increase in wages and benefits	54%	
Increase in employees (above the number required by the service expansion)	17%	
Increase in fuel costs (above the amount needed for service expansion)	6%	
Insurance, electricity, parts, etc.	21%	

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[6]Calculated from figures in James E. Sale and Bryan Green, Operating costs and performance of American public transit systems, Journal of the American Planning Association, January 1979, 45(1), p. 24.

this period, but the increase was only 1.4%, which is far too small to account for the overall increase.

The lower part of Table 2-1 looks at the components which produce the increase over and above the inflation rate. More than half of this increase, 54%, is produced by the increase in wages and fringe benefits for the 1967-size labor force. The next biggest single component, 17%, results from the increase in the number of employees used by the average transit agency. (Presumably, these represent an increase in the number of white collar workers to handle things such as planning, and federal grant applications.) Thus the increase in labor costs, to expand the white collar labor force and to pay higher wages to other labor, amounts to 71% of the real-dollar cost increase.

In summary, about half of the increase in costs was produced by inflation; looking at the other half, the real cost increase, about half was produced by increased wages and fringe benefits for the existing labor force. Another 17% of the real cost increase was produced by expansion of the overhead labor force beyond the amount required for service expansions.

Revenue Trends

For the period 1967-1976 transit revenues increased by 39%, while the rate of inflation was about twice as great. The failure to keep up with inflation came about for two reasons: the number of passengers declined by 14%; and the average transit fare, in real dollars, fell by 4%.[7] The trend over these ten years is not uniform: patronage decreased by 21% over the first half, then began rising, but was still 14% below the 1967 figure by the end of the second half. Unfortunately, this growth period, 1972-1977, was also accompanied by a 17% decrease in real dollar transit fares.

The decline in average transit fares was exacerbated by the increase in average trip lengths over the decade. That is, the revenue per trip fell at the same time that the average trip length was increasing substantially,[8] hence the revenue per mile of service fell even faster.

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[7]APTA, Transit fact book, pp. 23, 24.

[8]James E. Sale & Bryan Green, Operating costs and performance of American public transit systems, Journal of the American Planning Association, January 1979, 45(1), pp. 22-24.

At the same time that the number of passengers was declining, the number of transit employees necessary to produce a mile of service was increasing; hence gross labor productivity fell substantially: vehicle-miles per employee fell by 9%, and passenger-trips per employee fell by 19% from 1970 to 1976.[9]

In summary, there was a substantial overall decline in patronage and a substantial decline in fares (measured in real dollars). At the same time, increasing average trip length made transit even more of a bargain as fare per mile fell even faster than fare per trip.

Paying for the Deficit

With transit costs rising twice as fast as the rate of inflation, while revenues rose only about half as fast as inflation, a substantial deficit was inevitable. It was financed as follows: 52% from local government contributions, 22% from state government contributions, and 26% from federal government contributions.[10] The seemingly small proportion of federal support occurs because these are only the operating expense proportions of the transit budget. The federal role has been largely confined to capital subsidies in the past--federal capital subsidies were twice as large as federal operating subsidies in 1977--though it has increasingly begun to move into the area of operating assistance as well.

EXPLAINING THE GROWTH OF THE TRANSIT DEFICITS

What are the reasons behind this dramatic reversal in the economic health of the transit industry? Observers have pointed out five contributing factors: 1. declining productivity, caused in part by the problems of serving low density suburbs, and in part by increased peak-hour demand concentration; 2. changing demographic factors, especially the increase in personal income; 3. changes in the market for transit services, especially the increasing concentration of peak-hour demand; 4. increased labor costs, both in terms of the high rate of relative salary increments and also

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[9]Public Technology Inc., Proceedings of the First National Conference on Transit Performance, p. 40.

[10]APTA, Transit fact book, p. 20.

in terms of greater proportionate expenditure on non-operational employees; and 5. the changing function of public transit, as transit has been asked to undertake a number of uneconomic new services in order to assist in a variety of general social goals. Each of these factors is discussed below.

Trends in Labor Productivity

Productivity is simply the ratio of an output to an input; for example, the number of cars produced per man hour. However, it is not at all simple to operationalize this concept for the transit industry because it is difficult to decide on the appropriate measure of output: passenger trips, passenger miles, vehicle hours of revenue service, vehicle miles traveled, etc. Hence there are a number of alternative definitions in the literature, though all of them tell the same story: labor productivity has probably been declining over a long period of time. The decline has a multitude of causes, many of which are entirely outside the control of labor, as will be discussed below. Nontheless, since labor accounts for about 80% of the cost in a typical transit agency,[11] the decline in productivity is a very serious concern.

Meyer and Gomez-Ibanez[12] consider two possible measures of transit output: revenue-passengers carried and vehicle-miles traveled. They argue that revenue-passengers carried probably underestimates the output of transit since it does not take account of the increase in quality of service associated with reduced crowding in buses, increased average speeds, and installation of air-conditioning. They then argue that vehicle-miles traveled captures at least some of the quality improvement effects and also takes account of the fact that there was a deliberate public decision to maintain high levels of service despite declining patronage. For the period 1948-1970 they compute the following results.

[11] William C. Sproull, A method for evaluating the relationship of research, development and demonstration programs to operator labor cost components in bus transit systems. (Doctoral dissertation, American University, 1973), Chapter 2.

[12] John R. Meyer & Jose A. Gomez-Ibanez, Improving urban mass transportation productivity. Final report #UMTA-MA-11-0026. (Cambridge, Mass.: Harvard University, February 1977.)

1. Using revenue-passengers as the output measure: total factor productivity declined by 1.2% per year, and labor productivity declined by .75% per year.

2. Using vehicle-miles as the output measure: total factor productivity increased by .63% per year, and labor productivity increased by 1% per year.

Two comparisons are relevant. First, during the same period labor productivity in the non-farm sector of the economy increased at 2.9% per year. Second, despite the very low, or negative, productivity increase of transit labor, transit wages increased at a rate of 5.6% per year over this period.[13]

The analysis group at Transport Canada used a different measure of transit output: total transit revenues deflated by an index of transit fares. They argue that this measure has the virtue of representing the value of the transit trips to the riders. Calculating labor productivity for Canada during the period 1950-1975, they find a decrease in labor productivity of about 1% per year.[14]

Transport Canada also looked at the association between productivity trends and size of transit property and found no relationship. And they cite a number of results showing that there are no economies of scale in bus operations.

Changing Demographic Factors

The most important factor here has been the growth of personal income which has given people greater freedom of choice and, unfortunately, their choices have worked against transit in two major ways. First, higher incomes caused a decrease in the public's preference for transit: a) higher incomes produce a higher value of time, and transit is slower than the automobile in most situations; b) higher incomes allow more discretionary

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[13]Ibid., p. 73.

[14]Sage Management Consultants, Labour in urban transit operations: Profile and prospects. Working Paper #TP 1430. (Montreal, Quebec, Canada: Transport Canada, Surface Transportation Administration, Urban Transportation Research Branch, March 1978), p. 64.

spending and hence transit's principal advantage, its low cost, becomes less important in the modal choice decision. Second, higher incomes have allowed more and more people to move out to the suburbs to implement their taste for single-family, detached homes.[15,16] Such suburban growth means lower population density, and hence increasing difficulty in providing high quality transit service.

The end result is lower load factors on transit, due to serving low density suburbs, and a higher proportion of deadheading time on transit routes because they must start further from the central garages. Hence the measured output of transit service declines and productivity falls.

Changes in Peak-Hour Transit Demand

The basic problem here is that, over time, more and more of the demand for transit has tended to concentrate in the daily peak travel hours: two-thirds of all transit trips are now carried during the 20 peak hours of the week. Since transit systems must buy enough vehicles and hire enough labor to handle this peak load, and since the vehicles and labor must then remain underutilized for a major part of the day, transit systems are being forced into a very uneconomic mode of operation. Most transit resources are underutilized most of the time. And one major consequence of this fact is that the marginal cost of expanding peak-hour service is extremely high and far exceeds the revenues generated by peak-hour services.[17]

A variety of factors contribute to the increase in demand peaking: 1. The suburbanization of housing proceeded faster than the suburbanization of jobs, hence necessitating a large volume of work commute trips to the CBD.[18] 2. The cost of transit, relative to the auto, changes during the

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[15] Alan Altschuler et al., The urban transportation system: Politics and policy innovation. (Cambridge, Mass.: MIT Press, 1979), p. 377.

[16] John B. Lansing & Gary Hendricks, Automobile ownership and residential density. (Ann Arbor, Mich.: University of Michigan, Institute for Social Research, Survey Research Center, 1967).

[17] Oram, Peak period supplements, Progress in Planning, p. 117.

[18] Meyer & Gomez-Ibanez, Improving urban mass transportation productivity, p. 7.

off-peak times to favor the automobile: there are more family members travelling together in the off-peak trips, so auto-cost per person is lowered; and major arterials are less crowded during off-peak, hence the time-cost of the auto trip goes down; while frequent stops and long headways tend to raise the time-cost of transit during off-peak. 3. The growth of female employment: women, who are the majority of transit riders, have increasingly concentrated their ridership to the peak periods. 4. The dispersion of off-peak destinations (shopping, recreation, social visits) away from the CBD, hence reducing the ability of transit to serve them well. And 5. The new social goals imposed upon transit: in particular the desire to relieve peak-hour auto congestion has led to the provision of additional peak-hour transit service.

Peak/base ratios in transit have risen from 1.8 to 2.04 during the period 1960-1974,[19] and the average bus in the U.S. is now in service for only about 6 hours per day.[20]

"Peaking" was not generally regarded as a financial liability by transit managers in the past because, historically, the surplus revenues generated during the peak periods were actually the financial mainstay of the industry. However, this financial relation is no longer true, as will be seen below. A further reason why transit managers have ignored peaking has been their tendency to concentrate on average costs rather than marginal costs--marginal costs are harder to conceptualize and measure, and this level of detail was not really necessary in the past.[21] A manager added up all the costs, divided by total hours of service, and computed an average cost per hour of bus-operation. Then, taking this average cost figure as a given, the manager set out to maximize revenues. Since it was obvious that load factors were higher during the peak, managers concluded that the peak-hour service was the most economical to provide. This then led to

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[19] Oram, Peak period supplements, Progress in Planning, p. 114.

[20] Control Data Corporation & Wells Research Co. Trends in bus transit financial and operating characteristics, 1960-1975. Prepared for the U.S. Department of Transportation, Asst. Secretary for Policy and International Affairs (#DOT-P-30-78-43). (Rockville, Md.: September 1978), p. 7-6.

[21] Oram, Peak period supplements, Progress in Planning, p. 138.

opposition to van pooling, jitneys, and other paratransit because those operations would "skim the cream off the market."

A growing body of research shows that this average-cost orientation is increasingly misguided under current conditions. The conclusions of this new research are easily stated: A. If separate cost calculations are made for peak service and off-peak service, it turns out that peak-hour service is much more expensive; B. Furthermore, the increased revenue associated with the peak is not sufficient to compensate for the extra cost, hence the operating ratio is much lower for peak service. That is, peak service produces a disproportionate share of the transit operating deficit.

A study of Bradford, England, concluded that the marginal cost of peak-only service was 2.5 times greater than the marginal cost of all-day service. Then, allowing for the greater revenue produced by the peak-hour service, it calculated the revenue/cost ratios for the two kinds of services: all-day service covers 94% of its allocated cost, while peak-only service covers just 47% of its cost.[22]

Another U.K. study, of Merseyside, concluded that the off-peak segment of a typical route earned a contribution to fixed overhead of 2.73 pounds per bus-hour of operation, while the peak-segment incurred an overhead shortfall of 43 pence per bus-hour.[23] Oram cites two other studies which show a similar outcome and concludes with a quotation from the public transport research director of the U.K. Transport and Road Research Laboratory:

> "The (mean hourly) cost of operating public transport services . . . during the peak period (is) said to be greater than that in the off-peak by a factor . . . between 1.5 and 5, depending on whether all, or just some, of the overheads were loaded onto the peak hours

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[22] R. Travers Morgan & Partners, Buses in Bradford. Final report prepared for the West Yorkshire Passenger Transport Executive. (London: 1976), p. 56, 62.

[23] Arthur Anderson & Co., Bus route costing for planning purposes. TRRL Supplementary Report #108UC. (Crowthorne, England: Department of the Environment, Transport and Road Research Lab, 1974), p. 77.

. . . . With fares constant throughout the day, there is no doubt that off-peak travellers are subsidizing peak travellers in a large number of undertakings."[24]

A recent working paper by Transport Canada also reviews the Bradford study and then does theoretical calculations for Canadian Transit which show a peak-period cost of $1.80 per revenue-mile, and an off-peak cost of $.90 per revenue-mile.[25]

The increased peaking also has negative effects on labor productivity. If the structure of transit demand only permits a full-time employee to work for six hours a day, the employee's output will obviously be lower. This decrease in output will still occur even if the transit agency increases its day-base service to provide employment for otherwise idle drivers, because the excess day-base service implies fewer passengers carried per vehicle. Additional consequences of peaking will be discussed in the section on labor work rules below, but it should be obvious that peaking will lead to a decline in measured output per driver, and hence a decline in labor productivity.

These findings have enormously significant implications for transit, as Oram points out, and he advocates the development of paratransit options as peak period supplementary service to efficiently expand the supply of service in the transit industry. Paratransit can be used to make conventional transit significantly more efficient. It can expand the amount of peak service available while decreasing the cost of providing it, and may even be able to raise off-peak ridership as well. Hence, properly integrated peak period supplementary service should hardly be considered as the enemy of conventional transit.

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[24] Oram, Peak period supplements, Progress in Planning, p. 119.

[25] Transport Canada, The fundamentals of urban transit. (Unedited Working Paper #TP 1284.) (Montreal, Quebec, Canada: Transport Canada, Surface Transportation Administration, Urban Transportation Research Branch, February 1978), p. 7-17.

Increased Labor Costs

There are a number of problems here; the first two have already been discussed above. First, overhead labor has increased faster than service-mile increases in recent years. Second, operator wages have increased much more rapidly than the increase in labor productivity. A third factor is the now common custom of linking wage increases for non-operators to those received by operators: ticket collectors, clerks, and even the aides who give out schedule information over the phone now tend to be paid at, or close to, driver's scale. Thus the large salary increases of drivers become compounded across the entire transit property.

Changing Social Role of Transit

When transit was privately operated, its role was relatively simple: serve those passengers who could afford the ride, and set fares high enough to return a reasonable profit on investment. Now that transit is largely publicly operated, it has been given an array of tasks that simply are not compatible with paying its own way. For example, we ask that transit maintain more route-miles of service and more frequent schedules than are economically justifiable, in order to assure that everyone has access to high quality transit service. We set transit fares low enough so that they will not be a burden on the poorest segment of society, then charge these same low fares to everyone, regardless of income. We provide even lower fares for senior citizens and other special groups. And we rationalize this system of low fares as a means to attract people away from cars, even though all available evidence shows that the fare elasticity of transit demand is quite small.[26]

Of course, all these policies lead to deficits and the need for society to step in with large subsidy payments to keep the systems going. In addition to the direct cost of such intervention, there are, unfortunately, also substantial indirect effects on the long-term operation of the systems. According to Meyer and Gomez-Ibanez:

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[26] Meyer & Gomez-Ibanez, Improving urban mass transportation productivity, p. 39.

"Extensive government involvement may have been an important cause of transit's slow rate of productivity growth. Public subsidies, for example, may have unintentionally weakened management's incentives to control costs, to market services effectively, or to adopt other productivity-improving innovations."[27]

Or, according to the Transport Canada study:

"The longer run implications of subsidies based simply on deficit figures, however, were to encourage expansion of service without a significant incentive toward increased productivity and efficiency of operation."[28]

Finally, as noted by Altshuler, "It bears emphasis . . . that government involvement in the public transportation industry has tended overall to be a force of spending acceleration."[29]

IMPROVING TRANSIT PRODUCTIVITY

There are two general areas where change might lead to productivity increases. 1. Changes in labor work rules: since operator's wages account for roughly half of transit costs, changes in work rules might have significant effects on overall costs. 2. Load shedding: since peak-hour service is much more expensive than day-base service, reduction of peak/base ratios through use of paratransit (to take away some of the peak-hour load) might offer substantial savings. We analyze these possibilities in the chapters that follow.

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[27] Ibid., p. 5.

[28] Transport Canada, Fundamentals of urban transit, p. 22-29.

[29] Altschuler et al., The urban transportation system, p. 44.

CHAPTER 3
WORK RULES AND COSTS

The labor cost of bus service depends upon service requirements, work rules, and pay practices. Figure 3-1 shows schematically how these elements are incorporated in the processes of scheduling, run cutting and costing which culminate in a payroll.

There are four steps:

1. Planning. Planners design routes and decide upon headways (the time-spacing between buses) based on supply constraints, work rules, estimates of demand, and on the district's "policy headways" (maximum desirable time between buses).

2. Scheduling. Schedulers devise bus itineraries (blocks) which satisfy the planners' service requirements. There are many possible block schedules which meet a particular set of service requirements. Choice among these block schedules depends on the scheduler's skill and intuition, since the block schedule will shape the subsequent run cut in important but quantitatively unforseeable ways.

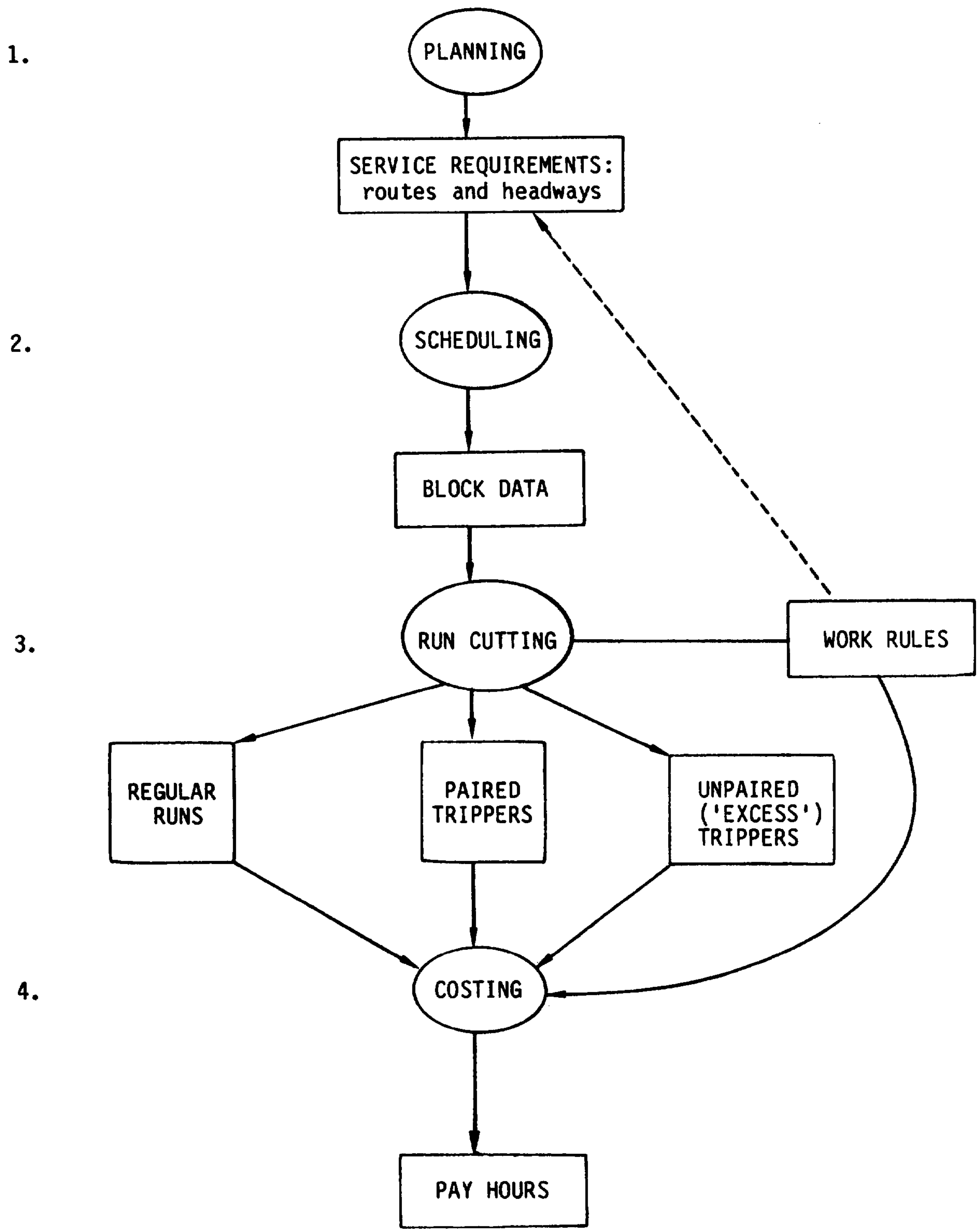
3. Run cutting. Operating under constraints set by the work rules,the run cutter carves the blocks into driver assignments (runs). This process is not deterministic; the efficiency of a run cut depends upon the run cutter's ingenuity.

4. Costing. The outcome of the run cutting process is a roster of regular runs and trippers, whose cost is determined by work rules and pay practices specific to the district.

This study is concerned with the effect of work rules on labor costs. Our analysis starts with Step 3 above. We begin with block data representing the service schedule of a division of some transit district. From this starting point, we perform alternative run cuts based on different work rule combinations. The run cuts are compared to examine the cost-effects of work rule changes.

Run cutting was done with the automated RUCUS system. Run cutting and costing methodologies are described in detail in Appendices A, B, and C.

Figure 3-1
DETERMINANTS OF PAYROLL COST OF RUNS



An Important Qualification on the Results

The fact that we are beginning at Step 3 has important consequences for our estimates of the effects of work rule changes, and is likely to bias these estimates in a conservative direction. We take the existing vehicle schedules as a given and only optimize in terms of what is there, rather than optimizing the vehicle schedules to take advantage of the flexibility offered by work rule changes such as part-time labor. It may be the case that these existing schedules provide more day-base service than is actually justified by demand conditions, because it is very cheap to do so: the vehicles have already been purchased to serve the peak and would otherwise be idle. Even the operator labor is essentially costless since operators hired to serve the peak are guaranteed eight hours of pay. Thus they might as well be utilized during the off-peak rather than be idle. In effect, the schedule may have been adjusted to the work rules.

(Another potential cause of "excess" day-base service is the work rule restriction on the maximum proportion of split-runs to straight runs. If management is running up against this restriction it will often fill in the center part of a split-run to convert it into a single long straight; thus preserving the necessary contract maximum ratio. Since part-time labor can cover runs that were formerly split-runs, the ratio of splits to straights is lowered and it becomes possible to convert some of the former straights back into splits without exceeding the contract maximum.)

If the existing vehicle blocks are characterized by "excess" day base service (excess as defined by either demand conditions, or by reasonable policy-headways) then a combination of work rule changes and adjustments to the vehicle blocks would yield greater savings than those estimated by our methodology.

On the other hand there are a number of reasons to believe that our estimates are upper bounds on the possible savings from use of part-time labor: we assume no increase in administrative costs to handle the additional drivers, and we assume that the districts will actually be able to implement their full quota of part-time labor. Neither of these assumptions is likely to be true, as we discuss later on.

Hence, on balance, unless a district is contemplating a quite radical restructuring of service to take advantage of part-time labor, and unless it also has the right to use very substantial amounts of part-time labor, then the estimates produced in Chapter Six and Appendix E ought to be about right. We have only been able to check our projections against actual operating experience at one district: that district had projected a saving about double what our tables indicate, but the measured outcome when they actually implemented part-time labor was within one-tenth of a percent of our estimater.

CHAPTER 4
DESCRIPTION OF TRANSIT DISTRICTS AND DATA

We chose five transit districts for our final analyses. The unit of analysis was actually one division (garage) of each district, since runs are generally cut on a division-by-division basis.

Two criteria governed our choice of districts. First, it was necessary that each study district already use a RUCUS-based computer scheduling system; manual coding of schedule data would have been prohibitively difficult. Second, we sought a spectrum of peak/base ratios.

Tables 4.1 through 4.5 present detailed descriptions of each database studied. The first page of each table presents service profiles. The top chart shows number of buses in service for each quarter-hour of the day. The bottom two charts show pull-ins and pull-outs by time of day.

The chart on the second page of each figure shows the relative distribution of block (bus-run) lengths. At the bottom of the second page are a number of statistics describing the service schedule and the district's own work rules.

In computing peak/base ratios, 'peak' was the maximum number of buses in service, while 'base' was the average number in service between 10 A.M. and 2 P.M. 'Peak-to-peak' time is the elapsed time between morning maximum and evening maximum. 'Shoulder-to-shoulder' time is the elapsed period from the first time morning service exceeds midday base to the last time evening service exceeds midday base.

Figure 4-1

CITY "A" SERVICE PROFILE

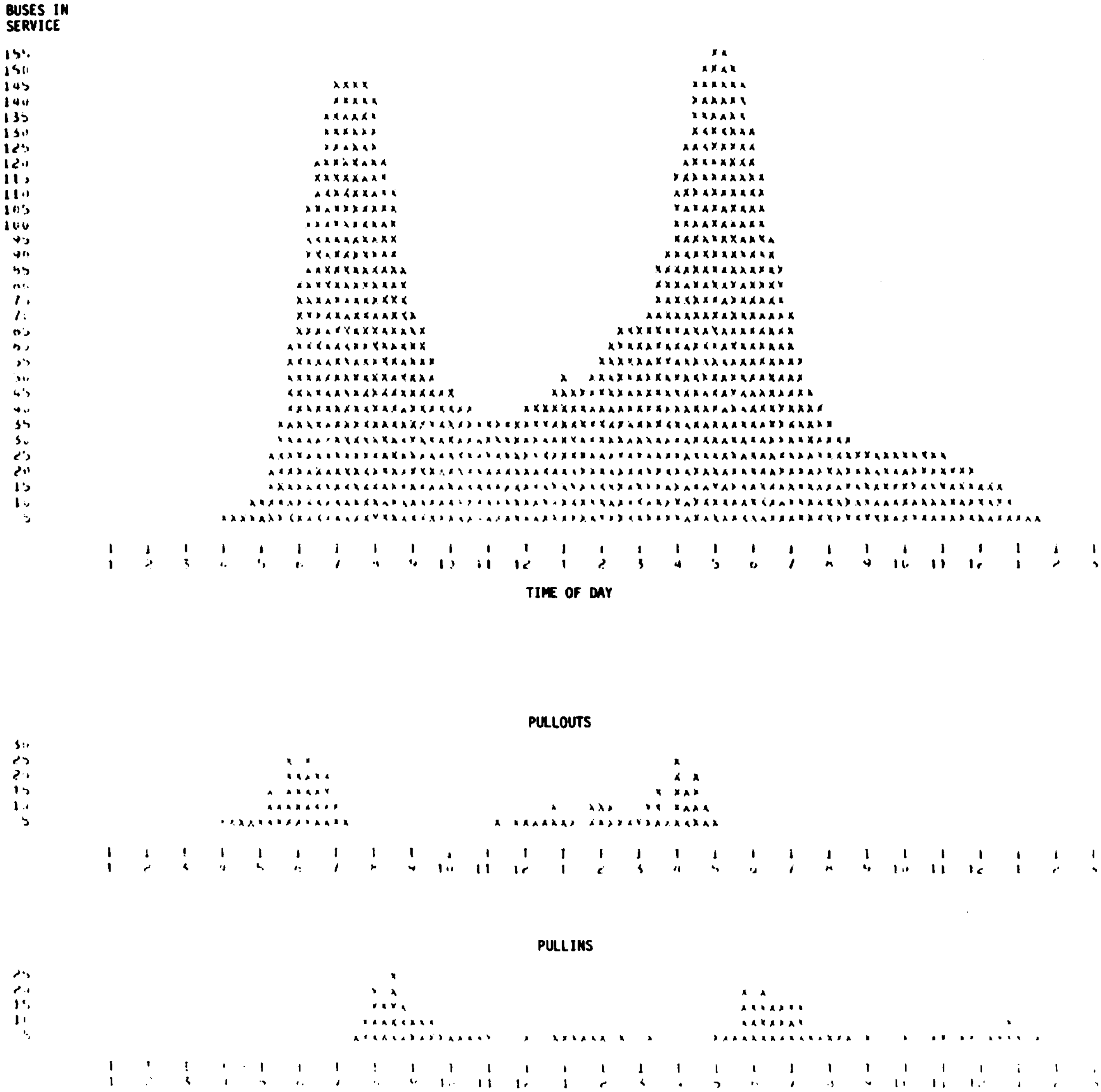
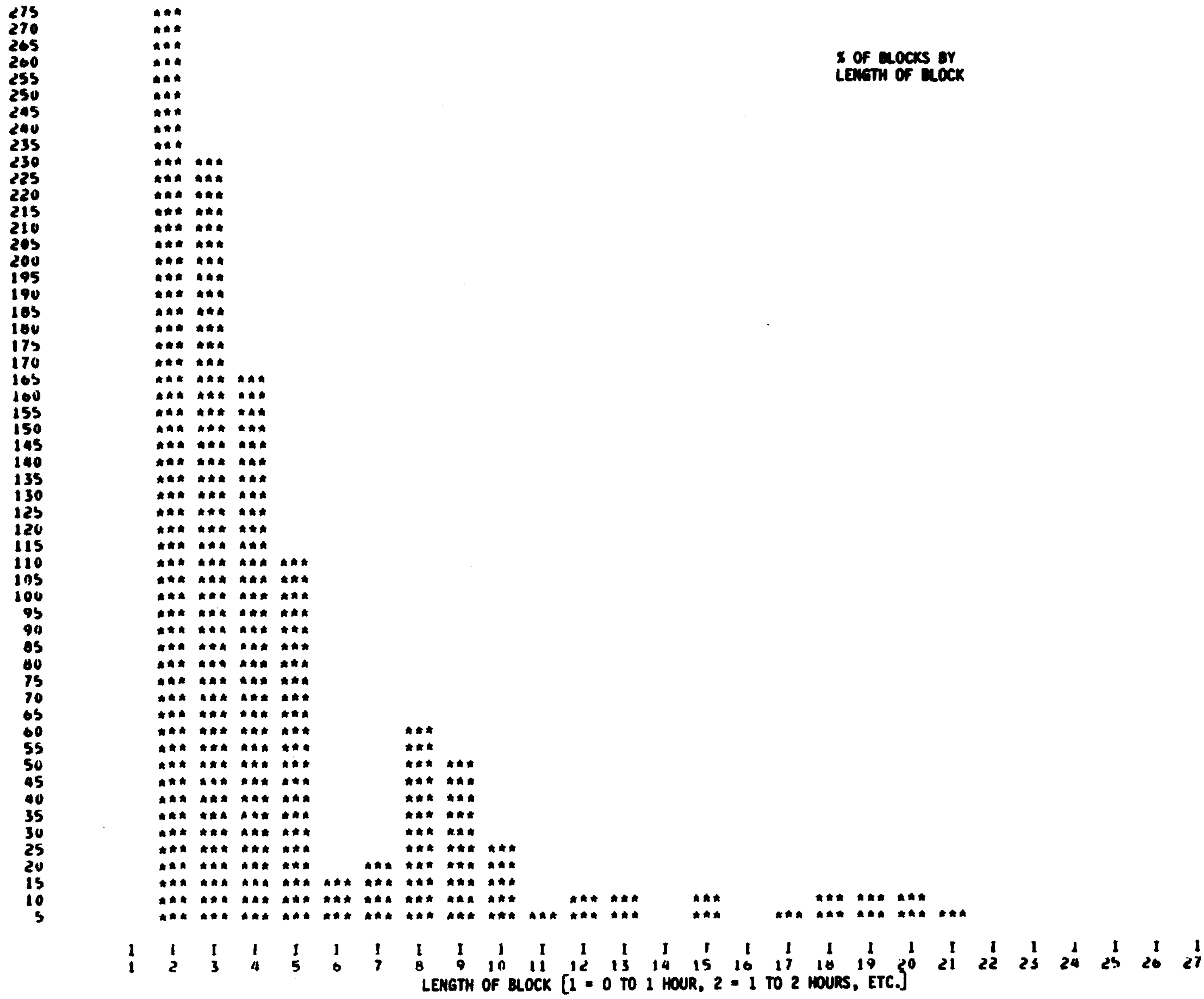


Figure 4-1

CITY "A" SERVICE PROFILE (Cont'd.)



STATISTICS

PEAK/BASE RATIO:	3.9
PLATFORM HOURS:	1212
NUMBER OF BLOCKS:	284
PEAK TO PEAK TIME:	9:45
SHOULDER TO SHOULDER TIME:	13:45

ORIGINAL CONTRACT PROVISIONS --

MAXIMUM SPREAD TIME:	13:00
SPREAD PENALTY TIME:	10:30

Figure 4-2

CITY "B" SERVICE PROFILE

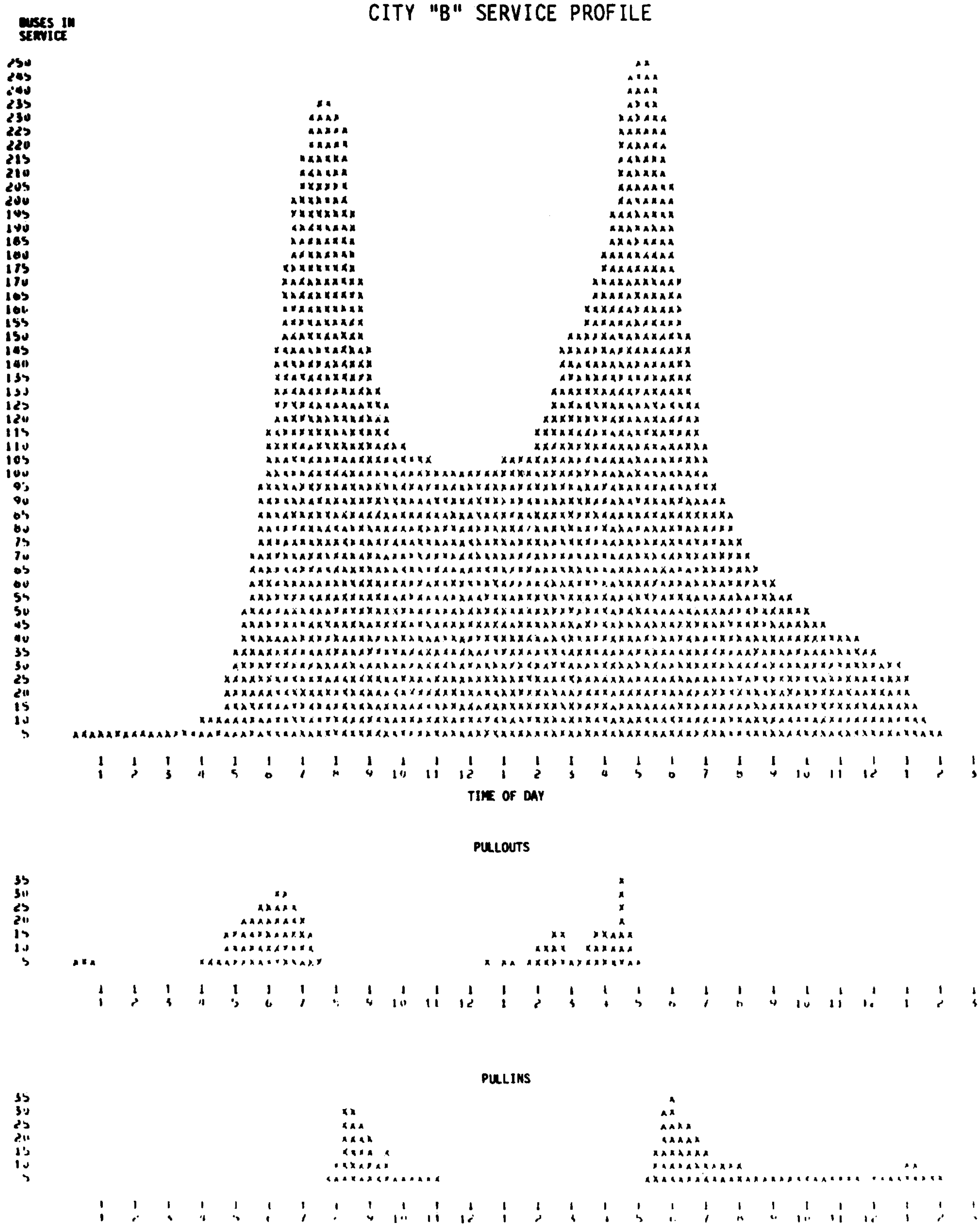
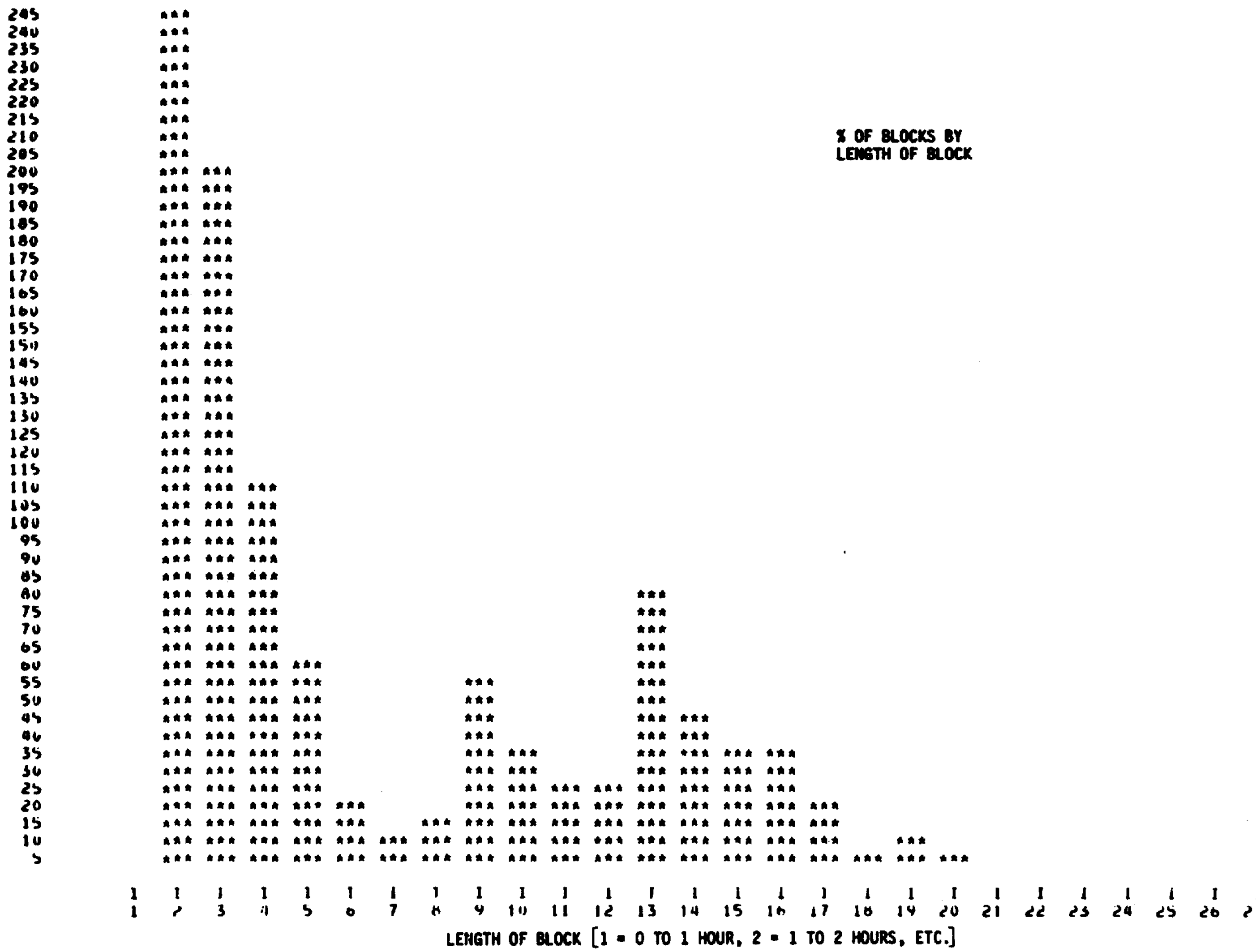


Figure 4-2
CITY "B" SERVICE PROFILE (Cont'd.)



STATISTICS:

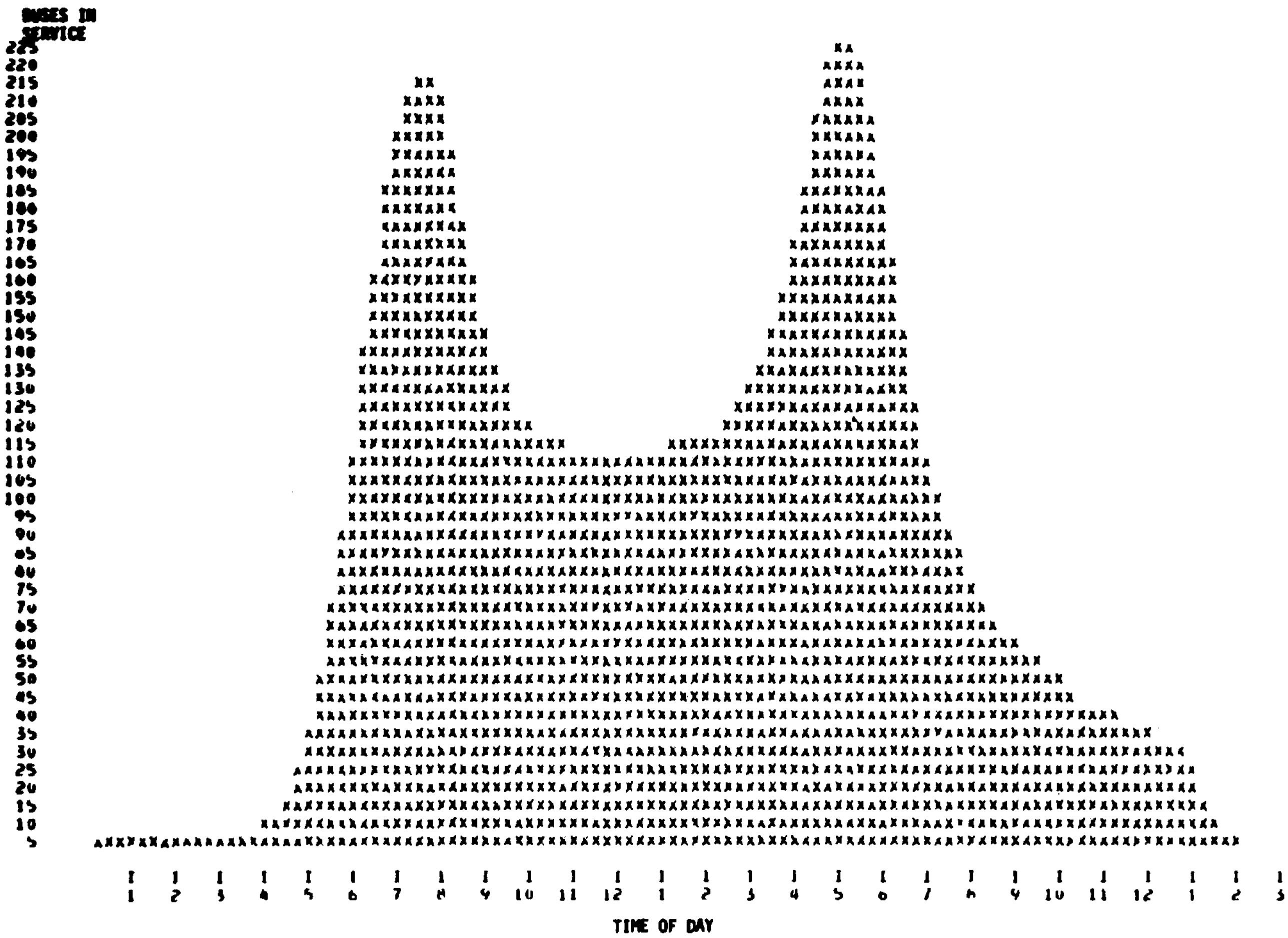
PEAK/BASE RATIO:	2.4
PLATFORM HOURS:	2337
NUMBER OF BLOCKS:	381
PEAK TO PEAK TIME:	9:30
SHOULDER TO SHOULDER TIME:	13:00

ORIGINAL CONTRACT PROVISIONS --

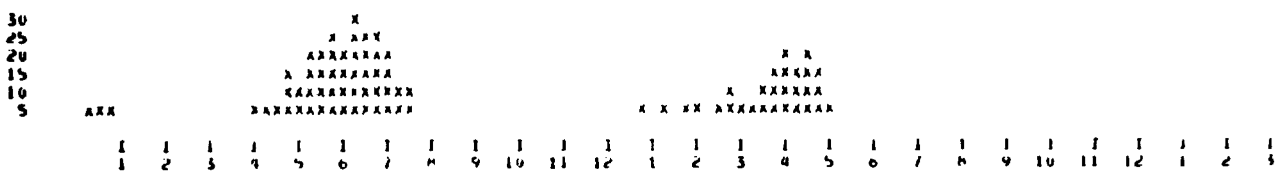
MAXIMUM SPREAD TIME:	13:20
SPREAD PENALTY TIME:	12:00

Figure 4-3

CITY "C" SERVICE PROFILE



PULLOUTS



PULLINS

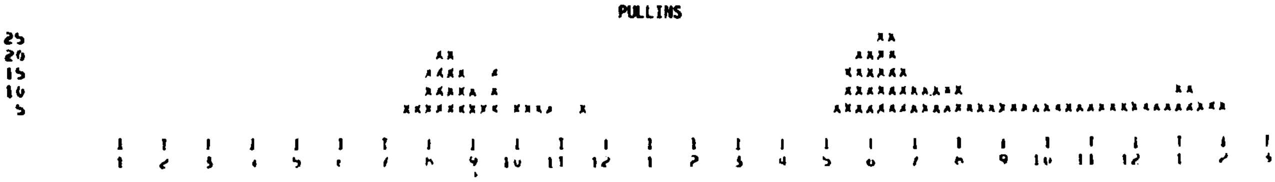
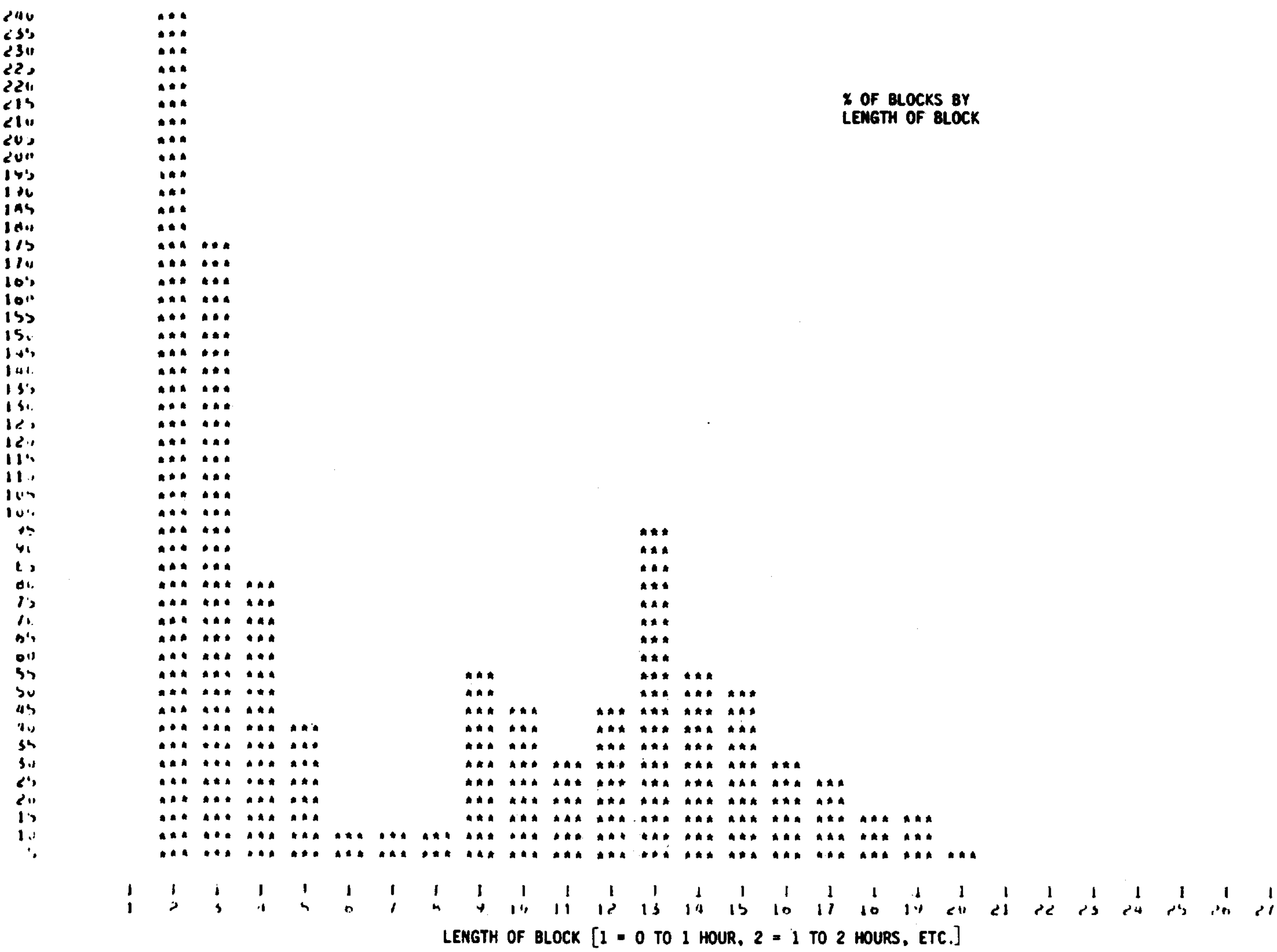


Figure 4-3
CITY "C" SERVICE PROFILE (Cont'd.)



STATISTICS:

PEAK/BASE RATIO:	2.0
PLATFORM HOURS:	2272
NUMBER OF BLOCKS:	326
PEAK TO PEAK TIME:	9:45
SHOULDER TO SHOULDER TIME:	12:30

ORIGINAL CONTRACT PROVISIONS --

MAXIMUM SPREAD TIME:	13:20
SPREAD PENALTY TIME:	12:00

Figure 4-4
CITY "D" SERVICE PROFILE

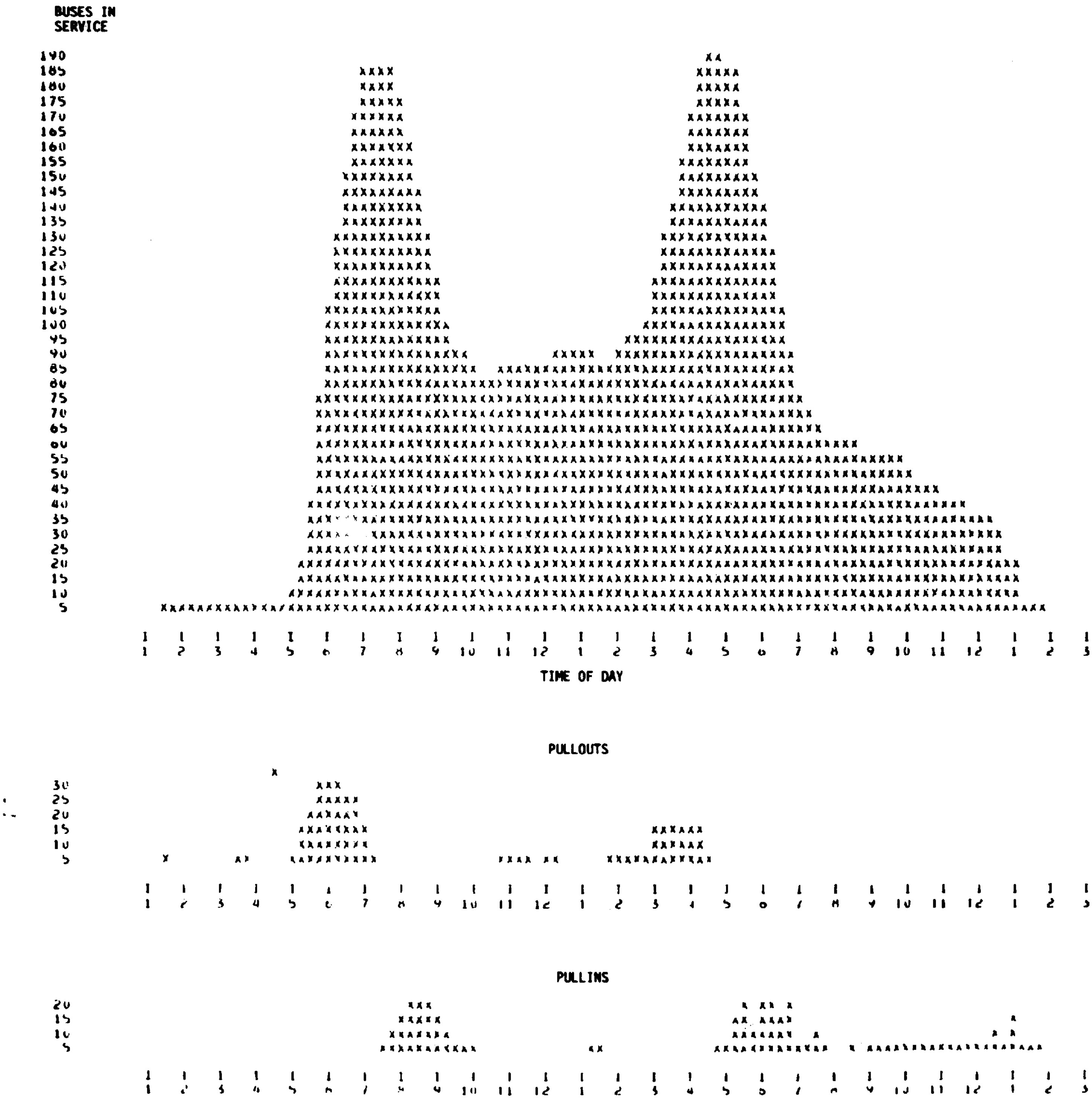
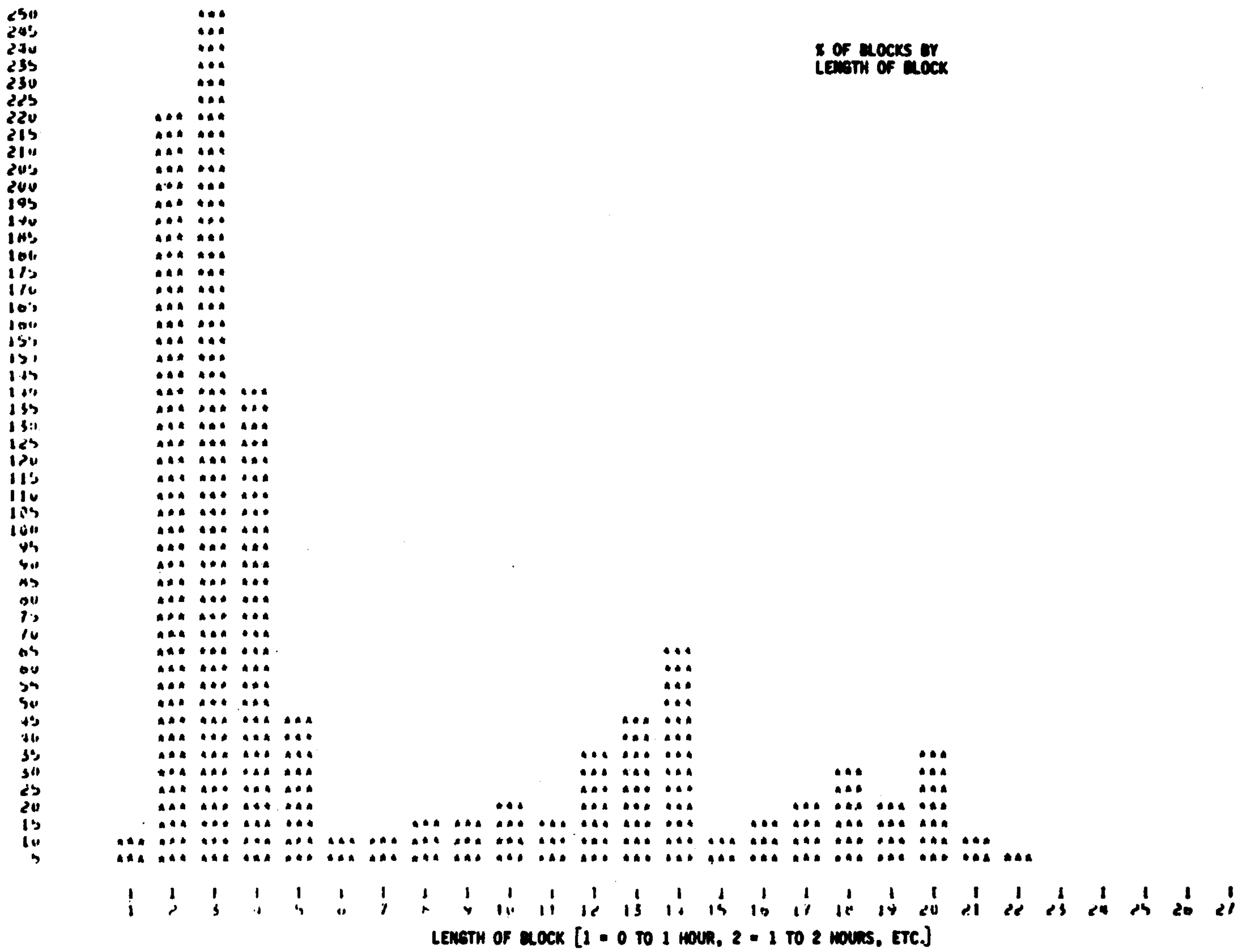


Figure 4-4
CITY "D" SERVICE PROFILE (Cont'd.)



STATISTICS:

PEAK/BASE RATIO:	2.2
PLATFORM HOURS:	1848
NUMBER OF BLOCKS:	291
PEAK TO PEAK TIME:	9:30
SHOULDER TO SHOULDER TIME:	12:45

ORIGINAL CONTRACT PROVISION --

MAXIMUM SPREAD TIME:	NONE
SPREAD PENALTY TIME:	12:00

THERE ARE PROVISIONS FOR SPECIAL RUNS
WITH LOW PLATFORM BUT NO SPREAD PREMIUM

Figure 4-5
CITY "E" SERVICE PROFILE

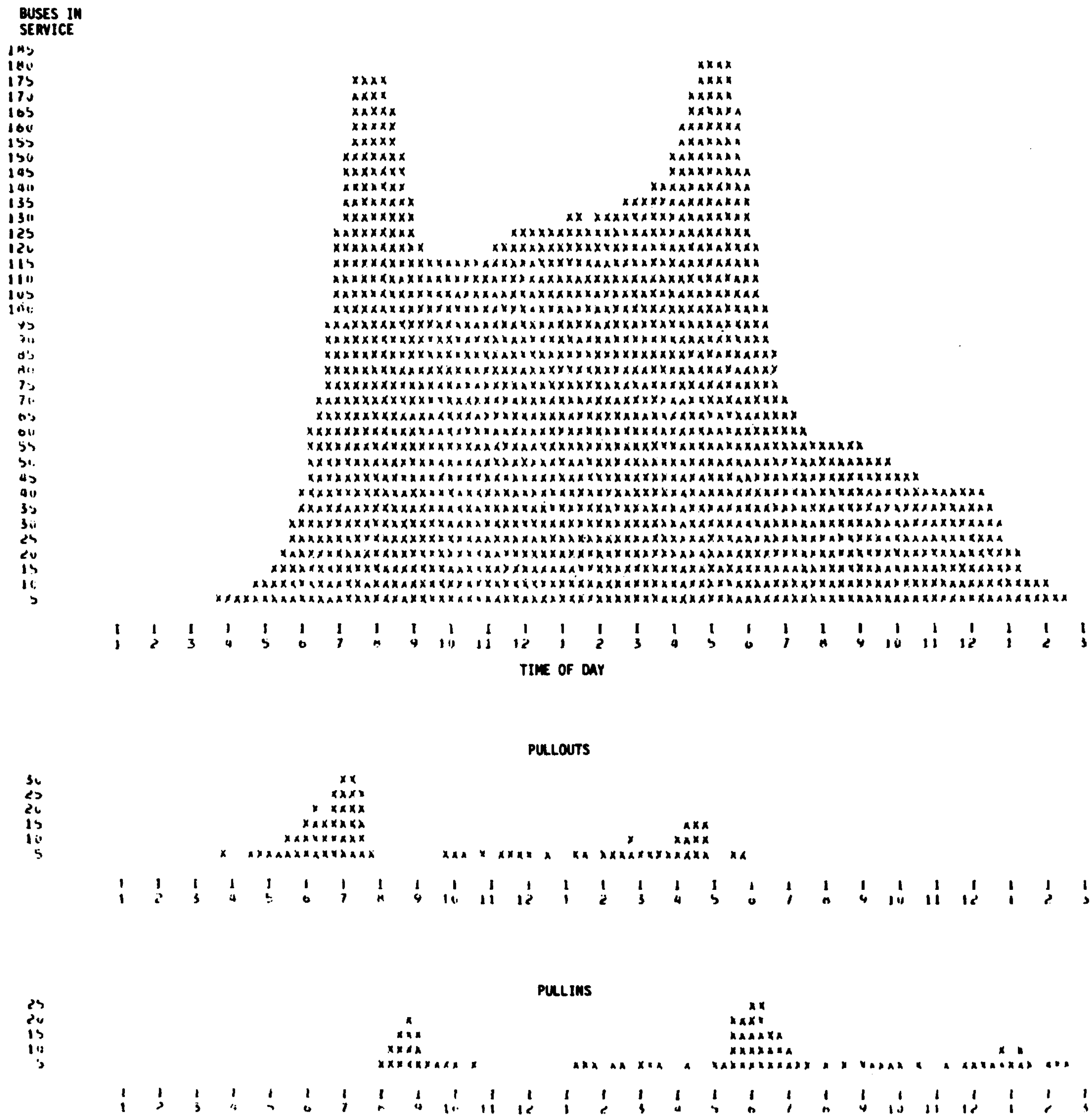
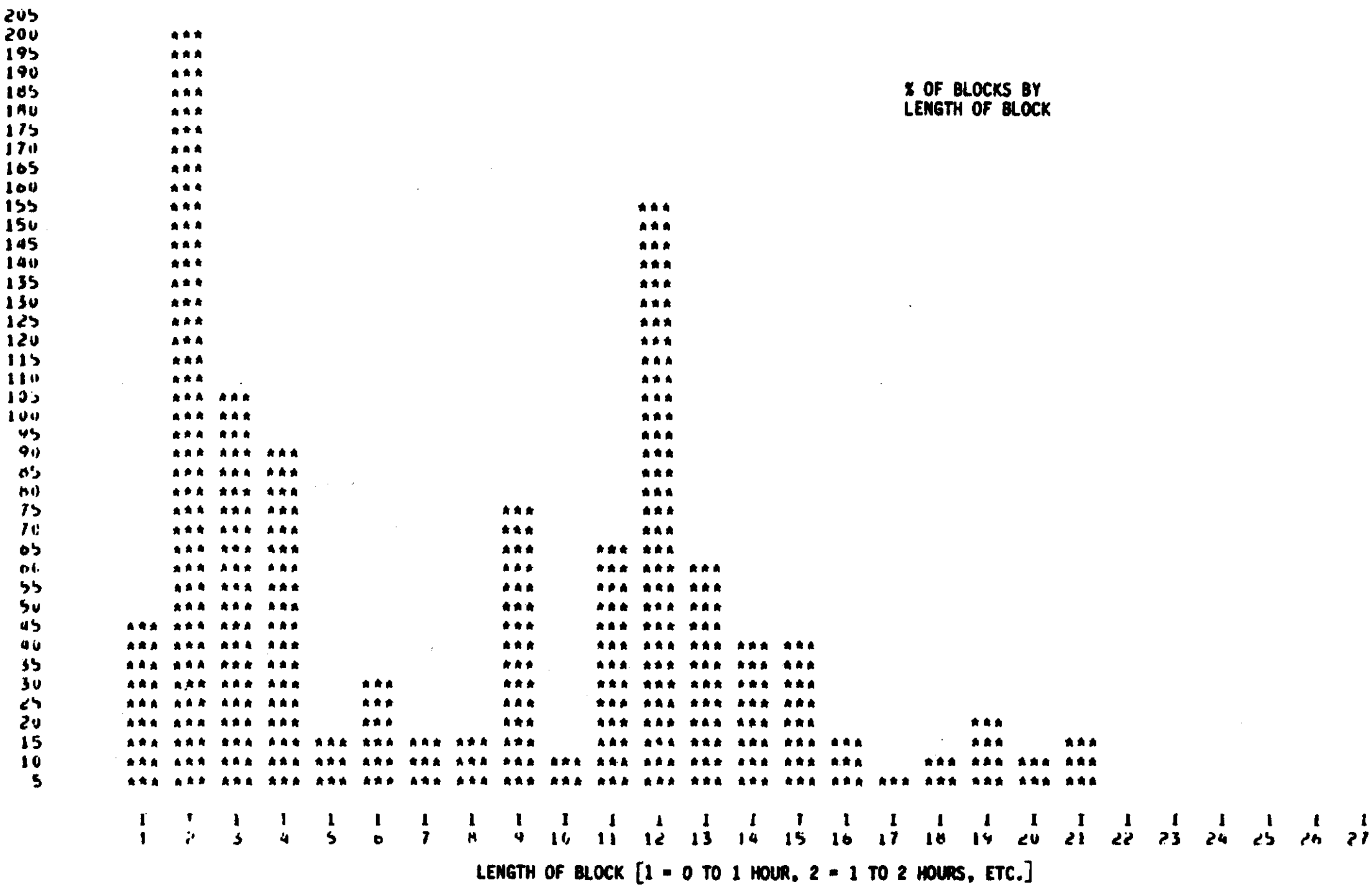


Figure 4-5

CITY "E" SERVICE PROFILE (Cont'd.)



STATISTICS

PEAK/BASE RATIO:	1.5
PLATFORM HOURS:	1930
NUMBER OF BLOCKS:	265
PEAK TO PEAK TIME:	9:15
SHOULDER TO SHOULDER TIME:	11:00

ORIGINAL CONTRACT PROVISIONS --

MAXIMUM SPREAD TIME:	NO CURRENT PROVISION: DE FACTO 12:00
SPREAD PENALTY TIME:	10:00

CHAPTER 5
CHANGES IN SPREAD RULES

Highly peaked schedules pose a problem for transit systems: drivers are needed for the morning and evening rush, but not in-between. If a full-time driver is required to work during both peaks, he is faced with a workday which may extend thirteen hours from start to finish, though there may be only five hours of work within that thirteen hour spread. Equity considerations dictate that drivers be compensated for such undesirable spreads, or else that these runs be prohibited in the first place.

Over the years, three principal mechanisms have arisen to alleviate the burden of runs with large spread times:

1. Payment of spread premium pay as a compensation to drivers of runs with wide spread. A bonus, similar to overtime, is paid for all work performed beyond a spread premium time. For example a typical contract might specify spread premium pay of time-and-a-half after ten hours; and a driver operating a run with 12 hours spread would receive an extra hour of pay.

2. Restriction of maximum spread by an outright prohibition of work assignments with greater than a specified spread time. For example a typical contract might ban runs of greater than 12.5 hours spread.

The Glossary at the back of the report contains illustrations of the key work rule terms.

It often happens that the maximum spread time is more restrictive for regular drivers than for extraboard drivers. (In the example above, the maximum spread time on the extraboard might be 13.5 hours.) In such cases, runs with long spread time, say 13 hours, which violate the regular drivers' maximum spread are given to the extraboard drivers, though they are not technically referred to as "runs." Thus the maximum spread for the extraboard becomes the effective constraint for the system. (Throughout this report, "maximum spread" refers to the extraboard's maximum spread, unless otherwise specified.)

3. Guarantee a minimum percentage of straights to set a lower limit on the ratio of straight runs to split runs. For example, a typical contract might specify that at least 60% of the regular runs must be straight runs.

There are a number of ways by which a run cutter can remedy a run cut which violates this constraint. Some contracts allow a sleight-of-hand maneuver whereby certain split runs are redesignated as extraboard work, rather than regular runs. If this option is not permitted, then some split runs must be paid "straight through," i.e., the driver is paid for the break between the two pieces of work as well. When this happens, there is a strong temptation for management to lengthen the bus schedule so as to fill in the break -- since the driver is paid in any case, why not keep the bus on the street? This kind of feedback between scheduling and work rules is hard to detect, since it is not always easy to assess the amount of "excess" midday service. We have therefore focused our attention on the two types of spread rules.

PATTERNS AND TRENDS IN SPREAD RULES

The general trend in recent labor contract negotiations has been toward more restrictive spread rules. Spread premium time and maximum spread time are being reduced, or else they are being instituted for the first time at properties which had no previous limitations. This trend is illustrated in Table 5-1, which compares spread provisions in force during 1976 and 1979 for the forty-seven districts surveyed in APTA's Transit Labor Information Review for both years. The tables cross-classify districts by the spread premium time and by the maximum spread time for extraboard runs. In 1976, only nine of the districts had an applicable maximum spread restriction in their contracts. Three years later, fourteen districts had such a restriction. In 1976, thirty-two of the districts paid spread premiums; by 1979, six more districts had adopted such provisions.

Summaries of spread rules in effect during 1979 are presented in Tables 5-2 and 5-3. For extraboard work, the median spread penalty time was between twelve and thirteen hours. More than half the contracts surveyed had no maximum spread for extraboard work.

Spread rules for regular runs were more stringent than those for non-run work. The median spread-premium time was between eleven and twelve hours. The median maximum-spread time was between thirteen and fourteen hours.

Table 5-1

NUMBER OF TRANSIT CONTRACTS WITH PROVISIONS FOR MAXIMUM SPREAD OR SPREAD PREMIUM ON THEIR EXTRABOARDS

1976

SPREAD PREMIUM	MAXIMUM SPREAD: Provision	MAXIMUM SPREAD: No Provision
Provision	9	23
No Provision	0	15

1979

SPREAD PREMIUM	MAXIMUM SPREAD: Provision	MAXIMUM SPREAD: No Provision
Provision	14	24
No Provision	0	9

Table 5-2

EXTRABOARD SPREAD RULES, 1979

(# Of Transit Districts In Each Category

SPREAD PREMIUM	MAXIMUM SPREAD TIME 10-10:59	11-11:59	12-12:59	13-13:59	14-14:59	15+ or No Provision	Row Totals
8-8:59						3	3
9-9:59							0
10-10:59		1	2	3	2	7	15
11-11:59		1	1	2	2	7	13
12-12:59		1	2	1		11	15
13-13:59				1		2	3
14-14:59							0
15+ or No Provision				1	1	25	27
Column Totals	0	3	5	8	5	55	76

Table 5-3

SPREAD RULES, REGULAR RUNS, 1979

(# Of Transit Districts In Each Category)

SPREAD PREMIUM	MAXIMUM SPREAD TIME 10-10:59	11-11:59	12-12:59	13-13:59	14-14:59	15+ or No Provision	Row Totals
8-8:59						1	1
9-9:59							0
10-10:59		1	9	7	2	7	26
11-11:59	1	1	4	6	2	8	22
12-12:59			3	7	1	12	23
13-13:59				1	1	2	4
14-14:59							0
15+ or No Provision	1			3		7	11
Column Totals	2	2	16	24	6	37	87

The labor cost of providing bus service depends importantly upon the interactions between maximum spread time, spread penalty time, and the peakedness of service. Qualitatively, certain relationships are clear:

-- For a given service schedule, a decrease in the spread penalty time will increase the number of of runs eligible for spread premium, and increases the premium paid per run.

-- Likewise, for a given service schedule, a decrease in maximum spread will limit the number of split runs; and work which formerly could have been scheduled as a split run must now be broken into two expensive trippers (see APPENDIX C: THE COST OF TRIPPERS).

-- For a given set of spread rules, increased peak/base ratio (or inter-peak time) will increase the proportion of runs subject to spread penalty, and will increase the proportion of trippers which cannot be incorporated into regular runs.

Thus, costs are positively related to the peak/base ratio and negatively related to spread penalty time and maximum spread time.

Our goal was to quantify these interrelations. Our motivations were twofold. First, we hoped that studying the effect of increased peak service would illuminate the controversy concerning load-shedding. Second, we suspected that a precise understanding of cost tradeoffs between spread penalty time and maximum spread time might allow the formulation of work rules which benefit both management and labor. Labor's goal is desirable work-assignments, management is trying to minimize costs; the two goals are not necessarily diametrically opposed.

ANALYSIS OF SPREAD RULE CHANGES

General results

We chose three combinations of spread rules for experimentation. They are: 13/12, i.e. 13 hours maximum spread, with premium pay after 12 hours of spread; 13/10; and 12/10. The maximum spread is assumed to apply to both extraboard and regular drivers.

The 12/10 combination is stringent, by current standards, while the 13/12 is more lenient than most current contracts (see Table 5-2). The intermediate combination, 13/10, was chosen to allow evaluation of the effects of changing just one of the spread rules, while keeping the other constant.

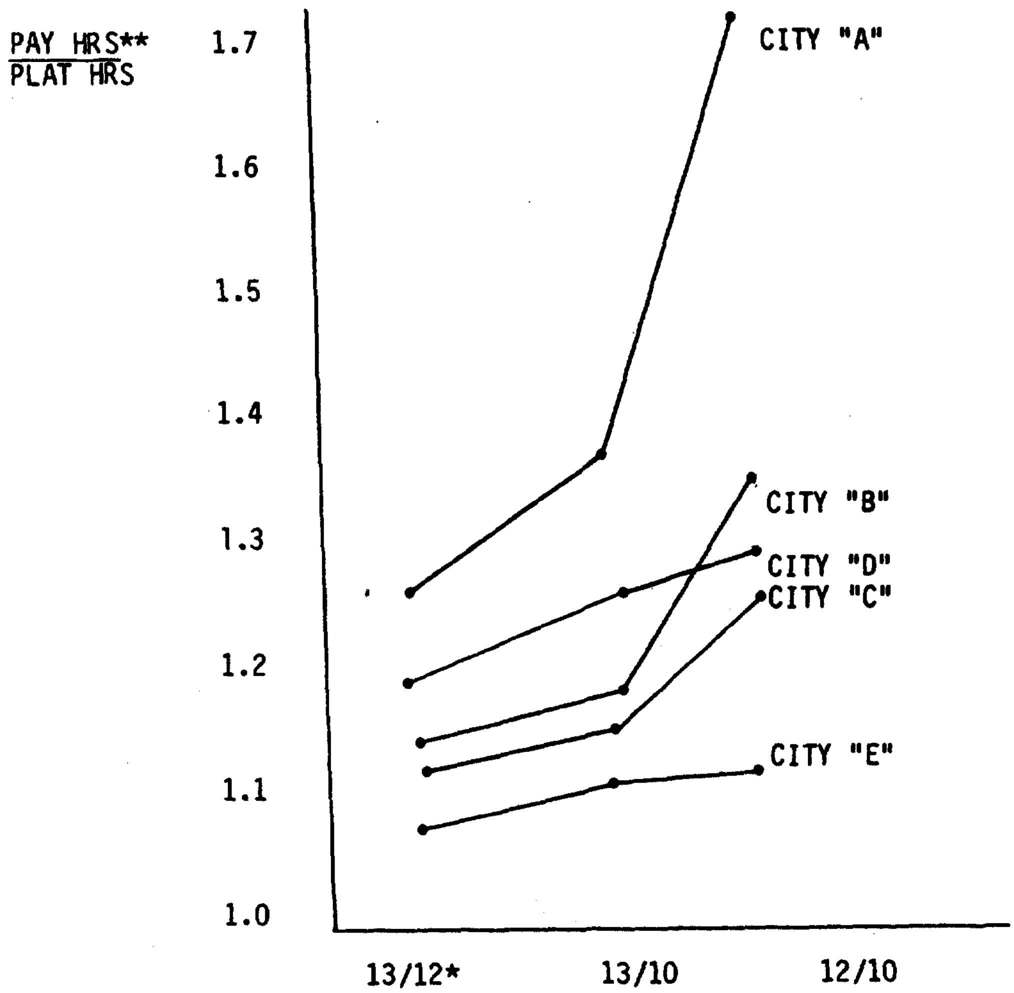
The overall results of our run cuts are summarized in Figure 5-1. (More detailed versions of these figures may be found in Appendix E.) The vertical axis shows a measure of inefficiency, the ratio of pay-hours to platform-hours. For example, suppose that some run covered both the daily peaks for a total of six platform hours of service, and that because of spread penalties and make-up time, the driver received nine hours of pay for the run: thus the pay/platform ratio would be 9/6 or 1.5; and a perfectly efficient run would have a ratio of 1.0. This ratio can be calculated for any transit district (averaging over all its runs) at a specific point in time, and we can look at the effect of work rule changes on the ratio: changes which decrease the ratio will decrease the transit operating deficit and vice versa.

Examine the top line in Figure 5-1, which describes City "A". Under a 13/10 set of work rules its inefficiency ratio is about 1.4; but a one hour reduction in maximum spread time, to 12/10, increases the pay/platform ratio to about 1.7, a very substantial change. A liberalization of work rules that decreased the spread premium time by two hours, to 13/12, would improve the pay/platform ratio to about 1.26. Looking at the five districts over a single set of work rules, say 13/10, we can see that they are each operating at substantially different inefficiency levels and that these correspond roughly to their peak/base ratios. Notice also that the slope of the line for each city, the measure of sensitivity to work rule changes, also corresponds roughly to the peak/base ratios: City "A" has a very high peak/base ratio and is very sensitive to work rule changes; while City "E", with a flat profile, is relatively insensitive to contract changes. This produces the result that City "E" can afford to experiment with work rule changes but has little incentive to do so since it is already relatively efficient, while City "A" has very high incentive to experiment, but must do so very carefully.

(The exception to these generalizations, and to many of the other generalizations below, is City "D". Although the shape of its response curve in Figure 5-1 is intermediate between "C" and "E", where its peak/base ratio predicts it should be, the level of this curve is too high. That is, for some given set of work rules, say the 13/10 rules, its inefficiency ratio is

Figure 5-1

PAY HRS ** / PLAT HRS AS A FUNCTION OF SPREAD RULES



*13/12 means 13 hours maximum spread time and a 12 hour spread penalty time.

**Pay hours including wages and bonuses, excluding fringe benefits.

higher than would be expected. We think this is a result of the peculiar block structure of City "D": It has a markedly atypical set of work rules--by the norms of the average APTA property--and its schedulers have produced an unusual set of blocks to adapt to these peculiar rules. The end result is that when we take the existing "D" blocks and apply our standard set of rules to them with our standard COST routine, we produce a run cut of much lower efficiency than would be expected.)

The general lesson is easy to see: tightened work rules mean increased costs. In the next two sections, we examine these results in detail.

<u>Spread premium time</u>

The effect of changing the spread premium time from twelve to ten hours is illustrated in Figure 5-2. The vertical axis shows the percentage cost increase associated with the two hour change in spread premium for each of the transit districts on the horizontal axis. In City "A" costs, including fringe benefits, increased 7%, while at City "E" costs increased only 3%. The other districts fell in between. The size of these spread premium impacts is strongly related to peak/base ratio -- compare Figures 5-2 and 5-3. This is a reasonable result since we would expect that a district with a higher peak/base ratio would have a larger percentage of runs subject to the spread premium.

Although the change in spread premium time significantly affected cost, the staffing requirements were virtually unaffected. For no district was there a change of more than one operator between the 13/12 and 13/10 run cuts. That is, the optimal run cut did not change much, only its associated pay cost.

<u>Maximum Spread Time</u>

The most striking feature of this set of run cuts is the differential effect of reducing maximum spread time from thirteen hours to twelve. While the reduction has no effect at all on the district with the lowest peak/base ratio, City "E", it boosts costs a tremendous 23% at the peakiest district, City "A". The difference in impact stems from differential proportions of "unpairable" trippers in the two districts. (A tripper is a short bus run, e.g. 4-7pm, left over after all the other runs have been cut. The optimal

Figure 5-2

EFFECT OF CHANGING SPREAD PREMIUM TIME 13/12 TO 13/10, FULLTIME

```
                   10
                    9
                    8
                    7    ***
                         ***
                    6    ***
                         ***
% COST              5    ***      ***
INCREASE                 ***      ***
                    4    ***      ***      ***      ***
including                ***      ***      ***      ***
fringes             3    ***      ***      ***      ***      ***
                         ***      ***      ***      ***      ***
                    2    ***      ***      ***      ***      ***
                         ***      ***      ***      ***      ***
                    1    ***      ***      ***      ***      ***
                         ***      ***      ***      ***      ***
                         "A"      "B"      "C"      "D"      "E"
```

Figure 5-3

PEAK/BASE RATIO

```
                    4
                         ***
peak buses               ***
base buses          3    ***
                         ***      ***
                         ***      ***               ***
                    2    ***      ***      ***      ***
                         ***      ***      ***      ***
                         ***      ***      ***      ***      ***
                    1    ***      ***      ***      ***      ***
                         ***      ***      ***      ***      ***
                         "A"      "B"      "C"      "D"      "E"
```

way of handling such trippers, and their resultant cost is discussed in Appendix C. One of the cheaper ways of handling them, though, is to pair a morning tripper and an evening tripper and assign them to a single driver on the extraboard. However, in many cases such pairing will prove impossible because of restrictions on the maximum spread time since the given start and stop times produce a work shift of illegal length. Hence each of the unpairable trippers must be assigned to a single driver and the resultant run will have a very high ratio of pay-hours to platform-hours because the drivers must receive so much makeup pay.)

The ratio of unpairable trippers to regular runs (counting each pair of pairable-trippers as a single regular run) is shown in Figure 5-6 for 12/10 run cuts. This ratio closely parallels the peak/base ratio, though there is one slight anomaly for City "D" due to the vagaries of block-scheduling discussed on page 42.

Unpairable trippers are expensive because they each require a full-time driver. Thus a decrease in maximum spread time, by making it more difficult to pairup trippers, will boost driver requirements and hence, costs. The effects of decreased maximum spread time on number of operators is shown in Figure 5-5. Note, comparing 5-4 and 5-5, that the number of operators increases more rapidly than cost. This is because with narrower spreads, fewer runs earn spread premiums. Thus pay hours per driver decrease, while pay hours per platform hour increase.

Figure 5-4

EFFECT OF DECREASING MAXIMUM SPREAD TIME 13/10 TO 12/10

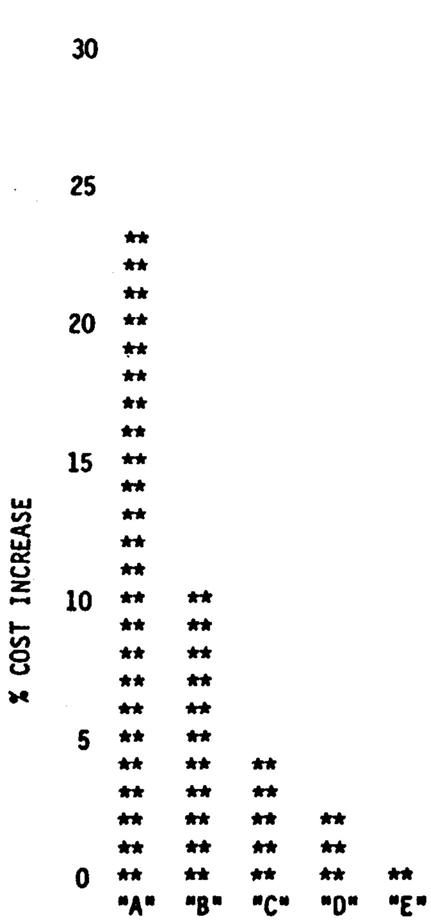


Figure 5-5

EFFECT OF DECREASED SPREAD ON NUMBER OF OPERATORS REQUIRED

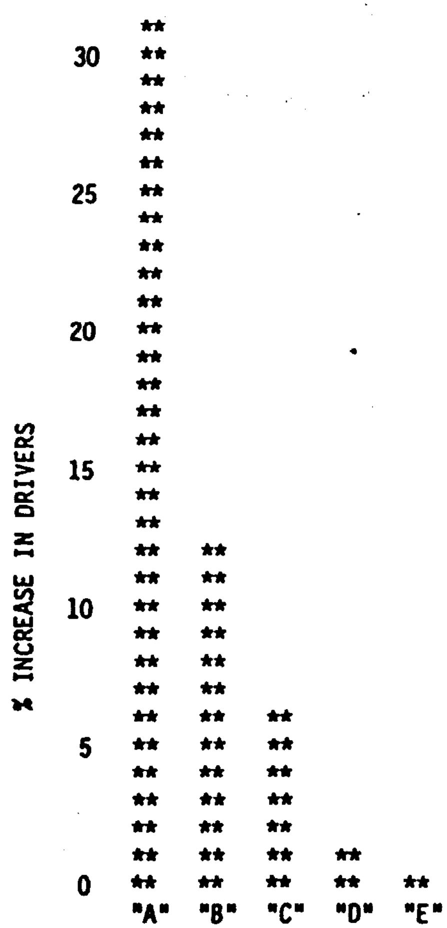
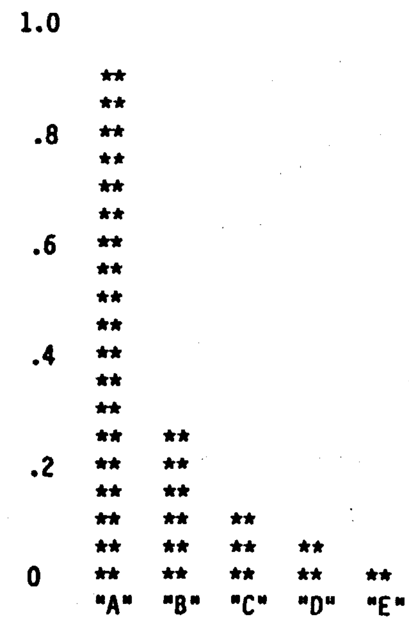


Figure 5-6

#TRIPPERS / #RUNS, 12/10



CHAPTER 6
SAVINGS FROM PART TIME DRIVERS

Part-time labor is not a new idea in transit, though in the near-term past its use was generally confined to smaller transit districts. The current interest in it stems from Seattle METRO's 1977 contract which granted them the right to use up to "100%" part-time drivers, i.e. they can have an equal number of part- and full-time drivers. A number of other transit districts won the right to use 10% part-time drivers in the ensuing years (Miami, WMATA, Baltimore, Twin Cities, and Portland) and 1979 saw a whole spate of part-time contract awards in California, in large part because of the passage of a state law which said the state would reduce transit subsidies to any district that did not have a provision for part-time labor in its contract.

At first glance it would seem that use of part-time labor will benefit both the drivers and the transit district. Full-time drivers are spared the burden of runs with large spread times, and the district saves money on spread premiums and make-up pay. Drivers who only want to work part-time, can be assigned peak hour work; drivers who want to work full-time can have decent work shifts.

The unions find flaws in this argument. The long spreads currently worked by full-time drivers involve substantial amounts of compensatory pay and (at least some) drivers would rather have the extra pay than the better work shifts. Some drivers are concerned that part-timers will be substituted for regular drivers, leading to layoffs (although management has been willing to give guarantees that this will not happen). Some drivers are inherently suspicious of any idea that comes from management. And some drivers are uneasy about the introduction of a new and disparate group of members, and are concerned about the reliability and competence of the part-time drivers.

We address the question of part-time driver reliability in Appendix D. (Preliminary evidence shows that they are very reliable.) Our concern here is with the potential savings from the adoption of part-time labor. What are the tradeoffs between the use of part-time labor and changes in spread rules?

Rules About Part-Time Labor

The labor contracts which permit part-time labor always place very strict constraints on how it can be used. Most importantly, the number of part-time drivers is generally restricted to a small percentage of the number of full-time drivers, e.g. a typical restriction is to limit part-time drivers to 10% of the regular drivers. In addition, part-time drivers are usually restricted to certain types and lengths of runs, e.g. garage to garage runs of 4 hours or less. (On the other hand, part-time drivers' fringe benefits are usually inferior to those of full-time drivers.) Current work-rules relating to part-time labor are summarized, by transit system, in Table 6-1

For our simulations, we chose a set of part-time work rules which were representative of existing contracts, and were also easily compatible with our run-cutting machinery.

These rules include:

1. Maximum part-time force equivalent to 10% of the number of full-time drivers. (For comparison, we raised the maximum to 20% in a second set of simulations.)
2. One piece per part-time driver.
3. Maximum of six hours work per day; no minimum guarantee.
4. Part-time drivers may make road reliefs (that is, they are not restricted to trippers which begin and end in the garage).

Some of these rules deserve comment. Most districts restrict part-time drivers to garage-to-garage trippers. We are more liberal, allowing part-time operators to work any short piece. This was done for ease of run cutting, but should not have a major effect on the overall cost of service.

The one-piece-per driver rule is more restrictive than the industry standard: most districts permit part-time drivers to work two pieces, though all of them will not be able to do so, in practice, because of restrictions on their total platform hours and maximum spread time. So we

Table 6-1

CURRENT PART-TIME WORK RULES

	BALTIMORE M.T.A.	DADE CO. TRAN AGEN	TRI-MET TRAN DIST	SACRAMENTO REG TRANS DIST	SAN DIEGO TRAN CORP	SEATTLE METRO	TWIN CITIES AREA M.T.C.	WMATA
NUMBER OF PART-TIME ALLOWED AS % OF FULLTIME DRIVERS	10%	10% (1,2)	10%	10%	10%	100% (2)	10%	10%
MINIMUM WORK HOURS GUARANTEE	NONE	1 1/2 HRS PER TRIPPER	2 HRS PER TRIPPER	NONE	NONE	1 1/2 HRS PER. TRIPPER	NONE	NONE
MAXIMUM ALLOWABLE PLATFORM TIME	30 HRS/ WEEK	24 HRS/ WEEK	3 HRS/ TRIPPER	30 HRS/ WEEK	25 HR/WK 5 HR/DAY		30 HRS/ WEEK	30 HRS/ WEEK
TYPE OF WORK	TRIPPERS	TRIPPERS	TRIPPERS	TRIPPERS	TRIPPERS	TRIPPERS	TRIPPERS	TRIPPERS
PT DRIVER MAY WORK TWO PIECES	YES	YES	YES	YES	YES	YES	YES	YES
MAXIMUM SPREAD RESTRICTION	NONE	NONE	13 HRS	NONE	11 1/2 HRS	NONE	NONE	NONE
UNIFORM ALLOWANCE	YES	YES*	YES	YES	YES	YES	YES	YES
HOLIDAY PAY	NO	NO	YES*(3)	NO	NO	NO	NO	NO
SICK LEAVE	NO	YES*	NO	NO	NO	NO	NO	NO
VACATION LEAVE	NO	YES*	YES*(4)	YES*	NO	NO	NO	NO
PENSION/RETIREMENT PLAN	NO	NO	YES*(5)	NO	NO	NO	NO	NO

* EARNED ON A PRO RATA BASIS
(1) PER PEAK PERIOD; I.E., DISTRICT IS PERMITTED 10% DOUBLE-PEAK OF 20% SINGLE-PEAK DRIVERS
(2) MINIMUM NUMBER OF BIDDABLE TRIPPERS GUARANTEED TO FULLTIME DRIVERS
(3) AFTER 12 MONTHS OF EMPLOYMENT
(4) AFTER 2 YEARS OF EMPLOYMENT
(5) AFTER 5 YEARS OF EMPLOYMENT, RETROACTIVE TO START OF EMPLOYMENT

have computed the effects of employing either a 10% or 20% quota of one-piece part-time drivers. Thus for the usual 10% contract limit, if a given district has very restrictive work rules regarding its part-time drivers, then the result will correspond to our 10% analysis. If the district has very liberal restrictions then the result will correspond to our 20% analysis.

ANALYSIS OF PART-TIME LABOR

General

For each of the three combinations of work rules (13/12, 13/10, 12/10: 12/10 is 12 hours maximum spread time, with spread premium pay after 10 hours) three part-time scenarios were costed out: no part-time permitted; up to 10% part-time; up to 20% part-time. (The Glossary at the back of the report has illustrations of these key terms.) Thus nine sets of work rules were examined for each of the five properties.

(Details: the percentage restriction is computed as a fraction of the total driver labor force. A district with 800 drivers on regular runs plus 200 drivers on the extra board could hire 100 part-time drivers under a 10% contract. A critical question here is how many trippers can be covered by these 100 part-time drivers. Our assumption was that each driver would work only one tripper. Some part-time contracts do limit the drivers to a single tripper, some make no mention of an explicit restriction. However even in those cases where there is no explicit restriction on number of trippers, all part-time drivers will not be able to work two trippers per day; there are still restrictions on the total number of hours a part-time driver may work, and sometimes restrictions on the maximum spread as well (see Table 6-1). For a typical contract with 10% part-timers allowed, if a given transit district has relatively restrictive rules on the maximum spread for part-time drivers, or if its trippers are long relative to the permitted daily platform time, then an analysis of its contract would correspond to our 10% case. On the other hand, for a district whose trippers are short relative to the permitted daily platform time, and whose spread restrictions are relatively liberal, then the typical 10% part-time contract corresponds to our 20% analysis.)

The results of our simulations are summarized in Figures 6-1 and 6-7. (More detailed versions of these tables may be found in Appendix E.) Figures 6-1 through 6-3 show the change in the inefficiency ratio, pay-hours divided by platform-hours, as a function of the amount of part-time labor used, and also of the context of both the other work rules. Inefficiency declines as the proportion of part-time drivers increases, and the improvement is greater when the context of the other work rules is more restrictive -- which are both expected results. The relative ranking of the five properties by peak/base ratios is also as expected, with the exception of City "D" for the reasons discussed on page 42.

The direct measure of the effect of part-time labor is the percentage savings in operator costs, shown in Figures 6-4 through 6-6. See also Appendix E. The three figures illustrate the sensitivity of savings to the restrictiveness of other work rules; with 6-6 being the most restrictive. We see that the greatest savings are associated with the most restrictive spread-rule contexts. The work rules analyzed in Figure 6-4 are probably most typical of those found in the United States (see Table 5-3), and for these work rules part-time labor reduces operator costs by 4-7%, with the greatest savings associated with the highest peak/base ratios.

Trippers again play the key role in determining cost-savings. The greater the number of otherwise unpairable trippers that can be assigned to part-time drivers, the greater the savings. This is shown by a comparison of Figures 6-6 and 6-7. Note, however, that although City "A" has more trippers than City "B", part-time has similar effects at both districts. This is because the number of part-time operators permitted is much less than the number of unpairable trippers (20% part-time is not enough at City "A"); if there were no such limit, City "A" would be able to realize much greater proportional savings.

These savings-estimates represent, in our opinion, the upper limit of available savings from part-time operators; further restrictions on the use of part-time labor could drastically whittle down the possible savings, as will be discussed in the concluding chapter.

Figure 6-1
PAY HOURS/PLATFORM HOURS
(INCLUDING FRINGES)

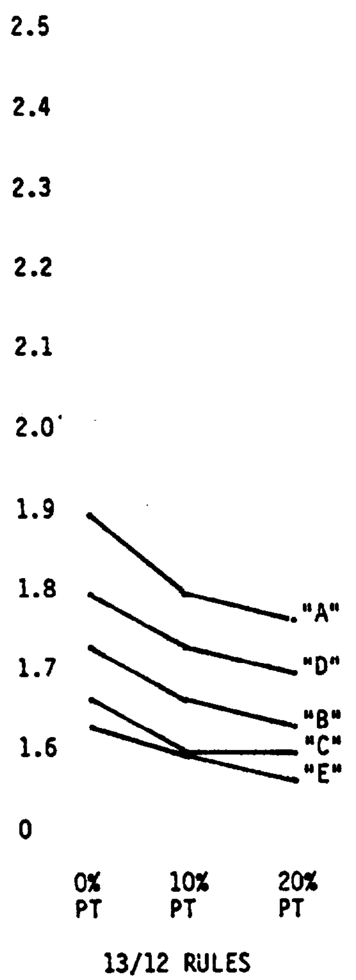


Figure 6-2
PAY HOURS/PLATFORM HOURS
(INCLUDING FRINGES)

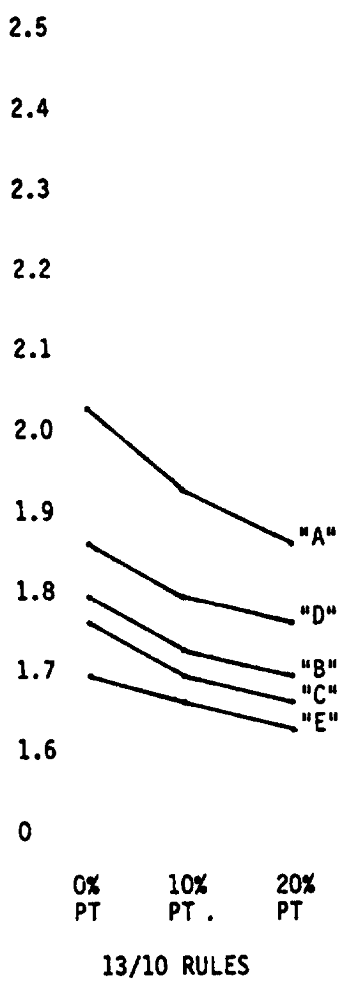


Figure 6-3
PAY HOURS/PLATFORM HOURS
(INCLUDING FRINGES)

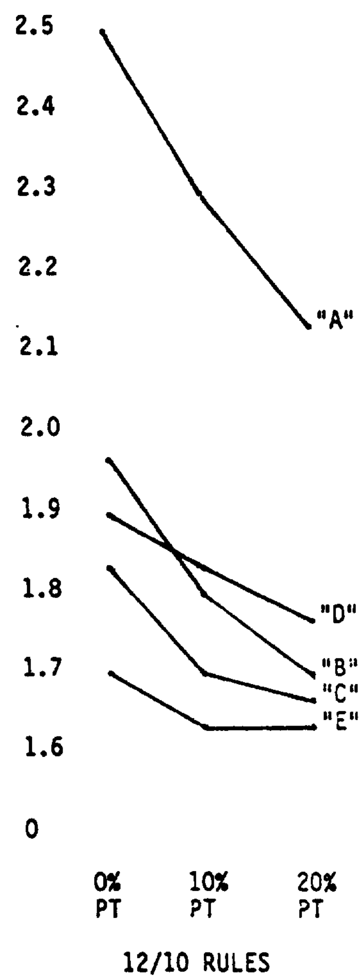


Figure 6-4

SAVINGS FROM IMPLEMENTING PART-TIME (RELATIVE TO 13/12, NO PART-TIME)

```
                                                            ( 000
                                                  20% PT    | 000
                                                            | 000
                                                            { 000
                                                            | ***  )
                                                            | ***  }   10%
           10                                               ( ***  )

% SAVINGS       000
                000                 000
            5   000        000      000        000
                ***        000      ***        000       000
                ***        ***      ***        ***       ***
                ***        ***      ***        ***       ***
                ***        ***      ***        ***       ***
            0   ***        ***      ***        ***       ***

                "A"        "B"      "C"        "D"       "E"
```

Figure 6-5

SAVINGS FROM IMPLEMENTING PART-TIME (RELATIVE TO 13/10, NO PART-TIME)

```
                                                            ( 000
                                                  20% PT    | 000
                                                            | 000
                                                            { 000
                                                            | ***  )
                                                            | ***  }   10%
           10                                               ( ***  )

                000
% SAVINGS       000
                000        000      000        000
            5   ***        000      000        000       000
                ***        ***      ***        000       000
                ***        ***      ***        ***       ***
                ***        ***      ***        ***       ***
                ***        ***      ***        ***       ***
            0   ***        ***      ***        ***       ***

                "A"        "B"      "C"        "D"       "E"
```

Figure 6-6

SAVINGS FROM IMPLEMENTING PART-TIME (RELATIVE TO 12/10, NO PART-TIME)

```
                                                               ( 000
           15   000                                  20% PT   | 000
                000                                           | 000
                000      000                                  { 000
                000      000                                  | ***  )
                000      000                                  | ***  }  10% PT
           10   000      000      000                         ( ***  )
                000      000      000
                000      000      000
% SAVINGS       ***      ***      000      000
                ***      ***      ***      000
            5   ***      ***      ***      000      000
                ***      ***      ***      ***      000
                ***      ***      ***      ***      ***
                ***      ***      ***      ***      ***
                ***      ***      ***      ***      ***
            0   ***      ***      ***      ***      ***

                "A"      "B"      "C"      "D"      "E"
```

Figure 6-7

TRIPPERS/# RUNS, 12/10

```
          1.0

                ***
                ***
           .8   ***
                ***
                ***
                ***
           .6   ***
# TRIPPERS      ***
---------
# RUNS          ***
                ***
           .4   ***
                ***
                ***
                ***      ***
           .2   ***      ***
                ***      ***
                ***      ***      ***
          0     ***      ***      ***      ***      ***

                "A"      "B"      "C"      "D"      "E"
```

Effect of spread rules

Part-time labor offers the greatest cost reduction for those districts where stringent maximum spread time restrictions have generated large numbers of unpairable trippers. Figures 6-8 and 6-9 (for 10% and 20% part-time drivers, respectively) show that savings are much greater for 12/10 rules than for 13/10 or 13/12, though their relationship becomes less pronounced at less peaky districts.

Effect of fringe benefits

At many districts, part-time drivers receive lower fringe benefits than full-time drivers (see Table 6-1). Figure 6-10 illustrates the extent to which part-time labor's cost advantage is attributable to scrimping on fringe benefits, rather than reducing the ratio of pay-hours to platform-hours. The shaded portions of the bar graphs represent the level of savings that would be realized if part-time operators received full fringes, including proportional vacations and pensions. The unshaded portions show the additional savings realized by eliminating all part-time fringes except social security and unemployment insurance. The difference is a fairly constant 2% of the total cost of service.

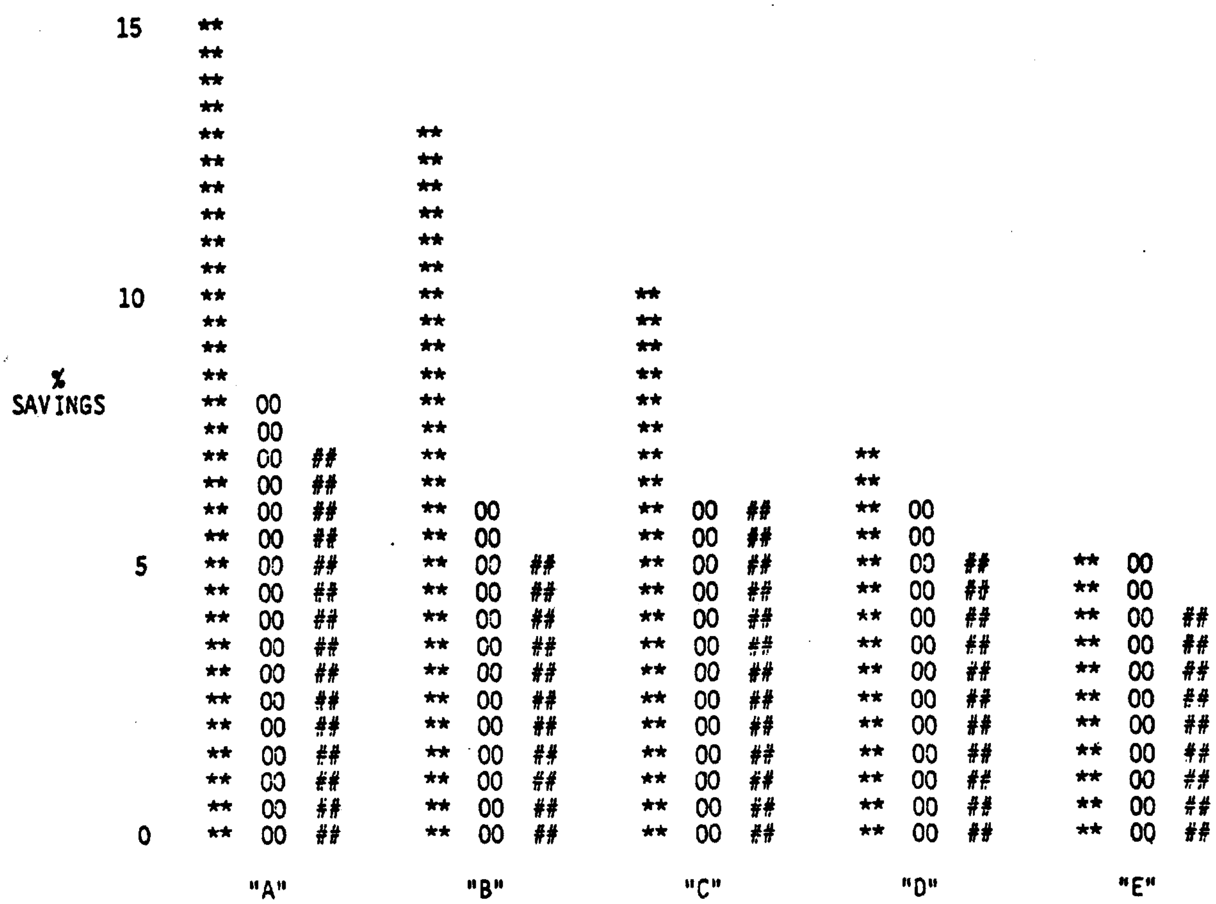
Figure 6-8

EFFECT OF SPREAD RULES ON SAVINGS FROM 10% PART-TIME (FRINGES INCLUDED)

```
           10



                  **                **
                  **                **
                  **                **
                  **                **
                  **                **                **
      %           **                **                **
SAVINGS    5      **   00           **                **
                  **   00           **                **
                  **   00   ##      **   00           **   00   ##      **
                  **   00   ##      **   00           **   00   ##      **
                  **   00   ##      **   00   ##      **   00   ##      **   00   ##      **   00   ##
                  **   00   ##      **   00   ##      **   00   ##      **   00   ##      **   00   ##
                  **   00   ##      **   00   ##      **   00   ##      **   00   ##      **   00   ##
                  **   00   ##      **   00   ##      **   00   ##      **   00   ##      **   00   ##
                  **   00   ##      **   00   ##      **   00   ##      **   00   ##      **   00   ##
                  **   00   ##      **   00   ##      **   00   ##      **   00   ##      **   00   ##
           0      **   00   ##      **   00   ##      **   00   ##      **   00   ##      **   00   ##

                      "A"               "B"               "C"               "D"               "E"


      12/10   13/10   13/12
       **      00      ##
       **      00      ##
       **      00      ##
```

Figure 6-9

EFFECT OF SPREAD RULES ON SAVINGS FROM 20% PART-TIME (FRINGES INCLUDED)



12/10	13/10	13/12
**	00	##
**	00	##
**	00	##

Figure 6-10

SAVINGS FROM 20% PART-TIME (RELATIVE TO 12/10, NO PART-TIME)

AS A FUNCTION OF FRINGE BENEFITS ALLOWED

```
          15  000
              000                                              000 )
          14  000                                              000 }
              000                                              000 {  SAVINGS:
          13  ***       000                                  ( *** >  PT @ 10%
              ***       000                    SAVINGS:      } *** {  FRINGES
          12  ***       000                    PT @ 50%      { *** }
              ***       000                    FRINGES       ( *** )
          11  ***       ***
              ***       ***
          10  ***       ***       000
              ***       ***       000
           9  ***       ***       000
 %            ***       ***       000
SAVINGS    8  ***       ***       ***
              ***       ***       ***
           7  ***       ***       ***       000
              ***       ***       ***       000
           6  ***       ***       ***       ***
              ***       ***       ***       ***
           5  ***       ***       ***       ***       000
              ***       ***       ***       ***       000
           4  ***       ***       ***       ***       000
              ***       ***       ***       ***       000
           3  ***       ***       ***       ***       000
              ***       ***       ***       ***       000
           2  ***       ***       ***       ***       ***
              ***       ***       ***       ***       ***
           1  ***       ***       ***       ***       ***
              ***       ***       ***       ***       ***
           0  ***       ***       ***       ***       ***

              "A"       "B"       "C"       "D"       "E"
```

CHAPTER 7

NEGOTIATING WORK RULE CHANGES: A MODEL OF TRANSIT COSTS

The kinds of work rule changes discussed can only be implemented through the collective bargaining process, the give and take of negotiation. If management wants the right to change spread-rules, or to use part-time labor, it must be prepared to offer something that labor wants in return. The exact exchange will be determined by a variety of economic and non-economic factors too complex to model here. However, some insight can be gained by looking at the outcome of a greatly simplified version of the bargaining process.

We assume that the bargaining process will involve management trading a particular rate of future wage gains in return for labor giving management the right to make certain work rule changes. For example, suppose that management wants to use part-time labor to operate trippers, and that this change would yield a 5% reduction in total driver pay hours. The union opposes the change because "it takes away our overtime pay and gives it to the part-timers"; and they are likely to demand an increase in the base wage rate as compensation for the loss in take home pay. Management will probably be willing to give some increase in the base wage to compensate for the change; after all, if they can achieve a 5% reduction in total driver pay hours, then an extra wage increase of, say, 1% seems a reasonable tradeoff. (As evidence that such bargaining actually occurs in the real world, we note that during the 1980 New York City transit strike, a senior executive officer of the transit system was quoted as stating that he would promise higher than average wage rate[1] increases in order to compensate the drivers for giving him the right to use part-time labor in their new contract.)

Obviously the same kind of bargaining, and the same arguments would apply to a situation where management wanted to use part-time drivers to cover regular runs with very long spreads (hence high penalty payments); and the increase in the base wage would be compensation for reducing the driver's spread-premium income.

---

[1]"Transit talks heat up in New York as strike deadline draws near," Wall Street Journal, March 26, 1980, p. 32.

To evaluate the overall effect of these kinds of bargaining tradeoffs we need a model of transit operating cost so that the relevant short- and long-term consequences of the contract can be calculated. We develop such a model in the next section.

A Simple Model of Transit Costs

In a survey of 36 transit properties, Sproull[2] found the following median cost relationships:

DC = driver's costs = .5 (total cost)

ND = non-driver labor = .3 (total cost)

M = materials and other non-labor costs = .2 (total costs)

Hence for a median transit property

TC = DC + ND + M

100 = 50 + 30 + 20

Assume that the result of some innovation is to reduce the number of driver pay hours by s percent. Thus the new cost would be (1 - s) x 50; also assume that both of the labor components would normally be expected to grow by some yearly percentage rate, d and n, respectively; where, for example, a 1% yearly growth in driver wages would imply d = 1.01.

Thus we can rewrite the equation as:

$$TC = d\,(1 - s) \times 50 + n \times 30 + 20$$

That is, a labor negotiation causes a one-shot reduction in driver pay-hours, and after that the components go on growing as usual.

Note that only the incremental increase over any trend increase in wages due to inflationary effects, maintaining parity with other categories of workers, etc., is modeled here. Additional coefficients to take account of inflation and general wage trends could be incorporated in the model, but this would only complicate the algebra without affecting the analysis. Thus a 1% wage increase in this model means a change of 1% over and above any general increase which labor would normally have expected to receive.

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[2]William C. Sproull, A method for evaluating the relationship of research, development and demonstration programs to operator labor cost components in bus transit systems. (Doctoral dissertation, American University, 1973), Chapter 2.

For purposes of this analysis we assume that d = n; that is, the yearly rate of wage increase for drivers and other personnel is the same. (In fact, sometimes the percentage increase for non-drivers tends to be even larger, as when a lump sum amount negotiated for drivers is given to other personnel as well.)

Thus the equation now becomes,

TC = d((1 - s) x 50 + 30) + 20.

<u>Cost Savings Versus Wage Increases: The Tradeoffs</u>

Table 7-1 presents projected yearly costs from this model under a variety of different assumptions about the amount of savings that might result from work rule changes, and a variety of assumptions about how much management will have to give up in the form of greater wage increases in order to obtain the right to make these changes. The table explores the interaction between cost saving and wage increase in order to calculate the net effect. We look at work rule changes that reduce operator costs by 3%, 6%, 9%, 12%, and 15%. And we contrast these to a variety of possible wage increase bargains:

a) a 3% per year extra increase in the base wage for the length of the contract (assumed to be three years), then no extra increase during subsequent contracts;
b) a 2.5% per year extra increase for the contract period;
c) a 2% per year extra increase for the contract period;
d) a 2% per year increase for the contract period, followed by a 1% per year increase during the second contract period (because labor brings up the work-rule change again, and makes an issue of it again), then no extra increase during subsequent contracts;
e) a 1.5% per year increase during the first contract period, followed by the 1% per year increase during the second period, then no extra increase during subsequent contracts;
f) a 1.5% per year increase during first contract period only;
g) a 1% per year increase during the first two contract periods only;
h) a 1% per year increase during the first contract, followed by a 0.5% per year increase during the second period, then no extra increase during subsequent contracts; and
i) a 1% per year increase for the first contract only.

Table 7-1

NET EFFECT OF NEW CONTRACT

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
BASE CASE: No wage increase, and no reduction in driver pay hours.	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3% per year compensating increase in base wage during first contract period, 0% from then on.							
Case # 1: 3% reduction in driver pay hours	100.9	103.3	105.8	105.8	105.8	105.8	105.8
Case # 2: 6% reduction in driver pay hours	99.3	101.7	104.1	104.1	104.1	104.1	104.1
Case # 3: 9% reduction in driver pay hours	97.8	100.1	102.5	102.5	102.5	102.5	102.5
Case # 4: 12% reduction in driver pay hours	96.2	98.5	100.9	100.9	100.9	100.9	100.9
Case # 5: 15% reduction in driver pay hours	94.7	96.9	99.2	99.2	99.2	99.2	99.2
2.5% per year compensating increase in base wage during first contract period, 0% from then on.							
Case # 6: 3% reduction in driver pay hours	100.5	102.5	104.5	104.5	104.5	104.5	104.5
Case # 7: 6% reduction in driver pay hours	98.9	100.9	102.9	102.9	102.9	102.9	102.9
Case # 8: 9% reduction in driver pay hours	97.4	99.3	101.3	101.3	101.3	101.3	101.3
Case # 9: 12% reduction in driver pay hours	95.9	97.7	99.7	99.7	99.7	99.7	99.7
Case #10: 15% reduction in driver pay hours	94.3	96.2	98.1	98.1	98.1	98.1	98.1
2% per year compensating increase in base wage during first contract period, 0% from then on.							
Case #11: 3% reduction in driver pay hours	100.1	101.7	103.3	103.3	103.3	103.3	103.3
Case #12: 6% reduction in driver pay hours	98.5	100.1	101.7	101.7	101.7	101.7	101.7
Case #13: 9% reduction in driver pay hours	97.0	98.6	100.1	100.1	100.1	100.1	100.1
Case #14: 12% reduction in driver pay hours	95.5	97.0	98.5	98.5	98.5	98.5	98.5
Case #15: 15% reduction in driver pay hours	93.9	95.4	96.9	96.9	96.9	96.9	96.9

Table 7-1

NET EFFECT OF NEW CONTRACT (Cont'd.)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
2% per year compensating increase in base wage during first contract period, 1% per year for second contract period, 0% from then on.							
Case #16: 3% reduction in driver pay hours	100.1	101.7	103.3	104.1	105.0	105.8	105.8
Case #17: 6% reduction in driver pay hours	98.5	100.1	101.7	102.5	103.4	104.2	104.2
Case #18: 9% reduction in driver pay hours	97.0	98.6	100.1	100.9	101.7	102.5	102.5
Case #19: 12% reduction in driver pay hours	95.5	97.0	98.5	99.3	100.1	100.9	100.9
Case #20: 15% reduction in driver pay hours	93.9	95.4	96.9	97.7	98.5	99.3	99.3
1.5% per year compensating increase in base wage during first contract period, 1% per year for second contract period, 0% from then on.							
Case #21: 3% reduction in driver pay hours	99.7	100.9	102.1	102.9	103.7	104.6	104.6
Case #22: 6% reduction in driver pay hours	98.2	99.3	100.5	101.3	102.1	103.0	103.0
Case #23: 9% reduction in driver pay hours	96.6	97.8	98.9	99.7	100.5	101.3	101.3
Case #24: 12% reduction in driver pay hours	95.1	96.2	97.4	98.2	98.9	99.7	99.7
Case #25: 15% reduction in driver pay hours	93.6	94.7	95.8	96.6	97.3	98.1	98.1
1.5% per year compensating increase in base wage during first contract period, 0% from then on.							
Case #26: 3% reduction in driver pay hours	99.7	100.9	102.1	102.1	102.1	102.1	102.1
Case #27: 6% reduction in driver pay hours	98.2	99.3	100.5	100.5	100.5	100.5	100.5
Case #28: 9% reduction in driver pay hours	96.6	97.8	98.9	98.9	98.9	98.9	98.9
Case #29: 12% reduction in driver pay hours	95.1	96.2	97.4	97.4	97.4	97.4	97.4
Case #30: 15% reduction in driver pay hours	93.6	94.7	95.8	95.8	95.8	95.8	95.8

Table 7-1

NET EFFECT OF NEW CONTRACT (Cont'd)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
1% per year compensating increase in base wage during first contract period, 1% per year for second contract period, 0% from then on.							
Case #31: 3% reduction in driver pay hours	99.3	<u>100.1</u>	100.9	101.7	102.5	103.3	103.3
Case #32: 6% reduction in driver pay hours	97.8	98.5	99.3	<u>100.1</u>	100.9	101.7	101.7
Case #33: 9% reduction in driver pay hours	96.3	97.0	97.8	98.6	99.4	<u>100.1</u>	100.1
Case #34: 12% reduction in driver pay hours	94.7	95.5	96.2	97.0	97.8	98.6	98.6
Case #35: 15% reduction in driver pay hours	93.2	94.0	94.7	95.4	96.2	97.0	97.0
1% per year compensating increase in base wage during first contract period, 0.5% per year for second contract period, 0% from then on.							
Case #36: 3% reduction in driver pay hours	99.3	<u>100.1</u>	100.9	101.3	101.7	102.1	102.1
Case #37: 6% reduction in driver pay hours	97.8	98.5	99.3	99.7	<u>100.1</u>	100.5	100.5
Case #38: 9% reduction in driver pay hours	96.3	97.0	97.8	98.2	98.6	99.0	99.0
Case #39: 12% reduction in driver pay hours	94.7	95.5	96.2	96.6	97.0	97.4	97.4
Case #40: 15% reduction in driver pay hours	93.2	94.0	94.7	95.1	95.4	95.8	95.8
1% per year compensating increase in base wage during first contract period, 0% from then on.							
Case #41: 3% reduction in driver pay hours	99.3	<u>100.1</u>	100.9	100.9	100.9	100.9	100.9
Case #42: 6% reduction in driver pay hours	97.8	98.5	99.3	99.3	99.3	99.3	99.3
Case #43: 9% reduction in driver pay hours	96.3	97.0	97.8	97.8	97.8	97.8	97.8
Case #44: 12% reduction in driver pay hours	94.7	95.5	96.2	96.2	96.2	96.2	96.2
Case #45: 15% reduction in driver pay hours	93.2	94.0	94.7	94.7	94.7	94.7	94.7

That is, the reader should find at least one part of the table relevant to his own situation among these 45 combinations, the anticipated savings level and the anticipated extra wage increase, and hence find the net result of the negotiating bargain.

The first row of Table 7-1 shows the base case, where transit costs start out at 100 units at time zero and remain at 100 throughout the simulation, since only incremental costs are being modeled. The results of the 45 scenarios are shown with respect to this base case, hence scenarios with cost-values less than 100 units show that expenses have been reduced, and scenarios with cost-values greater than 100 units imply that the overall result of the work-rule/wage-increase tradeoff has gone against management.

Examine Case #15 at the bottom of the first page of the table. It assumes that a work rule change is made which reduces operator costs by 15% and that, in return, management gives an extra 2% per year wage increase during the length of the contract. The net result during the first year is a cost of 93.6 units, i.e. a 6.4% reduction in overall costs. (Calculated as follows: the 15% reduction in driver pay hours reduces the operator-cost component to 42.5; then add in other labor of 30 for a total labor cost of 72.5 units. This grows at 2%, because of the compensating base pay increase, and becomes 73.6; then add in the 20 for materials to get the total cost of 93.6 units.) The 73.6 units of labor grows to 76.9 units by the end of the contract period and remains at that level from then on, producing a total cost of 96.9 units.

That is, a very substantial reduction, 15%, in driver pay hours works out to be a 3.1% reduction in overall costs after three years. And in Cases 11, 12, and 13 (3%, 6%, and 9% operating cost reductions, respectively), the effect of the 2% compensating increase in base wage is sufficient to produce a net negative cost saving by the end of the contract period: The 3% work rule change has become a 3.3% overall cost increase, the 6% work rule change has become a 1.7% overall cost increase, and the 9% work rule change has become a 0.1% overall cost increase by the end of the first labor contract.

In each row we have underlined the cost projection at that point in time when the new contract has actually become more expensive than the base-line contract, the contract before the work rule change. And, of course, for the years following that point the cost grows even more in most of these cases.

Overall, the scenarios where management gives up an extra wage increase during the first contract period to compensate for the change in work rules seem quite reasonable. It is not easy to guess about the realism of those scenarios where some increase continues into the second contract period as well. The question is: once a change is won, is it settled for all time, or does labor bring it up again at the next contract renewal? To the extent that a change is bitterly contested, and to the extent that the actual experience confirms some of labor's fears, it seems likely that the change will again be a bargaining issue at renewal time, and that labor will again ask for some kind of extra compensation for maintaining the provision.

Summary of Results: Part-Time Labor and Costs

It can be seen that in the majority of cases, a seemingly important reduction in total pay hours during the first year is eventually wiped out, and ultimately the labor force makes even more money than it did before the new contract. Since the table presents a wide variety of possible scenarios, the question is: which of these cases are the most realistic? Our runcut simulations of the use of part-time labor make it seem very unlikely that any district will achieve initial reductions of 12% or 15%. Indeed we could produce such results only by simultaneously reducing maximum spread time by one hour, and then adding part-time labor. Furthermore even the 9% case was only produced at a district with an extreme peak/base ratio, 3.9. The typical transit district can expect initial labor cost reductions of less than 6%. If we look at all of the 3% and 6% cases in Table 7-1, we note that in 17 of the 18 cases the initial reduction in driver costs has been wiped out by the compensating increase in base wage necessary to win the contract, and even in the one exception, Case #45, the net savings from the use of part-time labor are only 7/10 of one percent by the end of the first contract period.

That is, the granting of any compensating increase in base pay in order to win the right to use part-time labor seems to quickly nullify any cost savings that could have been achieved by the use of part-time labor. Furthermore, most of these contract changes eventually end up costing substantially more than the previous contract. Thus it is extremely important that management and labor not begin bargaining over part-time while holding exaggerated notions of how much money it can save. Such exaggerations encourage labor to ask for too much compensation, and they encourage management to be more inclined to grant it. The end result will be increased deficits and weaker transit districts, an event which is good for neither management nor labor.

From management's perspective the conclusion of the analysis would be something like this, "Any extra pay increase you give to obtain the use of part-time labor is quickly going to grow to haunt you; the savings from part-time operators are not large enough to allow this kind of bargain. Concentrate bargaining talks on the improvement in working conditions that will result from part-time labor. After all, overtime and premium pay were originally justified as compensation for undesirable work shifts; if hours can be made more regular, then the loss of 'compensating' pay is no real loss to the operators."

From labor's perspective the conclusion would be something like, "Give management the right to use part time labor if they wish, but above all, keep your eye on the operator wage increase itself. That is the important factor. Maybe you give up some operators now (insist that it be through attrition only), but if you trade this for a better yearly wage increase you will more than make up the difference eventually."

From society's perspective the results are, perhaps, discouraging. The projected 2-3% cost reduction at a typical district can not cure a 47% deficit. On the other hand, cost-cutting changes with greater result than this are rare in any industry; and such changes are clearly worth pursuing even though they will not cure the deficit problem. It must also be pointed out that society played the major role in creating the deficit in the first place, as will be discussed in the concluding Chapter.

CHAPTER 8

TRANSIT DEFICITS AND WORK RULE CHANGES: CONCLUSIONS FROM THE RESEARCH

We have explored the cost consequences of a variety of work rule changes. The sample transit districts analyzed constitute a reasonable cross section of the industry and a policy analyst interested in making projections from the tables to the industry can do so with as much certainty as such projection exercises ever allow. For the person interested in making projections for a given individual district, Appendix F provides general guidance and three separate procedures ranging from a very easy approximation method to a relatively difficult, but more precise method.

One of our more important conclusions, in fact, is that experimental run cutting is a potentially useful tool for transit negotiations. Joint union-management run cuts could be used to realistically explore available tradeoffs involved in a contract negotiation. The computation costs are small compared to the sums at stake, and informed negotiations are likely to yield a better outcome than blind bargaining. In particular, we feel that creative exploration of tradeoffs among spread premiums, guaranteed platform time, and maximum spread time, could yield work rules which both management and labor would prefer to present ones. Some Canadian districts are already engaged in this type of experimentation.

More specific conclusions from our research are outlined below.

Savings From Part-time Labor

Under the typical part-time labor contracts that are being negotiated around the country, we would project cost savings in the range of 3% to 8%, depending on the context of the other work rules and the shape of the daily service-profile. This result is subject to several caveats:

a) 3-8% is the reduction in operating cost, but the reduction in total cost will only be about half this level.

b) These estimates are somewhat optimistic since they presume it will be possible to fully implement the amount of part-time labor provided for in the contract, even though most districts have not been able to do this.

c) They are somewhat optimistic in the sense that they presume there will be no offsetting increases in supervisory costs or other overhead expenditures.

d) They are optimistic in the sense that they presume that management will not have to give away any compensatory increase in base pay in order to obtain the right to use part-time labor.

e) Since the estimates take the existing service schedule as a given they ignore the possibility of putting part-time drivers into peak hour service and then cutting back any "excess" day base service. Such a change would be very difficult to implement, because of political considerations, but it could significantly increase the savings associated with use of part-time labor.

f) The savings from part-time labor are highly sensitive to the context of the other work rules at the given transit district, and to the shape of the daily service profile (peak/base ratio and shoulder-to-shoulder time-width are expecially critical) -- these points are illustrated in our tables (Chapter 6 and Appendix E) for a variety of work rules and service-profile shapes.

Points (b) and (d) are probably the most serious qualifications on the results. In practice, the districts which have won the right to use part-time labor have experienced a variety of idiosyncratic difficulties which have prevented full implementation of the contract provisions. It is apparent that the changeover will be more complicated than is commonly supposed. And the results in the last chapter show that even a small increase in the basic labor wage rate, as a concession to win the use of part-time labor, can easily swamp any potential cost savings.

Cost of Spread Rule Changes

Decreases in the maximum allowable operator spread time can cause cost increases ranging from 0% to 24%, depending on existing peak/base ratios, and initial spread rules. The greatest effect occur when maximum spread time becomes narrower than the shoulder-to-shoulder time-width of the daily peaks. Once maximum spread time is reduced much below this point the number of new trippers created rises explosively and it becomes essentially impossible to offset the cost increase with any conceivable use of part-time labor.

These effects, too, are highly sensitive to the shape of the daily bus-service profile at the individual district. The tables (Chapter 5 and Appendix E) showed that one district could reduce maximum spread time by an hour with essentially no increase in costs; while at another district, the same one hour decrease in maximum spread caused a cost increase of 23.5%. The differences between districts are not random and unpredictable. As we showed in Chapter 5, sensitivity to reduction in maximum spread is easily predictable from knowledge of the peak/base ratio and the shoulder-to-shoulder time-width of the daily schedule. (Appendix F shows how to make the calculations for an individual district.)

Our point here is that transit districts should approach any suggested change in maximum spread with great caution. If the district is at the point where further decreases are going to create an explosive proliferation of trippers, then they ought to consider other kinds of labor tradeoffs, such as increased spread premium pay; or they might consider more fundamental kinds of action such as recutting their basic service blocks to narrow the shoulder-to-shoulder width of the service profile, or else encouraging the growth of paratransit services to accomodate some of these expensive peak hour passengers in a more economical fashion.

TRANSIT DEFICITS AND WORK RULE CHANGES

Since we began this study with the motivation of reducing transit deficits it is appropriate to end it from this perspective. Although we have concluded that the cost savings associated with work-rule changes are not going to be be able to affect the deficit in a significant way, they are clearly worth making. The "villain" behind the deficit lies elsewhere.

Labor, Management or Society?

The transit deficit has increased enormously over the past decade and is continuing to grow. To the extent that it is useful to look for a villain behind the deficits, we should be careful to remember that the major fault does not lie with work rules, management, or labor, but rather with the new goals that society has assigned to transit: transit has been asked to solve the congestion and pollution problems by running more service during peak hours to attract commuters out of cars; it has been asked to solve the mobility problems of the transit dependent by running frequent service through low density suburban neighborhoods; and it has even been asked to help solve the poverty problem by giving highly subsidized fares to the poor and to senior citizens.

The end result of these new social policies is that transit revenues cannot keep pace with costs: 1) Fares must be kept low for everyone in order that they not harm the few poor people we are concerned with--no one has had the courage to try targeting the low fares to the relevant groups rather than shot-gunning them through the entire population; and 2)buses must run in low density neighborhoods where they cannot possibly attract enough patronage to pay their costs.[1]

At the same time, these new social policies cause an automatic decrease in labor productivity: 1) The drivers who operate these low-patronage routes cannot possibly serve as many passengers per hour as they did in the "old days". 2) The increased social emphasis on diverting peak hour commuters onto buses creates a corresponding peaking problem in the demand for buses which, in turn, causes the scheduling of highly undesirable work shifts, and labor rightfully demands that these undesirable shifts receive extra pay compensation -- either a bonus payment for working an 11-12 hour split day, or a make-up payment to assure that they receive a full day's pay for their full-time job commitment even though management can only figure out how to use them for 6-7 hours per day.

Bargain Fares and Excess Service

Since our conclusion from the analysis of part-time labor was that the deficit problem is not going to be solved from the cost side, we now turn to the revenue side of the picture. The factors behind lagging revenues are

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[1]Goldschmidt, Neil, 1979,

not difficult to find: first, despite greatly increased costs, transit fares have not even been able to keep up with inflation -- they fell 13%, in real dollars, between 1970 and 1976. Second, expansion of service into the suburbs has taken bus-miles of service from high density cities and moved it into low density neighborhoods where it cannot attract as many passengers per bus-mile: route-miles of service increased by 103%, while bus-miles traveled remained constant, during 1970-1976.

Without question, raising transit fares and dropping low-patronage routes are the most effective, fastest actions that could be taken to reduce transit deficits. Yet these actions are rarely considered because of the political forces allied against them. Urbanists want low fares because they believe this will encourage commuters to switch to transit and hence preserve our cities. Environmentalists want low fares because they too believe that price incentives can get people out of cars, and hence reduce smog and energy consumption. Liberals want low fares because they are concerned about the budgets of poor people. And finally, even the transit unions want low fares because greater use of transit means more jobs for them. It seems likely that all of these groups are greatly overestimating the price elasticity of demand for transit services during rush hours and ignoring the fact that transit's greatest handicap, from the perspective of potential users, is not its cost but its slow travel times. Also, as we have argued above, it makes little sense to subsidize the fare for everyone in order to help the few poor families who are our target; some kind of direct "user subsidy" would be far cheaper and more effective.

But in any event, if we make a conscious public decision to continue low fares and excess service, we may not then turn around and attribute the blame for the resultant deficits to "inefficient management" or "greedy unions." That deficit is society's fault, not theirs.

SUMMARY

We began this research with a question: what are the savings from the use of part-time labor? We now know this to be a misformulated question, for there is no single answer to it. The savings from part-time labor, or almost any other work-rule change, are entirely dependent upon both the context of the other work rules in a given transit district, and the daily service profile of that district. A given change, e.g., 10% part-time labor, might produce a 1% cost change at one property, and an 8% change at another. There is no simple answer to our original question and hence we have sampled a variety of transit districts, and produced extensive tables to show the sensitivity of work-rule changes to the environmental characteristics of the individual district.

Part-time labor can reduce operating costs at most districts, and it is worth implementing, though it is not going to be a panacea for the financial ills of the transit industry. We must also be mindful that the kinds of contract concessions necessary to win the use of part-time labor can ultimately cost more than the initial savings in operator costs. Hence, such contract changes must be approached cautiously, with very careful consideration of long term costs. Alternatively, it may be simpler to attack the peaking problem directly through load-shedding via supplementary paratransit services.

Finally, no cost cutting measures are going to reduce the deficit to zero so long as social goals and political considerations require transit systems to operate so many low-patronage routes, and prevent the raising of transit fares.

APPENDIX A
RUN CUTTING IN THEORY AND PRACTICE

General Theory

The run cutter's task is to cut a bus service schedule into driver assignments, or runs. The objective is to minimize the total payroll cost of serving this schedule while meeting a variety of constraints on the nature of the runs. These constraints include restrictions on individual runs such as maximum spread time; and aggregative restrictions such as a maximum percentage of split runs.

Run cutting is an exercise in constrained optimization, and as such it is theoretically amenable to a precise solution via an integer programming algorithm. In practice, however, a typical runcutting problem involving a few hundred buses would require an astronomical number of variables if cast in integer programming format. Ward and Durant[1] (1979) have experimented with a runcutting technique in which integer programming is applied piece-wise to subsets of a service schedule. A global application remains computationally infeasible.

Lacking a practical algorithm, run-cutting remains more an art than a science. Run cutters, both human and automated, arrive at their solutions via time-tested heuristics, or rules of thumb. A runcut should not be regarded as a mathematical optimum, but merely as an approximation to that ideal.

Procedure

Run cutting is a three-step procedure. In the first step, straight runs (unbroken pieces of work of approximately eight hours duration) are cut. The process is illustrated in Figure A-1. This leaves a scattering of smaller pieces of work, mostly during the two peak periods. The second step

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[1]Richard E. Ward & Phillip A. Durant, Feasibility of a complimentary solution to the bus operator scheduling problem. Final report #UMTA-WV-11-0001-80-1. (Morgantown, W.Va.: West Virginia University, Department of Industrial Engineering, December 1979).

Figure A-1

STYLIZED EXAMPLE OF RUNCUTTING

STARTING POINT: The block schedule

```
Block #
(Bus run)
          6                                      1
          am                                     am
101       =======================================

          6                                        2
          am                                       am
102       =========================================

          6       10
          am      am
103       ========

                         1         6
                         pm        pm
104                      ==========
```

STEP 1: Cut straight runs

```
Block #
(Bus run)
          6                                      1
          am                                     am
101       ======AAAAAAAAAAAAAAAABBBBBBBBBBBBBB

          6                2         6              2
          am               pm        pm             am
102       CCCCCCCCCCCCCCCC=========DDDDDDDDDDDDDD

          6       10
          am      am
103       ========

                         1         6
                         pm        pm
104                      ==========
```

```
Key:  === unassigned
      AAA assigned to driver A
      BBB assigned to driver B
      CCC assigned to driver C
      DDD assigned to driver D
```

Figure A-1

STYLIZED EXAMPLE OF RUNCUTTING (Cont'd.)

STEP 2: Cut split runs

```
Block
(Bus run)

          6                                     1
          am                                    am
101       EEEEEExxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx


          6               2        6              2
          am              pm       pm             am
102       xxxxxxxxxxxxxxxxEEEEEEEEExxxxxxxxxxxxxxx


          6       10
          am      am
103       FFFFFFFF
                        1         6
                        pm        pm
104                     FFFFFFFFFF
```

Key: xxx assigned in previous step

STEP 3: Optimization
(Runs E and F have switched "tails".)

```
Block #
(Bus run)

          6     9                               1
          am    am                              am
101       EEEEEExxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx


          6               2        6              2
          am              pm       pm             am
102       xxxxxxxxxxxxxxxxFFFFFFFFFxxxxxxxxxxxxxxx


          6       10
          am      am
103       FFFFFFFF

                        1         6
                        pm        pm
104                     EEEEEEEEEE
```

Figure A-1

STYLIZED EXAMPLE OF RUNCUTTING (Cont'd.)

DRIVER ASSIGNMENTS, BEFORE AND AFTER OPTIMIZATION

	Before		After	
Run	Platform hours	Pay hours	Platform hours	Pay hours
A	8	8	8	8
B	8	8	8	8
C	8	8	8	8
D	8	8	8	8
E	7	8	8	8
F	9	9.5	8	8
Total	48	49.5	48	48

Savings from optimization: 1.5 pay hours

(Assumed work rules: no spread premium; eight hour guarantee; time and a half after eight hours; no travel, report or clear allowances)

FINAL RUN CUT

Run	Block #	Time on	Time off	Block #	Time on	Time off
A	101	9:00 AM	5:00 PM (end)			
B	101	5:00 PM	1:00 AM (end)			
C	102	6:00 AM	2:00 PM (end)			
D	102	6:00 PM	2:00 AM (end)			
E	101	6:00 AM	9:00 AM	104	1:00 PM	6:00 PM (end)
F	103	6:00 AM	10:00AM	102	2:00 PM	6:00 PM (end)

is to pair these pieces (loose ends) to produce split (two-piece) runs. It is therefore crucial that step 1 should have left a balance between AM and PM pieces. Finally, in step 3, the pieces are juggled and reshifted between the runs in an attempt to find a less costly solution.

Our runcuts were executed with RUNS, a computer program from the RUCUS package of automated scheduling routines. RUCUS (an acronym for RUnCUtting and Scheduling) was originally developed by MITRE Corp. for UMTA. The program was subequently released into the private domain, and modified versions are now available from several private vendors. We obtained Sage Management's version of RUNS and adapted it for use on a Digital Equipment PDP-10 computer.

RUNS requires two kinds of input data: first, a description of the bus service schedule; second, a description of the relevant work rules and pay practices.

The service schedule is in the form of block data, where each block is a description of a particular bus' daily itinerary (e.g., 101, 102, 103, in Figure A-1 are each blocks). Our runcuts were done on a division (garage) basis. That is, the block data described all the buses based at a particular garage, and our runcuts permitted mixed runs -- runs with components from different routes (lines) at that garage. Some properties, in contrast, cut their runs line-by-line, dealing individually with small, homogeneous sets of blocks.

Information about the work rules at a property is entered in two ways. Maximum spread time, spread penalty time, and some other important rules are parameterized in the Sage version of RUCUS, i.e., their values can be altered by changing an input instruction card. Most other work rules and pay practices are pre-programmed (hardcoded) in the RUCUS cost routine, hence the cost routine must be rewritten for each property. Since the differences between cost routines tend to be small but idiosyncratic, we adopted a single, standard cost routine for use with all the schedules we examined. Our standard work rule assumptions are outlined in Table A-1 below.

Table A-1

STANDARD WORK RULES

Maximum spread time:	12 or 13 hours.
Spread premium time:	10 or 12 hours.
Daily guarantee:	8 hours.
Platform overtime:	time-and-a-half after 8 hours platform work
Spread premium:	time-and-a-half after spread premium time. Spread premium is paid in addition to make-up (i.e., over and above the eight-hour guarantee). However, where both spread premium and platform overtime are applicable, only the greater of the two is paid.
Report and clear:	ten minutes report time paid per pull-out. No clear time.
Breaks:	breaks of less than an hour are paid straight-through.

RUNS' execution follows the three-step process described above. Output consists of a description of each run, including its cost, and a list of trippers (loose ends) which could not be paired within the relevant maximum spread time. The costing of these trippers must be done manually; this process is described in Appendix A-3. Furthermore, RUNS was not designed to handle part-time runs, and these too must be handled manually.

Procedure for Assigning Part-Time Runs

To maximize the savings from part-time labor, our strategy was to reassign to part-time drivers those pieces of work which were receiving the greatest premiums for spread or make-up. This strategy was implemented as follows. Step 1: assign single (i.e., unpaired) trippers to part-time; shortest trippers first. Here the savings is in make-up time: transferring a two-hour unpaired tripper from the extraboard to part-time saves about six hours pay. Step 2: Break up split runs (or paired trippers) into two part-time runs, breaking up the pairs with the highest total of make-up and spread premium first.

The reassignment process continues until the maximum permissible force of part-time drivers is utilized. This maximum part-time force is given as a percentage of the total full-time driver roster; where the roster includes drivers for weekend runs, and the crew needed to fill in for vacationing and absent drivers. We assumed weekend service equivalent to weekday day-base service, and assumed an average of 11% absences due to sickness and vacation.

Thus, in a typical labor contract, if part-time drivers are allowed to a maximum of 10% of total full-time, the permissible number is given by:

$$PT = (.1)(1.11)(FT + 2\ DB/5)$$

where PT = no. of permissible part-time drivers

FT = no. of weekday full-time drivers (extra board plus regular runs)

DB = no. of day-base runs

Validating Our Run Cuts

The run cuts reported in this study represent the final product of eighteen months' study in the craft of run cutting. Before running the experimental cuts reported here, we participated in actual run cuts at two transit districts and ran dozens of practice cuts on our own. But it is worth repeating that runcutting is an art, not a science, and even the use of a sophisticated tool like RUNS does not guarantee an optimal or even a unique solution to the problem of driver assignment. How then can we represent our results as being accurate guides to competitive costs?

Our reply is a pragmatic one: we can demonstrate that our runcuts are comparable to a professional runcutter's efforts. That is not to say that our runcuts would be suitable for use "on the street;" an immense amount of skill and experience is required for the fine-tuning. Nonetheless, we have demonstrated the ability to produce runcuts whose broad outline -- number of drivers and total pay hours -- mirrors an independent, professional cut.

The validation procedure was simple: we independently repeated a runcut using the actual work rules of the property involved, and compared our results with those obtained by that property's chief runcutter (an individual widely regarded as one of the best in the industry). The pay hour figures for the two run cuts were as follows:

	OUR RUN CUT	ACTUAL RUN CUT
Regular runs	266	270
Part-time runs	70	70
Total pay hours	2528	2552

Our estimates of savings from use of part-time labor involved both run-cutting skill and the ability to assign accurately the part-time drivers on a manual basis. One of the transit districts we worked with had made its own estimate of the savings from use of part-time labor before they negotiated their contract, and this figure was about double the estimate of savings that our procedure had produced. After this district had actually begun using part-time labor they calculated the actual, measured savings from the work rule change and this turned out to be within one-tenth of a percent of our estimate.

APPENDIX B
COMPUTING FRINGE BENEFITS

Fringe benefits -- including pensions, vacations and sick leave -- form an important part of operator compensation. Our calculations are based on data reported by Levinson and Conrad.[1] They provide a breakdown of costs for "a large transit property in the northeastern United States". Total expenditures on operators' fringe benefits, expressed as a percentage of the wage bill for operators, comprise the following:

Vacation allowance	8.8%
Holiday allowance	4.0%
Health and welfare	12.5%
Pension	25.8%
Total	51.1%

Thus the value of fringe benefits was fully half of wages. For our purposes, we assumed that pension benefits were paid in proportion to pay hours, but that other benefits were paid at a fixed amount per full-time driver. Taking the Levinson and Conrad figures as a rough guide, we allotted each full-time driver a fixed two pay hours per day for vacation, holiday, and health and welfare; plus pension benefits equivalent to 25% of the driver's wage. For part-time drivers we made two alternative assumptions. Our standard assumption was that part-time drivers received only FICA and unemployment insurance, at a rate equivalent to 10% of wages. Our alternative assumption was that part-time operators received the same fringe benefits as full-time operators, but proportional to pay hours, i.e., fringes equivalent to 50% of wages. The reader may easily experiment with alternative fringe benefit rates using the basic pay hour data in Appendix E.

[1] Herbert S. Levinson & Paul E. Conrad. How to allocate bus route costs, <u>Transit Journal</u>, Fall 1979, 5(4), 39-48.

APPENDIX C
THE COST OF TRIPPERS

Because most transit patronage occurs during normal commute hours, transit schedulers create many short driving stints centered about 8:00 AM and 5:00 PM. These short pieces of work, usually one to three hours in duration, are called trippers. Sometimes this term is extended to include all short pieces of work, and sometimes it is restricted to assignments which begin and end in the garage.

Trippers are the bane of run cutters, whose goal is to find approximately eight hours of work for each driver. In some cases, a tripper can be assigned as a component of a regular run by pairing it with a longer piece. However, not all trippers can be so easily dealt with. Any property with a pronounced peak/base ratio must have some trippers left over after all the regular runs have been cut. These "excess" trippers would be very expensive to operate with full-time drivers; this explains the widespread enthusiasm for assigning such work to part-time drivers. In fact, the argument supporting part-time labor's cost-effectiveness relies heavily on the assertion that each "excess" tripper requires its own driver, who receives eight hours guaranteed pay. The assertion implies that some trippers are effectively paid at triple time or more (e.g. a 2 hour tripper being worked by a driver who receives 8 hours pay). Yet this assertion, despite its importance, has received little examination in the literature.

We believe that for a reasonably high peak/base ratio, the marginal tripper does cost approximately eight pay hours. The average cost of excess trippers depends, however, both on the peak/base ratio and upon a variety of work rules and practices.

In the absence of part-time drivers, trippers may be:

1) incorporated into regular runs; or
2) voluntarily "bid" by the drivers of regular runs; or
3) assigned to the extraboard.

We examine the cost implications of each of these options below.

Trippers as Part of Regular Runs

The cheapest way to operate a tripper is to match it up with another piece of work to make a regular run. Such a run may even incur little or no spread penalty or overtime (see Figure C-1).

Given a peaky schedule, however, the supply of suitable matches will soon be exhausted, and the runcutter will have a number of left over morning and evening trippers. Some of these may be paired together to make rather expensive two-piece runs: expensive because the driver receives the eight-hour guarantee plus, in many cases, spread premium as well. For example a morning and evening tripper, totaling 5 hours of driving, might be paired within a spread time of 12 hours, receiving 3 hours of makeup pay and 1 hour of premium pay: hence 9 pay hours to produce 5 platform hours (see Figure C-1(b)). Even so, such trippers are effectively being paid at less than double time.

Not all trippers can be paired into regular two-piece runs, for three reasons:

1) some may be impossible to pair within the maximum spread limit for regular drivers;
2) there may be a contractual minimum on the platform time of a regular run (e.g. some contracts specify that a regular run must have at least 6 hours of platform time);
3) there may be a contractual maximum on the percentage of regular runs which are two-piece runs.

Thus there will usually be "excess" trippers that must be dealt with by the scheduler in some way or other.

Biddable Trippers

Many properties have the institution of "biddable" trippers: drivers of regular runs volunteer to work a tripper before or after their regular run, or on their regular day off. They are paid time-and-a-half for the tripper, but do not receive any additional spread premium (see Figure C-1(c)). In some cases, drivers may waive the maximum spread time in order to bid a tripper.

The practice of biddable trippers is widespread. Of twenty-one large transit properties surveyed, fourteen put trippers up for bid. In general,

Figure C-1

METHODS OF ASSIGNING TRIPPERS

(a) Regular run: 8 platform hours, 8 pay hours

```
6           8:30      10:30                      4
am          am        am                         pm
==========            ======================
```

(b) Paired trippers: 5 platform hours, 9 pay hours

```
6           8:30                          3:30        6
am          am                            pm          pm
==========                                ==========
```

(c) Bid tripper plus regular run: 9 platform hours,

9.5 pay hours

```
6                                      2             5    6
am                                     pm            pm   pm
================================                     ====
```

biddable trippers are popular both with drivers and management. Drivers are able to earn extra money for work which suits their personal schedule, but no one is compelled to operate an undesirable combination. Management receives considerable savings in pay hours compared to operating a tripper on the extraboard. In addition, many properties pay no additional fringes for work performed in excess of forty hours per week.

The potential savings from biddable trippers are significant. A two hour tripper would cost three pay hours if bid, but from 4.5 to 8 hours if assigned to the extraboard (see below). There are however intrinsic limitations to the number of trippers which feasibly can be bid. In order to combine a tripper with a regular run, the tripper must be relatively short. (California law, for instance, limits operators to ten hours platform daily; thus a tripper, to be biddable, will probably be less than two hours in length.) If maximum spread time applies to bid trippers, the number of tripper candidates is still further restricted. Bids by drivers on their regular day off do not face these restrictions, but the number of potential bidders is limited by the extent of weekend service, and by the unattractiveness of a five-and-a-half day work week.

The feasibility of biddable trippers is therefore very sensitive to the block schedule and to the operating context in general. Utilization of biddable trippers varies widely from property to property. Among the fourteen districts in our sample, the median ratio of biddable trippers to regular runs was .16. One district reported a ratio of .64, which may be a clerical error; the next highest ratio was .31.

Trippers on the Extraboard

Residual trippers, which cannot be patched into a regular run or be bid by a regular driver, are assigned to the extraboard. Some of these residual trippers may be pairable within the maximum spread time, like those in Figure C-1(b). These trippers will be paid, effectively, at about double time.

Some trippers, however, may not be pairable. Each of these will require an individual full-time driver, who receives a guaranteed eight hours pay. We impute the cost of these awkward trippers as the full eight payhours.

Objections can be raised to these cost allocation procedures because the extraboard performs a wide variety of other functions in addition to handling trippers. Its prime role is to cover for absent drivers, and it usually handles special charter runs. If an extraboard driver can combine some of these duties with the operation of an unpairable tripper, then the true cost of that tripper is less than eight pay hours.

Thus determining the cost of trippers requires an understanding of the extraboard assignment process: how efficiently does it combine tripper duties with other tasks on an average day? There are two approaches to the question. The normative approach is based on the operation of an idealized, optimal extraboard. The positive approach examines the experience of real-world extraboards.

NORMATIVE ANALYSIS

A detailed normative analysis of the extraboard would be a challenging, and valuable, exercise in operations research. To the best of our knowledge, no such analysis has been undertaken. We will merely sketch the extraboard's principal functions, indicating how each function might be efficiently combined with tripper operation.

Charters

Charter runs are potentially excellent complements to trippers. A short midday charter, for instance, could easily be combined with either a morning or evening tripper. However, the demand for midday charter or special runs is limited and undependable excepting, perhaps, properties which handle school runs. Full-day charters merely exacerbate the scheduling problem.

Vacations

At most properties, the extraboard is responsible for covering the runs of vacationing drivers. Two advantageous contingencies motivate the joint assignment of trippers and vacation runs:

a) It may be possible to hook the tripper onto the beginning or end of a straight run.

b) It may be possible to break up a two-piece (vacation) run and match each piece with a previously unpairable tripper; thus two drivers cover work which previously required three.

Either of the two techniques for absorbing trippers will substantially lower their cost. However, only a small proportion of runs can be successfully hooked up with trippers without violating spread or platform time restrictions.

Absences

The extraboard covers runs for drivers who are sick, late, or otherwise absent. Absent drivers' runs,like vacation runs, have the potential for absorbing some trippers. There are two complications which make it more difficult to mesh trippers with 'absence runs'. First, there is substantial day to day variance in the number of absences. Second, many absences are unanticipated, the driver gives little or no notice. These greatly complicate extraboard scheduling, and diminish the opportunities for absorbing trippers.

On days with little absenteeism, many of the trippers can be covered at virtually zero marginal cost since the extraboard drivers would have received eight hours pay in any event. And on days with high absenteeism, some of the trippers can be hooked onto the regular runs and worked at an average cost of about time-and-a-half (since spread penalties will probably be incurred).

Summary

Our brief sketch of extraboard assignment theory suggest that some trippers can be operated at about straight time because they can be paired; some can be operated at about time-and-a-half; and some -- the trippers that can neither be paired, hooked, nor assigned to an "idle" extraboard driver -- will have to be operated at very high cost. The average cost of a tripper, then, is determined by the proportion of them that fall into each category and this, in turn, is determined by the following factors: the maximum spread time permitted on the extraboard, the pattern and predictability of absences by regular drivers, and the pattern and predictability of special runs. It is obvious that when the ratio of trippers to extraboard drivers is low, the average cost of a tripper will be low; but when the proportion of trippers becomes high, an ever increasing number of them will be pushed into the high-cost catagories, and their average cost will become substantial.

POSITIVE ANALYSIS

In simplest terms, our problem reduces to a question: how is the size of the extraboard related to the number of trippers? Suppose a division which has an extraboard adequate to meet its current needs is given two more trippers to operate. Will it expand its extraboard by one driver? Two? None? An exhaustive literature search yielded no information on extraboard work-assignment or staffing procedures. To fill this gap, we undertook a questionnaire survey of twenty-three of the largest U.S. properties, plus one Canadian property. The questionnaire sought quantitative data concerning runs, staffing and duties in addition to descriptive information concerning the work-assignment procedure. Response was an overwhelming 87%, indicating a high degree of interest in the topic.

We were able to undertake a simple statistical analysis using the quantitative data they supplied. We hypothesized a linear relation between extraboard size and number of trippers operated on the extraboard. A plot of extraboard size as a function of extraboard trippers is shown in Figure C-2. (Both variables have been normalized by dividing by number of regular runs).The relation does indeed look roughly linear. We formalized the model as follows:

$$EB/RR = a + b(TR/RR) + c\ RDO$$

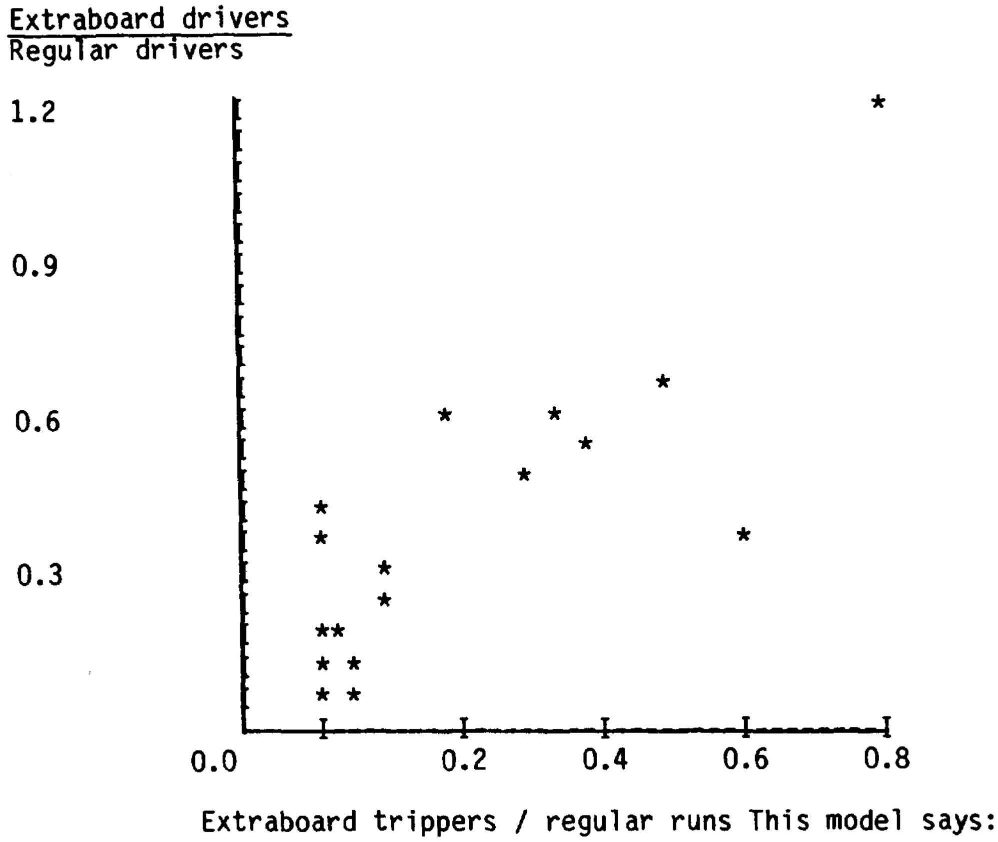
EB/RR is the ratio of weekday extraboard staff to weekday regular runs

TR/RR is the ratio of extraboard trippers to weekday regular runs (TR does not include trippers which are bid by regular drivers or which are assigned to part-time drivers)

RDO is a dummy; RDO=1 indicates that the extraboard handles the runs of drivers whose regular day off is a weekday; RDO=0 indicates that these relief runs are the responsibility of non-extraboard drivers.

Figure C-2

TRIPPERS AND EXTRABOARD SIZE



1) in order to cover for sick and vacationing drivers, the EB/RR ratio must at least equal the average absentee rate, a .

2) if, in addition, the extraboard is responsible for relief runs, its staff must be augmented by at least the c(RR) drivers whose regular day off is a weekday.

3) each extraboard tripper requires, on the average, b additional drivers on the extraboard. If trippers are mostly hooked before or after straight runs, b will be very small; if trippers tend to be operated in pairs, b will be approximately .5; and the more difficult it is to hook trippers with any other work, the closer b will approach unity.

Regression results were:

$n=18 \qquad \bar{R}^2 = .718$

$$EB/RR = .166 + \underset{(6.2)}{.901\ TR/EB} + \underset{(1.8)}{.137\ RDO}$$

(t-ratios in parentheses)

That is, an average 16.6% of the regular force is absent due to sickness or vacation; an additional 13.7% have a weekday as their regular day off; and each extraboard tripper requires on the average, slightly less than one additional extraboard driven. The extraboard driver/tripper ratio of .901 is significantly greater than .5 at the 99% level. Thus some trippers, at least, require a full-time driver.

Although this linear model fit the data reasonably well, our normative extraboard model suggests a nonlinear relationship between trippers and extraboard drivers. The theory says that an efficient extraboard can absorb small numbers of trippers without requiring extra personnel. Only as the tripper/run ratio becomes large will the marginal tripper require an additional extraboard operator.

A number of nonlinear specifications were tried, and none of them explained the data so well as the linear model. One explanation for the inferiority of the nonlinear model is the distorting influence of biddable trippers. Fourteen of the eighteen properties sampled permit biddable trippers. It is likely that for these properties, most of the easily hookable trippers are bid, leaving mostly difficult, unpairable trippers for the extraboard. Another reason for the failure of our sample to conform to the normative model is simply that real extraboards fall somewhat short of ideal efficiency.

These results suggest that in many cases, two- or three-hour trippers can cost eight pay hours to operate; it is the existence of these trippers which constitutes the incentive for adopting part-time labor. These results should not be interpreted as meaning that large numbers of drivers "get paid for doing nothing". Extraboard drivers are generally required to stand "on report" (as a hedge against unexpected absences) if there is no immediate work assignment. Extraboard drivers are also used for moving buses between garages. We feel that it may be possible, however, to utilize extraboards more efficiently, and we encourage research in this direction.

APPENDIX D
ANALYSIS OF ABSENTEEISM

There are two questions concerning driver absenteeism which are fundamental to this research: (1) the reliability and dependability of part-time drivers, since any potential savings from part-time labor could easily be vitiated by driver reliability problems, and (2) the normal pattern of absenteeism among regular drivers, since we cannot compute the cost savings from using part-time drivers to cover trippers if we do not understand enough about driver absenteeism and the operation of the extra-board to be able to compute the current cost of running trippers.

Reliability of Part-Time Drivers

One of the greatest initial concerns about use of part-time drivers was over the kinds of labor that would be recruited. Would the part-time drivers be hard to train, would they be unreliable, would they have less commitment to their jobs and hence incur more customer complaints, and would they have more accidents? We interviewed two of the districts in our sample, and two outside the sample, concerning these issues. Their positive opinions on the records of part-time drivers were unanimous. At various interviews we heard that part-timers have substantially lower absenteeism than regular drivers and fewer customer complaints, that part-timers caused no particular training problems, and that they seemed to have lower accident rates.

It is possible that some of these favorable results are not necessarily valid. For example, the part-timers are still essentially in their probation periods, and we would expect them to be on their best behavior. (In some cases the probation periods for part-timers are very long. We found one case where the normal 6 month probation period for regular drivers, roughly 1000 driving hours, was translated as a 1000 hour probation period for part-timers and, given their shorter working shifts, this translates into a calendar-time probation period of more than a year). Furthermore, since the transit districts are so determined to have part-time labor succeed, it is possible that part-timers are receiving better supervision;

or even that the part-timers, themselves, are simply more conscious of their circumstances and so we are seeing a kind of Hawthorne effect.

Psychological factors like these might account for some portion of the favorable records of the part-timers: the portion of their behavior which is voluntary, such as their attitude toward absenteeism and customer relations. But such psychological explanations cannot account for their better accident behavior. Hence, on balance the favorable results measured so far would lead us to believe that the part-timers will continue to perform in a manner which is at least equal to that of the regular drivers, even after they have completed their probationary periods, and even after everyone concerned begins to regard use of part-time labor as a normal situation.

Two districts also report that part-time labor has had a favorable affect upon the absenteeism of regular drivers. They say that the regular runs with the most absenteeism had been the most strenuous runs, those with very long spreads or very long platform times, and that such runs are now broken up and given to part-time drivers in many instances. Thus the regular drivers end up with more humane work shifts, and their absenteeism has dropped as a result.

Patterns of Absenteeism Among Regular Drivers

One of the fundamental questions that must be answered if we are to evaluate the potential savings from use of part-time labor is the cost of running a tripper using the extraboard. To answer this question we must understand the operation of the extraboard itself, and the characteristics of the absenteeism which it is designed to handle. Are there regular and predictable patterns of absenteeism. If they exist, can the size of the extraboard be optimized to take account of such patterns? What, then, are the implications for the cost of serving an additional tripper via the extraboard?

We were able to obtain detailed data on daily absences for one transit district for forty days, randomly chosen, over the calendar year. (A forty-first day, January 3, was excluded from the sample because it was the first day after the New Year's Holiday and the number of drivers reported absent was five times larger than normal.)

Table D-1 gives the means of the data and defines the abbreviations we will use in the analysis. Table D-2 shows the correlation matrix for the data.

Figures D-1 to D-4 show the pattern of daily absenteeism plotted against the day of the week. Figures D-5 to D-8 show the pattern of absenteeism plotted against day of the year. A few conclusions are evident from simple examination of these plots.

1. Regular drivers tend to be gone on Monday and Friday, which seems intuitively reasonable.

2. Extraboard drivers tend to be gone on Tuesday and Wednesday, hence they compensate for the pattern of the regular drivers, but we are at a loss to know why this "lucky" result occurs. Perhaps the extraboard drivers know that they are needed on Monday and Friday and so make a greater effort to be present on those days.

3. There is no apparent pattern of sicks or absenteeism by time of the year.

Although there is some reason to expect an absence pattern with a weekly cycle, because of the attraction of lengthening a weekend, we initially had no theory which would point to a yearly cycle. Upon reflection, we decided to look for a pattern in the context of the driving-year rather than the calendar-year. That is, every driver is allowed a certain number of paid sick days per year, and this quota begins on November 1. Scaling the plots with November 1 as the origin immediately clarified the pattern of driver behavior (see Figures D-9, D-11, D-13, D-14) and led to the following additional observations:

4. Both regular drivers and extraboard drivers tend to have a high number of sick days at the beginning of the sick-day year, and this declines until the end of the sick-day year. It seems likely that the decline is due to drivers using up their sick day allowance.

5. Absences, unlike sick days, are not paid. Both regular and extraboard drivers tend to have low absences at the beginning of the sick-day year, and there is a sudden build-up of absences at the end of the sick-day year. It seems likely that this is due to drivers taking an increased number of absences when their sick days have been used up.

Table D-1

DEFINITIONS OF VARIABLES AND THEIR MEANS AND RANGES

VARIABLE LABEL & #	MEAN	STD DEV (%MEAN)	MINIMUM VALUE	MAXIMUM VALUE	DEFINITION
DOY 1	194.0	51.	16.00	353.0	Day of Year (January 1 = 1)
DOW 2	3.775	34.	2.000	6.000	Day of Week (Monday = 2)
RWA 3	4.800	47.	1.000	11.00	Regular driver, Whole day Absences
RPA 4	.1250	323.	.0000	2.000	Reg. driver, Part day Absences
RWS 5	24.30	25.	10.00	37.00	Reg. driver, Whole day Sicks
RPS 6	.7250	104.	.0000	3.000	Reg. driver, Part day Sicks
EWA 7	1.400	85.	.0000	5.000	Extraboard driv., Whole day Abs.
EPA 8	.4000	232.	.0000	4.000	Extraboard driv., Part day Abs.
EWS 9	6.950	35.	3.000	15.00	Extraboard driv., Whole day Sicks
EPS 10	.1500	284.	.0000	2.000	Extraboard driv., Part day Sicks
RA 11	4.925	47.	1.000	11.00	Reg Absences: sum of RWA + RPA
RS 12	25.02	25.	11.00	38.00	Reg Sicks: sum of RWS + RPS
EA 13	1.800	81.	.0000	5.000	Extrbrd Absences: sum of EWA + EPA
ES 14	7.100	34.	3.000	15.00	Extrbrd Sicks: sum of EWS + EPS
R 15	29.95	20.	15.00	42.00	Regular: RWS+RPS+RWA+RPA
E 16	8.900	28.	4.000	15.00	Extrbrd: EWS+EPS+EWA+EPA
MON 17	.1750	220.	.0000	1.000	dummy for MONday =1, else 0
TUE 18	.3000	155.	.0000	1.000	dummy for TUEsday =1, else 0
WED 19	.2250	188.	.0000	1.000	dummy for WEDnesday =1, else 0
THU 20	.1750	220.	.0000	1.000	dummy for THUrsday =1, else 0
FRI 21	.1250	268.	.0000	1.000	dummy for FRIday =1, else 0
DAY**2 22	.4723E 05	81.	256.0	.1246E 06	"DOY" squared
DAY**3 23	.1277E 08	105.	4096.	.4399E 08	"DOY" cubed
X11/12 24	.2158	60.	.3570E-01	.5625	variable #11 divided by #12
NOV-DA 25	191.1	56.	6.000	364.0	day of year (NOVember 1=1)
N.D**2 26	.4780E 05	84.	36.00	.1325E 06	"NOV-DA" squared
N.D**3 27	.1319E 08	105.	216.0	.4823E 08	"NOV-DA" cubed
N.D**4 28	.3845E 10	124.	1296.	.1756E 11	"NOV-DA" to the fourth power
RW 29	29.10	21.	13.00	41.00	Reg. Whole sick + absences
EW 30	8.350	31.	4.000	15.00	Extrbrd Whole sick + absence

Table D-2

CORRELATION MATRIX FOR THE VARIABLES

CORRELATION MATRIX

		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
DOY	1	1.00									
DOW	2	-.22	1.00								
RWA	3	.24	-.14	1.00							
RPA	4	-.08	-.04	.00	1.00						
RWS	5	-.18	.15	-.18	-.29	1.00					
RPS	6	-.04	.15	.07	-.14	-.05	1.00				
EWA	7	.43	-.41	.26	.00	-.31	-.02	1.00			
EPA	8	.00	.12	-.17	.14	-.37	.16	-.08	1.00		
EWS	9	.23	.14	-.12	-.15	.20	.03	-.13	-.17	1.00	
EPS	10	-.30	-.17	-.02	.19	-.02	.05	-.17	-.03	-.12	1.00
RA	11	.22	-.14	.98	.18	-.23	.05	.25	-.14	-.14	.01
RS	12	-.19	.17	-.17	-.31	.99	.07	-.31	-.35	.20	-.01
EA	13	.35	-.26	.10	.09	-.49	.09	.77	.57	-.21	-.16
ES	14	.18	.11	-.12	-.12	.19	.04	-.16	-.18	.98	.06
R	15	-.11	.12	.20	-.25	.92	.09	-.22	-.41	.15	-.01
E	16	.38	-.05	-.06	-.06	-.10	.09	.30	.16	.83	-.03
MON	17	.00	-.64	.13	-.14	.22	-.18	.12	-.20	-.07	.15
TUE	18	.18	-.40	-.06	.07	-.32	.10	.33	.01	-.19	.03
WED	19	.07	.10	.16	.28	-.06	-.04	-.03	.03	.29	-.05
THU	20	-.08	.44	-.17	-.14	-.09	-.01	-.27	.30	-.10	-.01
FRI	21	-.26	.66	-.07	-.12	.37	.14	-.26	-.16	.10	-.13
DAY**2	22	.97	-.24	.23	-.12	-.04	-.06	.39	-.08	.30	-.27
DAY**3	23	.92	-.24	.21	-.14	.05	-.06	.35	-.14	.34	-.26
X11/12	24	.19	-.16	.83	.31	-.62	.05	.28	.07	-.24	.03
NOV-DA	25	.08	-.04	.21	.11	-.49	.09	.31	.27	-.44	-.06
N.D**2	26	.27	-.12	.29	.07	-.44	.07	.37	.22	-.35	-.11
N.D**3	27	.36	-.16	.33	.04	-.38	.06	.39	.17	-.29	-.13
N.D**4	28	.40	-.19	.35	.02	-.32	.06	.39	.12	-.25	-.15
RW	29	-.10	.10	.18	-.29	.93	-.03	-.21	-.43	.15	-.03
EW	30	.42	-.06	.01	-.14	.04	.02	.35	-.20	.89	-.19

Table D-2

CORRELATION MATRIX FOR THE VARIABLES (Cont'd.)

RA	11	1.00									
RS	12	-.23	1.00								
EA	13	.12	-.48	1.00							
ES	14	-.14	.20	-.24	1.00						
R	15	.15	.93	-.44	.15	1.00					
E	16	-.07	-.08	.35	.83	-.11	1.00				
MON	17	.10	.19	-.03	-.05	.23	-.06	1.00			
TUE	18	-.05	-.31	.28	-.19	-.33	-.02	-.30	1.00		
WED	19	.20	-.06	-.01	.28	.01	.26	-.25	-.35	1.00	
THU	20	-.19	-.09	-.03	-.10	-.16	-.11	-.21	-.30	-.25	1.00
FRI	21	-.09	.38	-.32	.08	.36	-.11	-.17	-.25	-.20	-.17
DAY**2	22	.21	-.04	.27	.25	.03	.40	.03	.19	.07	-.12
DAY**3	23	.18	.04	.20	.30	.11	.40	.02	.20	.06	-.13
X11/12	24	.87	-.62	.28	-.24	-.30	-.07	-.02	.13	.13	-.12
NOV-DA	25	.22	-.48	.42	-.46	-.41	-.20	.06	-.00	-.02	-.02
N.D**2	26	.30	-.43	.44	-.38	-.33	-.10	.11	-.00	.02	-.08
N.D**3	27	.33	-.37	.43	-.32	-.25	-.06	.15	.00	.04	-.12
N.D**4	28	.35	-.31	.40	-.27	-.18	-.03	.18	-.00	.05	-.15
RW	29	.13	.93	-.45	.15	.99	-.12	.26	-.34	.00	-.15
EW	30	-.02	.05	.16	.86	.04	.92	-.01	-.03	.26	-.22
		#11	#12	#13	#14	#15	#16	#17	#18	#19	#20

FRI	21	1.00									
DAY**2	22	-.24	1.00								
DAY**3	23	-.23	.99	1.00							
X11/12	24	-.17	.12	.07	1.00						
NOV-DA	25	-.01	-.10	-.23	.37	1.00					
N.D**2	26	-.06	.12	-.01	.39	.97	1.00				
N.D**3	27	-.07	.23	.11	.39	.91	.98	1.00			
N.D**4	28	-.08	.29	.19	.38	.85	.95	.99	1.00		
RW	29	.34	.05	.13	-.32	-.42	-.34	-.25	-.19	1.00	
EW	30	-.02	.46	.48	-.10	-.28	-.16	-.09	-.05	.05	1.00
		#21	#22	#23	#24	#25	#26	#27	#28	#29	#30

Figure D-1

EXTRABOARD ABSENCES VS. DAY OF THE WEEK

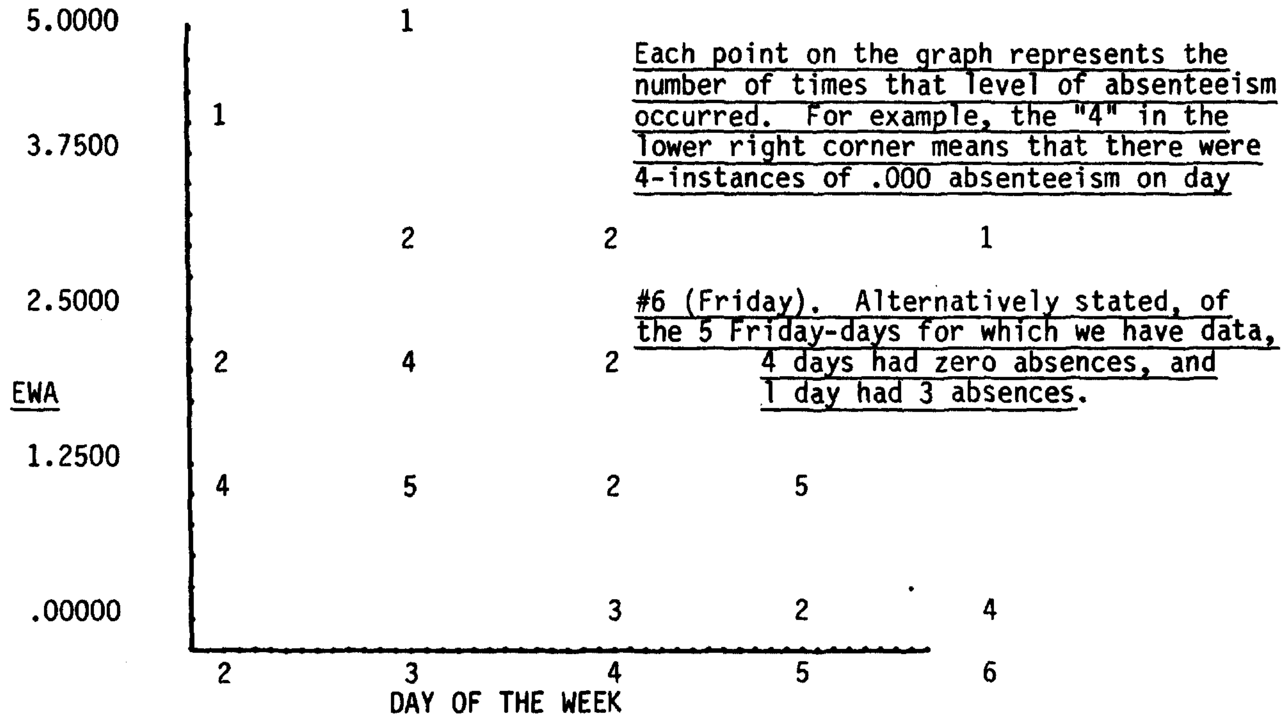


Figure D-2

EXTRABOARD SICKS VS. DAY OF THE WEEK

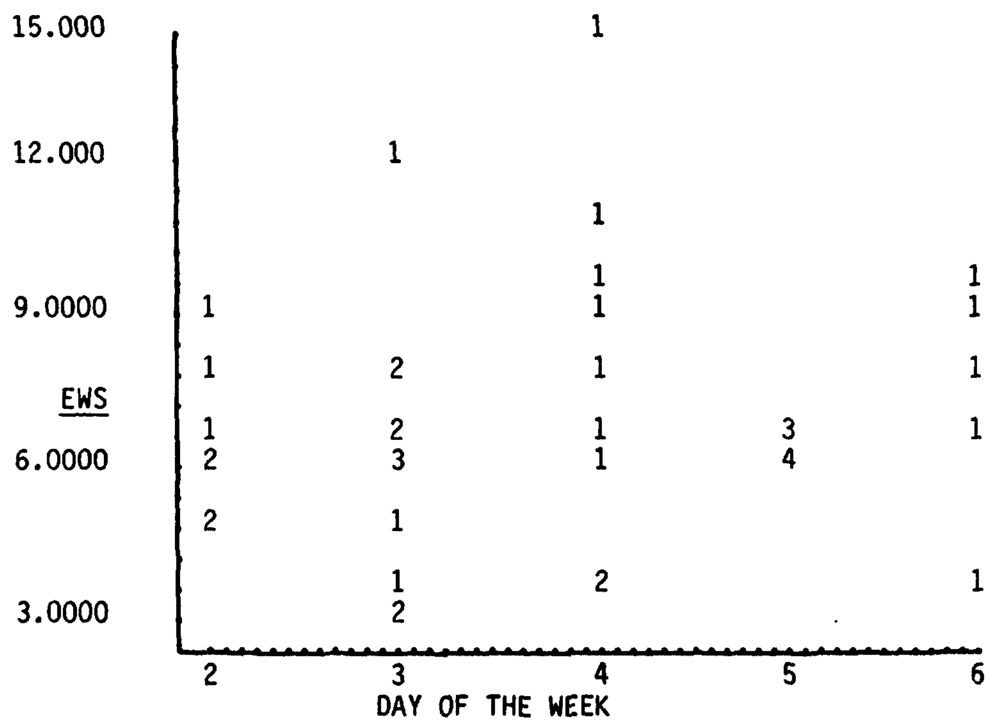


Figure D-3

REGULAR DRIVER SICKS VS. DAY OF THE WEEK

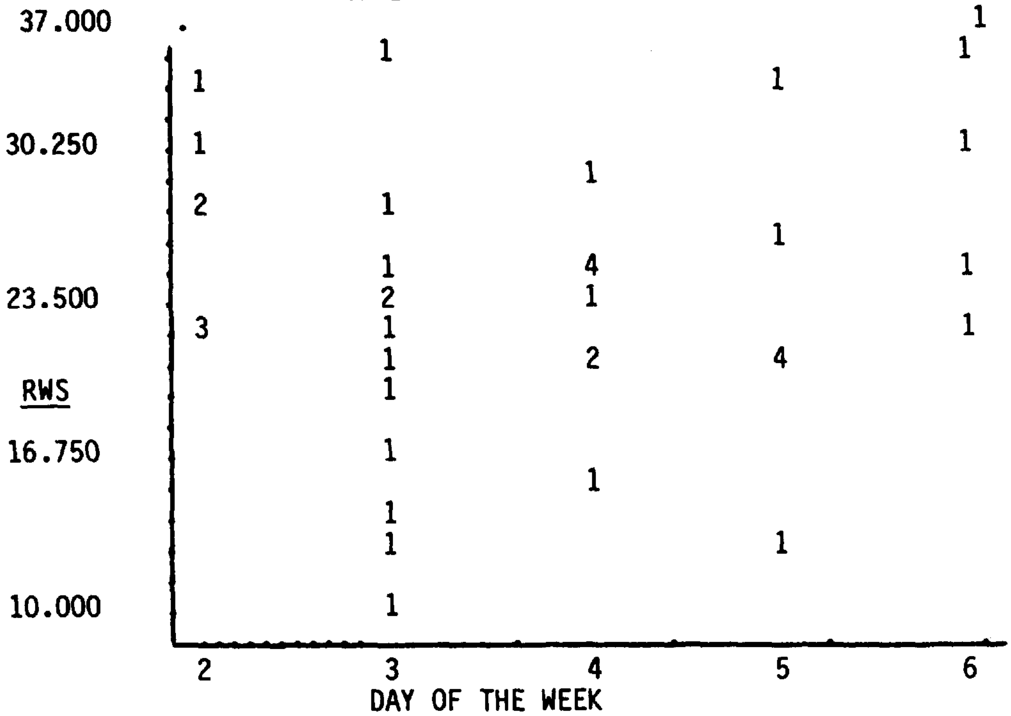


Figure D-4

REGULAR DRIVERS ABSENCES VS. DAY OF THE WEEK

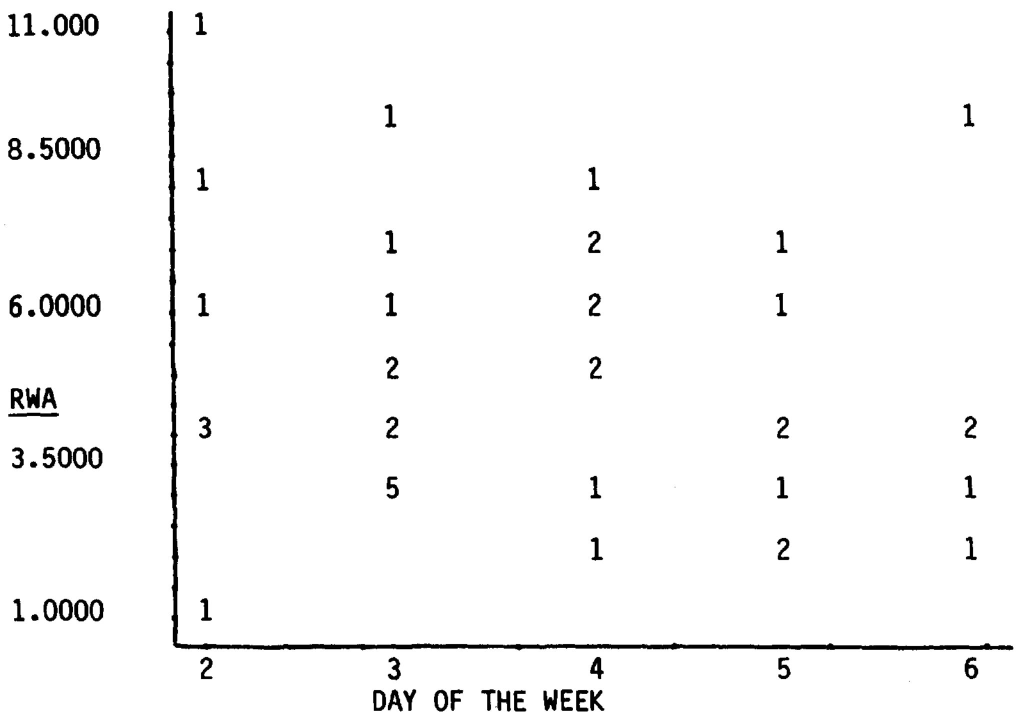


Figure D-5

EXTRABOARD ABSENCES VS. DAY OF THE YEAR

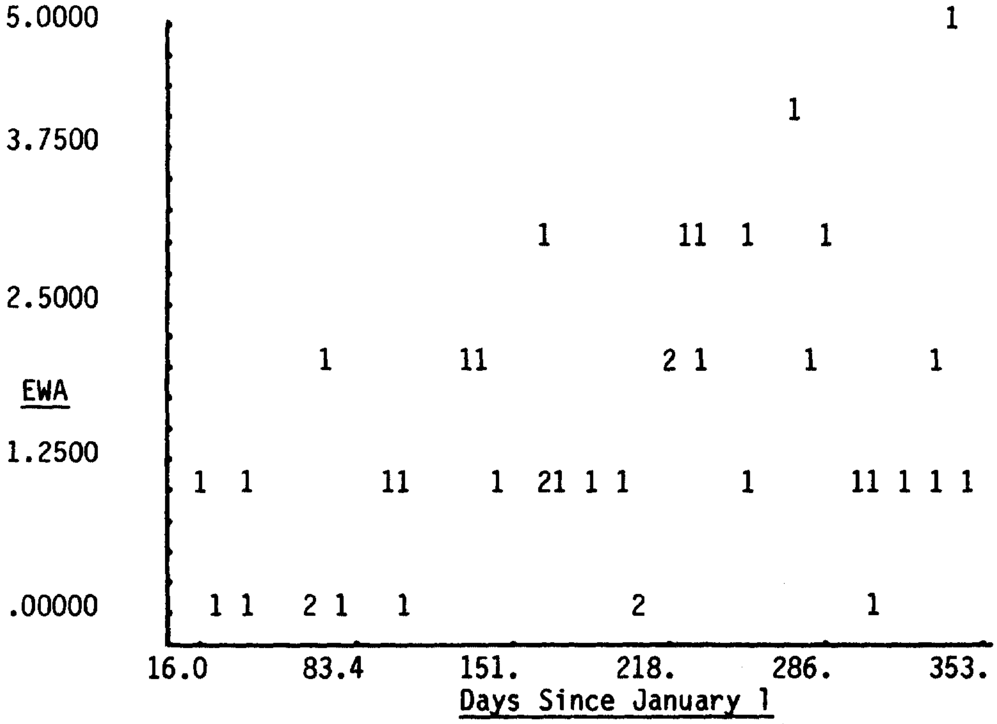


Figure D-6

EXTRABOARD SICKS VS. DAY OF THE YEAR

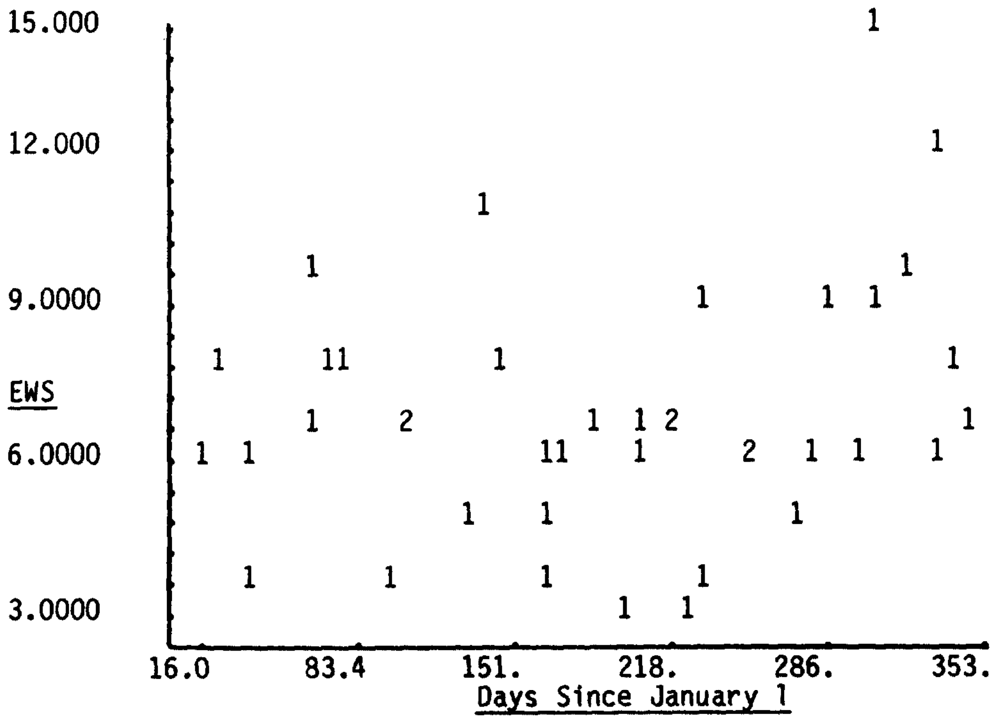


Figure D-7

REGULAR DRIVER SICKS VS. DAY OF THE YEAR

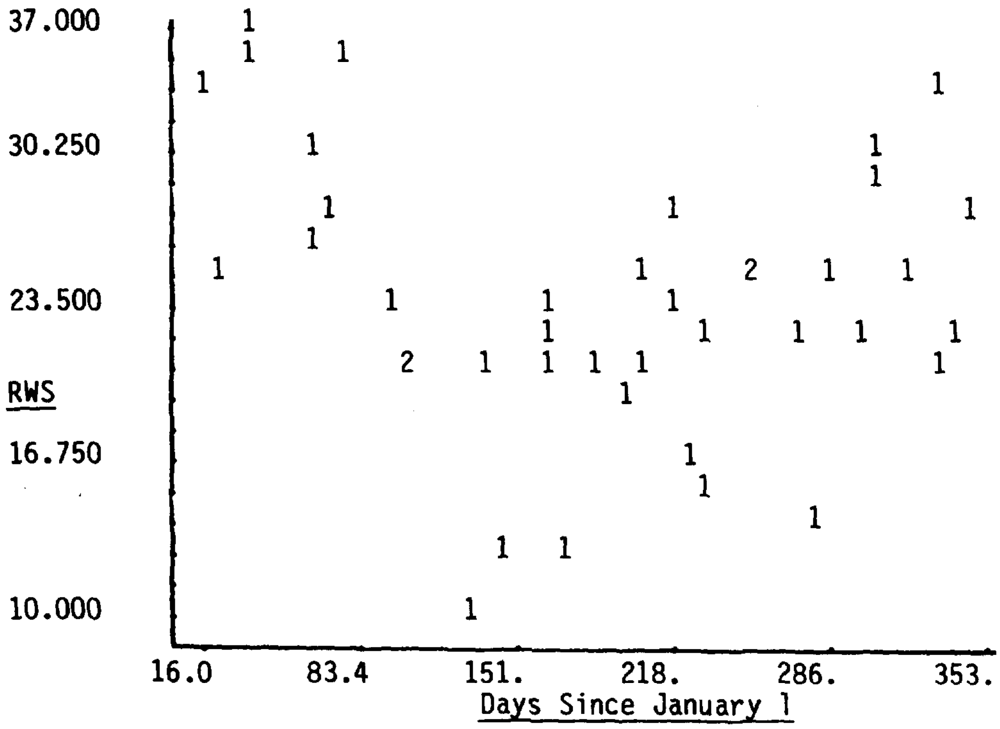
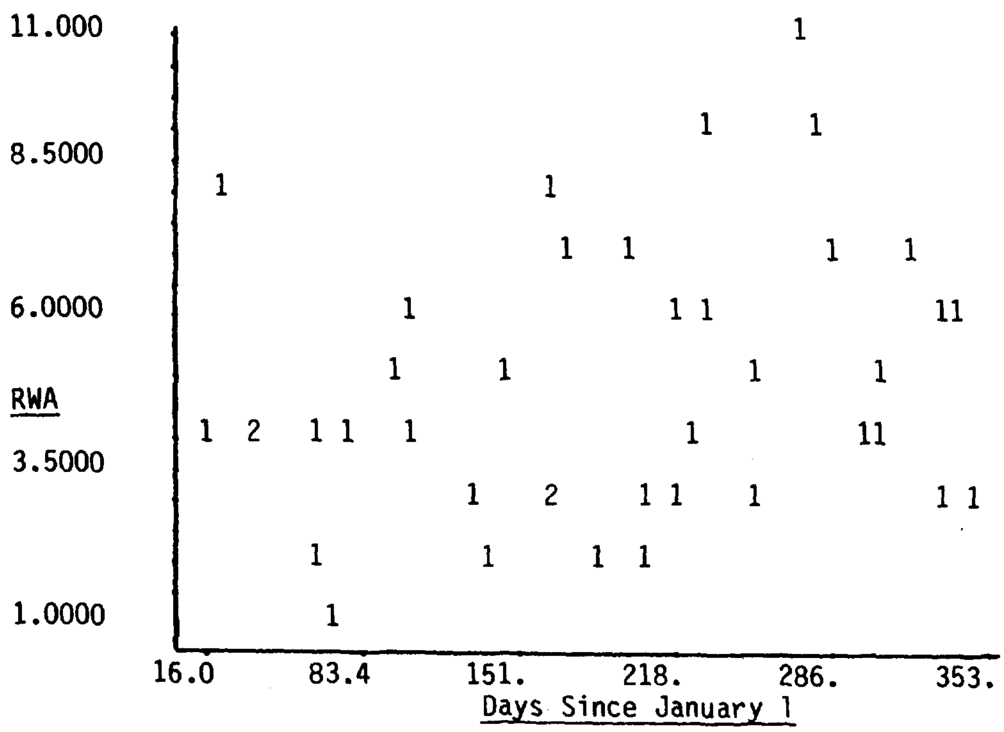


Figure D-8

REGULAR DRIVER ABSENCES VS. DAY OF THE YEAR



Regressions and Analyses of the Data

We decided to use regression analysis to quantify these patterns. This section shows the result of the regressions.

The best regression equation for Whole-Day Absences among the extraboard drivers was:

$$EWA = .70 + \underset{(2.4)}{.86\ (TUESDAY)} + \underset{(2.8)}{.34 \times 10^{-7}\ (NOV\text{-}DAY)^3}$$

t-ratios in ( ) R^2 =.224

No other variables were significant. Overall, the equation explains about 22% of the variance in the data. It shows an overall positive trend in absences, rising most steeply at the end of the sick-day year; and it shows that, other things equal, we expect an increase in absences of .86 drivers on Tuesdays.

Figure D-9 shows the raw data and Figure D-10 shows the fitted relationship from the regression equation. The change in scales between the two plots exaggerates the apparent effects. Figure D-10 shows two parallel curves: the upper one is for Tuesday, the lower one is for the other weekdays. Both curves rise evenly to increase the predicted absences by about one driver per day by the end of the sick-day year.

The best regression equation for Whole-Day-Sicks among the extraboard drivers was:

$$EWS = 9.9 + \underset{(1.7)}{1.4\ (WEDNESDAY)} - \underset{(2.6)}{.032\ (NOV\text{-}DAY)} + \underset{(1.9)}{.61 \times 10^{-4} (NOV\text{-}DAY)^2}$$

t-ratios in ( ) R^2 =.283

No other variables were significatnt. Overall, the equation explains about 28% of the variance in the data. The t-ratios for WEDNESDAY and NOV-DAY^2 are not quite as good as in the previous equation but are still high enough.

Figure D-9

EXTRABOARD ABSENCES VS. START OF SICK-DAY YEAR

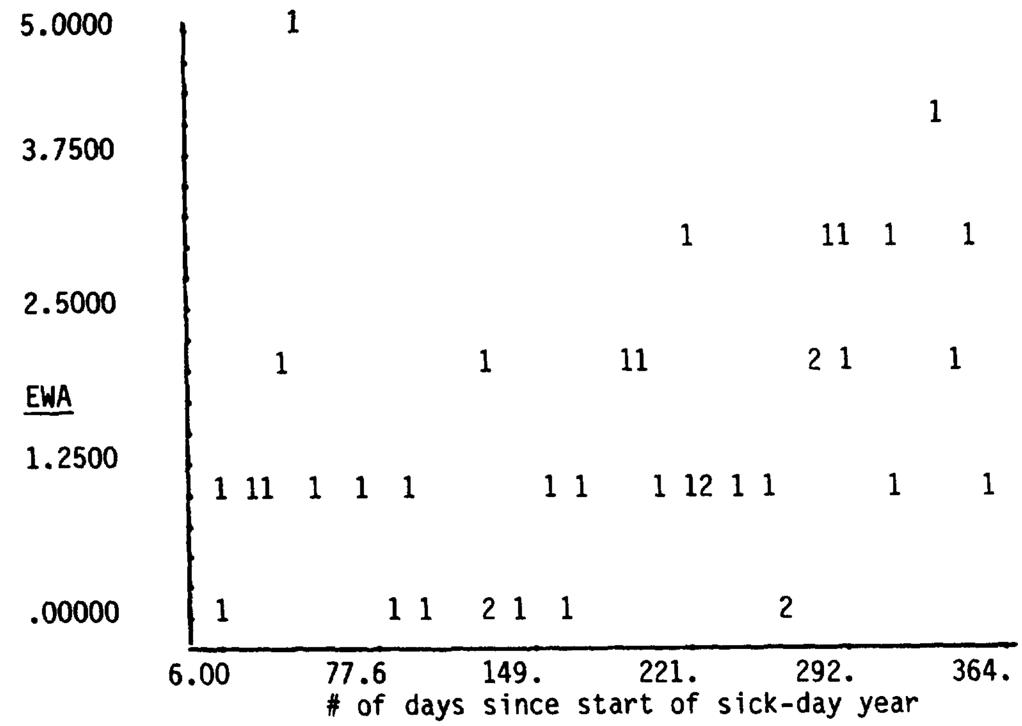
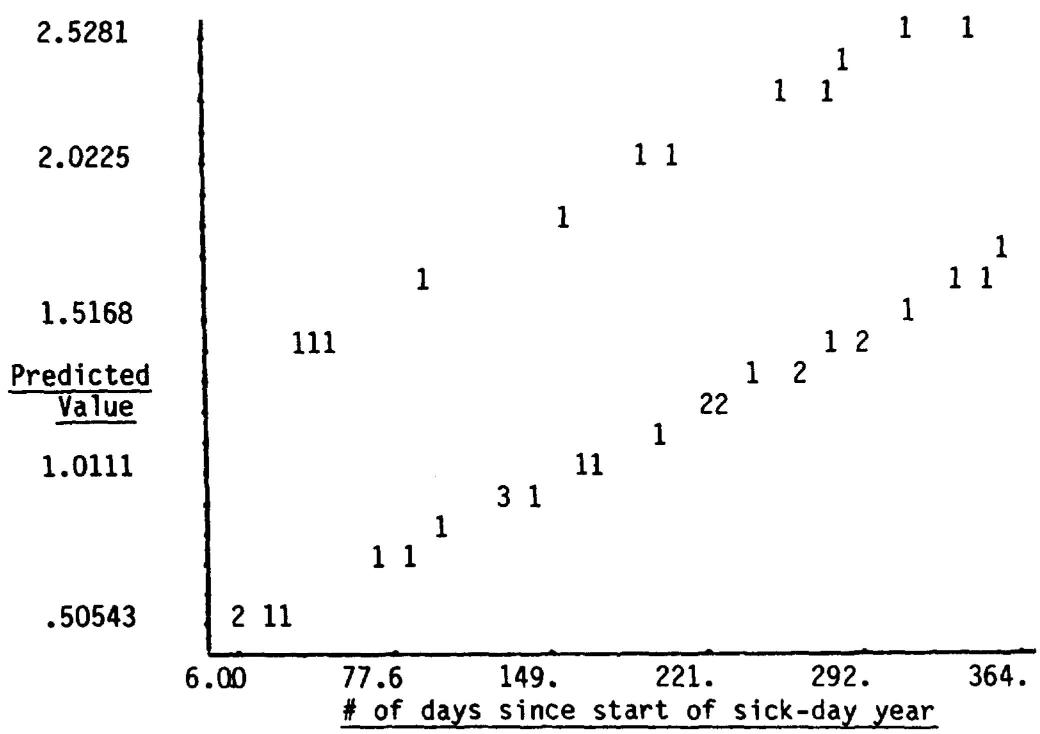


Figure D-10

PREDICTED RELATIONSHIP



for these purposes. The equation shows an overall negative time trend, and an average difference of about 1.4 extra driver sicks on Wednesdays.

Figure D-11 shows the raw data and Figure D-12 shows the fitted relationship from the regression equation. The scale changes between the two plots, which exaggerates the apparent effect of the time trend.

Figure D-12 show two parallel lines: the upper one is for Wednesday, the lower one is for the other weekdays. In both cases the number of sicks is high at the beginning of the sick-day year and gradually decreases to the end of the year. The overall difference is about five drivers per day over the year.

The best regression equation for Whole-Day-Sicks among regular drivers was:

$$RWS = 28.0 + \underset{(2.6)}{5.1\ (MONDAY)} + \underset{(3.4)}{7.7\ (FRIDAY)} - \underset{(4.2)}{.029\ (NOV\text{-}DAY)}$$

t-ratios in ( ) $R^2 = .429$

No other variables were significant. Overall, about 43% of the variance was explained. Figure D-13 shows a plot of the raw data and Figure D-14 shows a plot of the fitted relationship from the regression. Note that the scale changes between the two plots, which exaggerates the effect over the year.

The regression says that, other things equal, we predict that there will be 5.1 more drivers sick on Monday, and 7.7 more drivers sick on Friday, than are normally sick on Tuesday/Wednesday/Thursday.

Notice the pattern in the predicted value of RWS from the regression equation. The overall trend is clearly down over the sick-day year: drivers take their sick days at the beginning and run out of time at the end. The two rows of dots running above the main trend line show what happens when the day is a Monday or Friday, in addition to the main time trend over the year.

In terms of relative strengths of the effects, the overall difference due to the time trend is about nine drivers per day, between the beginning of the year and the end of the year. Monday can add an additional five drivers to that; or Friday can add an additional 7.7 drivers to that.

Figure D-11

EXTRABOARD SICK VS. START OF THE SICK-DAY YEAR

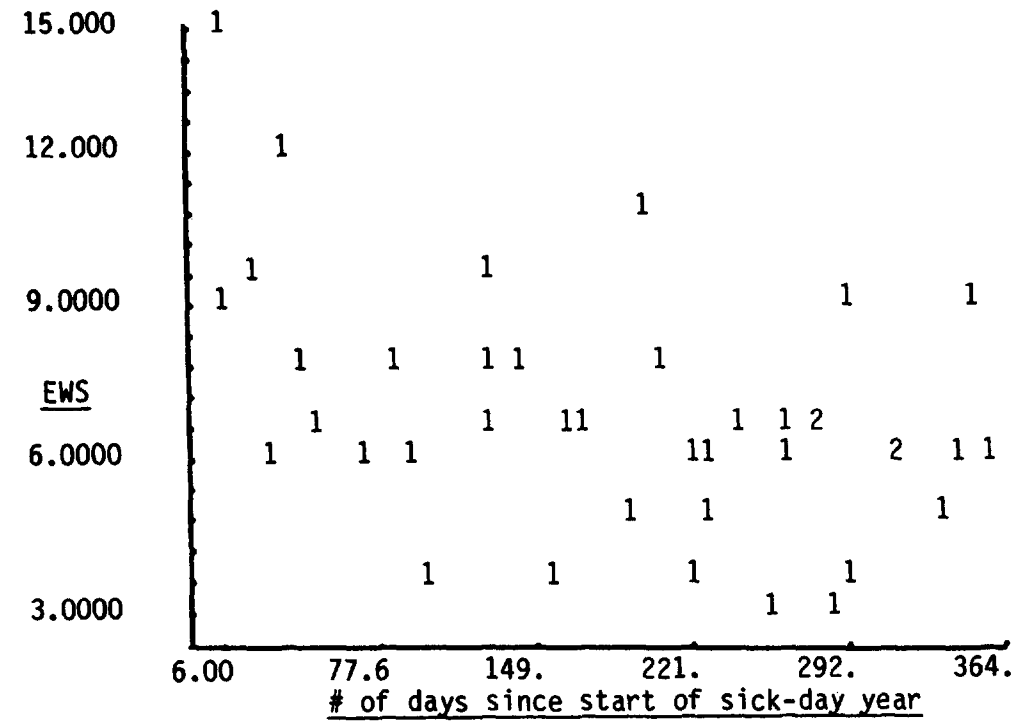


Figure D-12

PREDICTED RELATIONSHIP

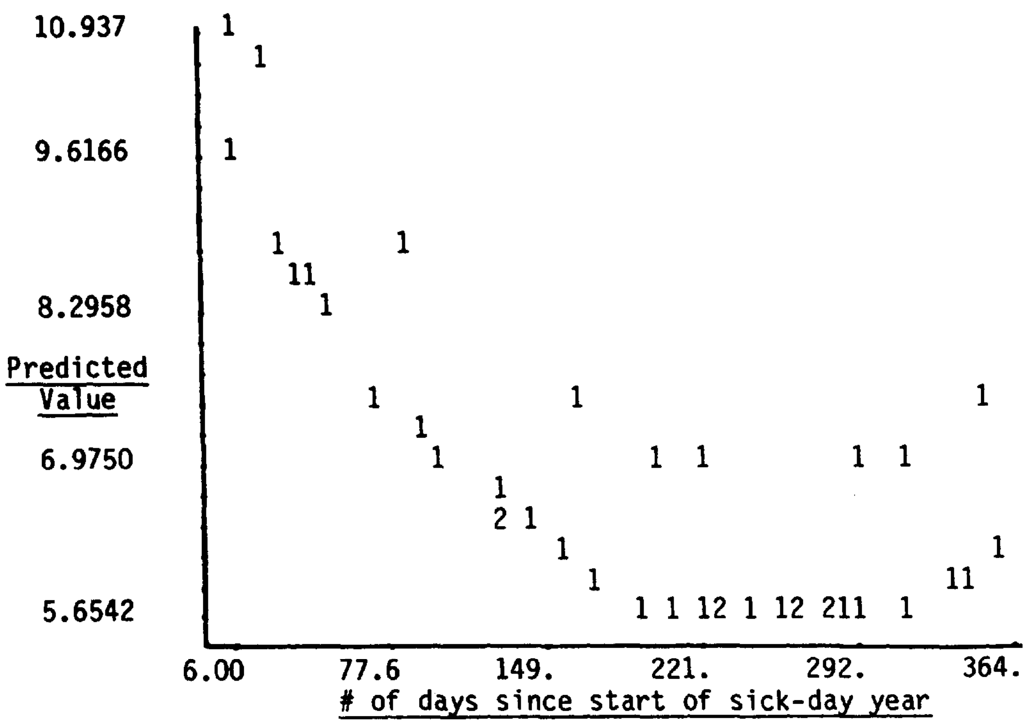


Figure D-13

REGULAR ABSENCES VS. START OF SICK-DAY YEAR

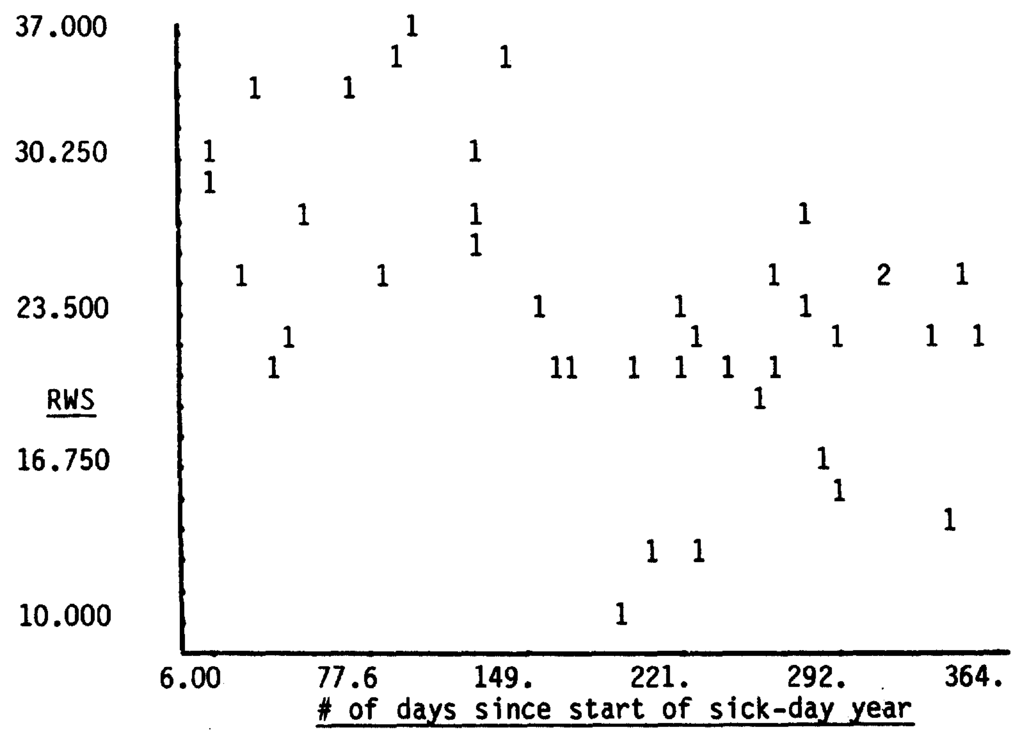


Figure D-14

PREDICTED RELATIONSHIP

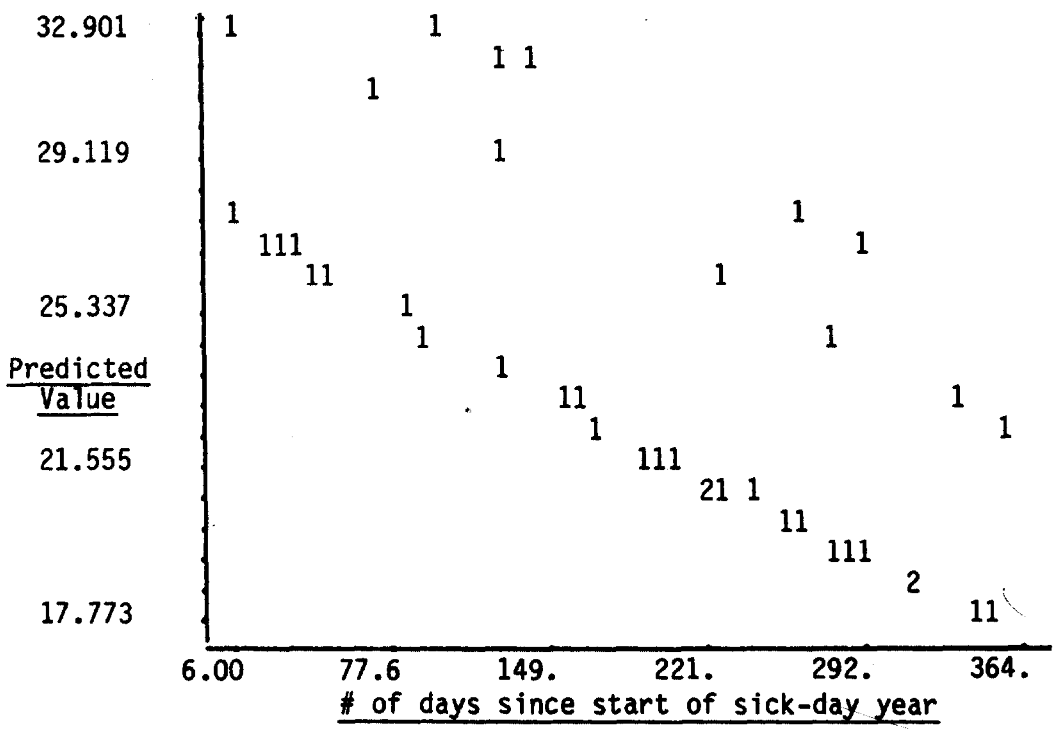


Figure D-15

REGULAR ABSENCES VS. START OF SICK-DAY YEAR

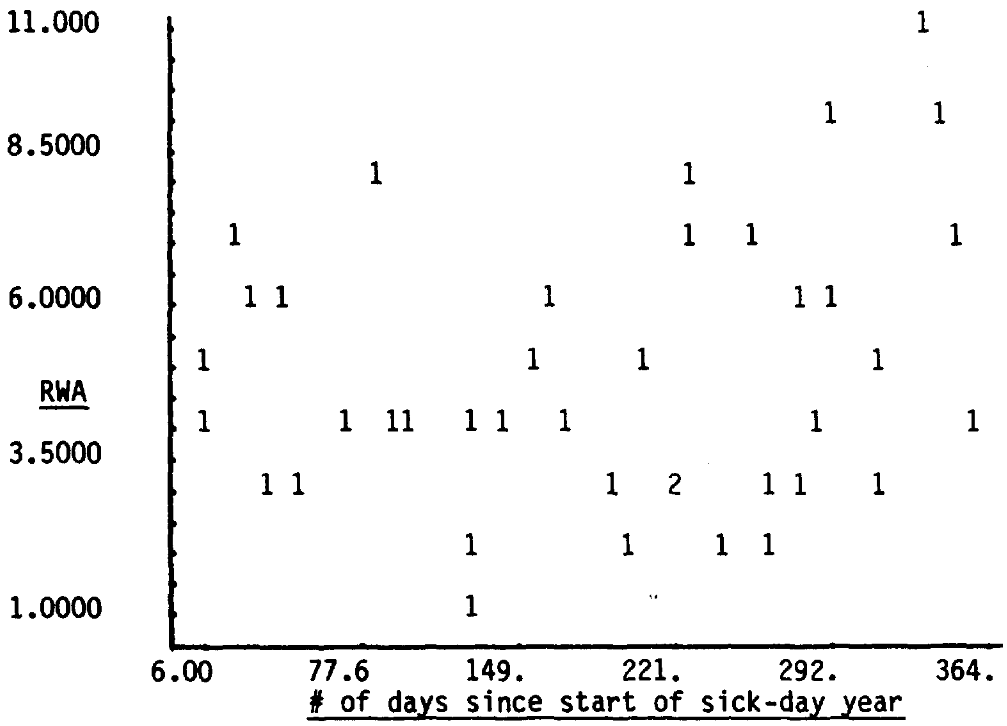
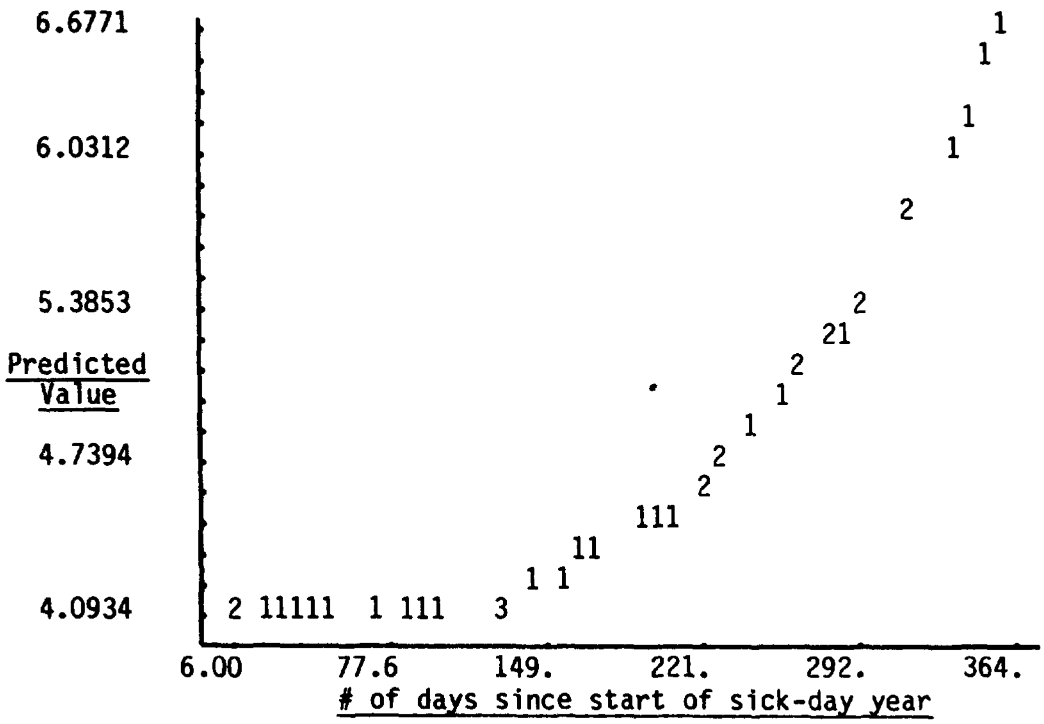


Figure D-16

PREDICTED RELATIONSHIP



APPENDIX E
RESULTS OF RUNCUT SIMULATIONS

The tables in this appendix give the detailed results from our runcut simulations for the nine sets of work rules across the five transit districts, to produce 45 separate scenarios.

Table E-1 shows the number of total driver pay-hours required to operate each of the 45 scenarios; the results are broken down to show the separate figures for full-time (FT) and part-time (PT) drivers. Only pay hours are shown; there are no fringe benefits included in the calculations. (Table E-3 shows the same information with fringe benefits added in.) Note that these are pay-hours, not platform-hours, and include any extra pay for overtime, spread premium, or makeup at the straight-time equivalent rate of pay.

Table E.2 shows the number of drivers needed under each of the 45 scenarios, broken down by full-time and part-time drivers.

Table E.3 repeats the calculations shown in E-1, but adds in the relevant fringe benefits and converts the total to the number of straight-time equivalent hours. Fringes are computed in a way typical of the transit industry. For full-time drivers this amounts to two pay hours plus 25% of wages for each day worked, i.e. roughly a 50% fringe benefit rate. For part-time drivers fringes are computed as 10% of wages (part-timers typically receive much lower fringe benefits than regular drivers).

Tables E-4 to E-6 convert the basic data from E-3 into index numbers to make comparisons between properties easier. The tables differ in terms of which entry is chosen to be the base index of 100. In Table E-4 the base index for each city is taken to be the case that uses no part-time labor, and 13/10 work rules (13 hours maximum spread, and premium pay after 10 hours).

Table E-5 focuses on the relative savings from part time labor and uses the no-part-time row as the base case, index 100, in each column. Hence it is easy to compare up and down in any column to see the effects of differing amounts of part-time labor, but it is not permitted to compare between columns.

Table E-6 focuses on the relative costs of changing spread rules, and uses the 13/10 column as the base case, index 100. Hence it is easy to mave across any row, for comparisons of the effect of spread rule changes, but it is not permitted to mave between rows.

To make a comparison involving both a change of row and a change of column one must use Table E-4.

Note: 10% and 20% part-time operators refer to contracts where a part-time driver is only permitted to work a single tripper each day. If you are trying to project the effect of a 10% limitation in a situation where all of the following are true -- no contract stipulation against 2 trippers per day, relatively wide limits on maximum spread time for part-time drivers, a relatively long maximum daily platform time allowed for part-timers, and where most of the trippers are short enough to be paired up within these daily maximums -- then the proper row to look at is the 20% row in our tables.

Table E-1

DAILY WAGES (STRAIGHT-TIME EQUIVALENT PAY HOURS)

Includes platform, make-up, overtime, spread premium, report, travel. Excludes all fringe benefits.

		13/12*	13/10	12/10
	No part-time operators	1540	1668	2037
CITY "A"	10% part-time operators***	FT:1441** PT: 43	FT:1556 PT: 41	FT:1837 PT: 47
	20% part-time operators	FT:1367 PT: 86	FT:1465 PT: 88	FT:1669 PT: 102

		13/12	13/10	12/10
	No part-time operators	2703	2855	3084
CITY "B"	10% part-time operators	FT:2549 PT: 101	FT:2681 PT: 95	FT:2772 PT: 88
	20% part-time operators	FT:2405 PT: 215	FT:2522 PT: 203	FT:2529 PT: 229

		13/12	13/10	12/10
	No part-time operators	2583	2721	2806
CITY "C"	10% part-time operators	FT:2382 PT: 122	FT:2535 PT: 94	FT:2540 PT: 124
	20% part-time operators	FT:2244 PT: 248	FT:2384 PT: 208	FT:2384 PT: 208

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** "FT" is number of pay hours to Full-Time drivers. "PT" is number of pay hours to Part-Time drivers

*** 10% & 20% part-time limits for one-tripper/day per part-timer.

Table E-1

DAILY WAGES (STRAIGHT-TIME EQUIVALENT PAY HOURS) (Cont'd.)

		13/12*	13/10	12/10
	No part-time operators	2228	2334	2372
CITY "D"	10% part-time operators***	FT:2108** PT: 70	FT:2206 PT: 69	FT:2221 PT: 69
	20% part-time operators	FT:2004 PT: 140	FT:2091 PT: 138	FT:2106 PT: 134

		13/12	13/10	12/10
	No part-time operators	2167	2236	2236
CITY "E"	10% part-time operators	FT:2015 PT: 124	FT:2094 PT: 100	FT:2094 PT: 100
	20% part-time operators	FT:1879 PT: 238	FT:1976 PT: 203	FT:1970 PT: 202

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** "FT" is number of pay hours to Full-Time drivers. "PT" is number of pay hours to Part-Time drivers

*** 10% & 20% part-time limits for one-tripper/day per part-timer.

Table E-2

NUMBER OF OPERATORS, WEEKDAY

Number of operators working a regular run or scheduled tripper on a particular weekday. No allowance for relief runs or report crew.

		13/12*	13/10	12/10
	No part-time operators	182	183	240
CITY "A"	10% part-time operators***	FT:170** PT: 20	FT:170 PT: 20	FT:215 PT: 25
	20% part-time operators	FT:161 PT: 38	FT:160 PT: 39	FT:194 PT: 46

		13/12	13/10	12/10
	No part-time operators	318	318	356
CITY "B"	10% part-time operators	FT:299 PT: 37	FT:299 PT: 37	FT:317 PT: 39
	20% part-time operators	FT:283 PT: 70	FT:282 PT: 71	FT:287 PT: 72

		13/12	13/10	12/10
	No part-time operators	297	297	315
CITY "C"	10% part-time operators	FT:277 PT: 35	FT:276 PT: 34	FT:282 PT: 35
	20% part-time operators	FT:264 PT: 68	FT:265 PT: 69	FT:265 PT: 69

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** "FT" is number of pay hours to Full-Time drivers. "PT" is number of pay hours to Part-Time drivers

*** 10% & 20% part-time limits for one-tripper/day per part-timer.

Table E-2

NUMBER OF OPERATORS, WEEKDAY (Cont'd.)

		13/12*	13/10	12/10
	No part-time operators	263	263	268
CITY "D"	10% part-time operators***	FT:248** PT: 26	FT:248 PT: 26	FT:250 PT: 26
	20% part-time operators	FT:235 PT: 52	FT:235 PT: 52	FT:237 PT: 52

		13/12	13/10	12/10
	No part-time operators	236	238	238
CITY "E"	10% part-time operators	FT:223 PT: 30	FT:222 PT: 30	FT:222 PT: 30
	20% part-time operators	FT:214 PT: 58	FT:212 PT: 56	FT:219 PT: 57

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** FT is number of Full Time operators. PT is number of Part Time operators.

*** 10% & 20% part-time limits for one-tripper/day per part-timer.

Table E-3

DAILY OPERATOR COMPENSATION: WAGES PLUS FRINGE BENEFITS

Fringes for full-time operators: two pay hours plus 25% of wages.
Fringes for part-time operators: 10% of wages.
Wages taken from Table E-1.

	13/12*	13/10	12/10
No part-time operators	2289	2451	3026
10% part-time operators**	2189	2330	2778
20% part-time operators	2125	2248	2586

CITY "A" (1212 platform hours)

	13/12	13/10	12/10
No part-time operators	4015	4205	4567
10% part-time operators	3895	4054	4196
20% part-time operators	3809	3940	3987

CITY "B" (2337 platform hours)

	13/12	13/10	12/10
No part-time operators	3823	3995	4138
10% part-time operators	3666	3824	3875
20% part-time operators	3606	3738	3738

CITY "C" (2272 platform hours)

Table E-3

DAILY OPERATOR COMPENSATION: WAGES PLUS FRINGE BENEFITS (Cont'd.)

	13/12	13/10	12/10
No part-time operators	3311	3444	3501
10% part-time operators	3208	3329	3352
20% part-time operators	3129	3236	3254

CITY "D" (1848 platform hours)

	13/12	13/10	12/10
No part-time operators	3181	3271	3271
10% part-time operators	3101	3172	3172
20% part-time operators	3039	3117	3123

CITY "E" (1930 platform hours)

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** 10% & 20% part-time limits for one-tripper/day per part-timer.

Table E-4

RELATIVE COST OF WORK RULES

(13/10, No part-time) = 100.0
Source: Table E-3

	13/12*	13/10	12/10
No part-time operators	93.4	100.0	123.5
10% part-time operators**	89.3	95.1	113.3
20% part-time operators	86.7	91.7	105.5

CITY "A"

	13/12	13/10	12/10
No part-time operators	95.5	100.0	108.6
10% part-time operators	92.6	96.4	99.8
20% part-time operators	90.6	93.7	94.8

CITY "B"

	13/12	13/10	12/10
No part-time operators	95.7	100.0	103.6
10% part-time operators	91.8	95.7	97.0
20% part-time operators	90.3	93.6	93.6

CITY "C"

Table E-4

RELATIVE COST OF WORK RULES (Cont'd.)

	13/12*	13/10	12/10
No part-time operators	96.1	100.0	101.7
10% part-time operators**	93.1	96.7	97.3
20% part-time operators	90.9	94.0	94.5

CITY "D"

	13/12	13/10	12/10
No part-time operators	97.2	100.0	100.0
10% part-time operators	94.8	97.0	97.0
20% part-time operators	92.9	95.3	95.5

CITY "E"

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** 10% & 20% part-time limits for one-tripper/day per part-timer.

Table E-5

RELATIVE SAVINGS FROM PART-TIME OPERATORS

(no part-time) = 100.0 for each combination of spread rules. Source: Table E-3

	13/12*	13/10	12/10
No part-time operators	100.0	100.0	100.0
10% part-time operators**	95.6	95.1	91.8
20% part-time operators	92.8	91.7	85.5

CITY "A"

	13/12	13/10	12/10
No part-time operators	100.0	100.0	100.0
10% part-time operators	97.0	96.4	91.9
20% part-time operators	94.9	93.7	87.3

CITY "B"

	13/12	13/10	12/10
No part-time operators	100.0	100.0	100.0
10% part-time operators	95.9	95.7	93.6
20% part-time operators	94.3	93.6	90.3

CITY "C"

Table E-5

RELATIVE SAVINGS FROM PART-TIME OPERATORS (Cont'd.)

	13/12*	13/10	12/10
No part-time operators	100.0	100.0	100.0
10% part-time operators**	96.9	96.7	95.7
20% part-time operators	94.5	94.0	92.9

CITY "D"

	13/12	13/10	12/10
No part-time operators	100.0	100.0	100.0
10% part-time operators	97.5	97.0	97.0
20% part-time operators	95.5	95.3	95.5

CITY "E"

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** 10% & 20% part-time limits for one-tripper/day per part-timer.

Table E-6

RELATIVE COSTS OF DIFFERENT SPREAD RULES

(13/10) = 100.0, for each level of part-time operator utilization Source: Table E-3

	13/12*	13/10	12/10
No part-time operators	93.4	100.0	123.5
10% part-time operators**	93.9	100.0	119.2
20% part-time operators	94.5	100.0	115.0

CITY "A"

	13/12	13/10	12/10
No part-time operators	95.5	100.0	108.6
10% part-time operators	96.1	100.0	103.5
20% part-time operators	96.7	100.0	101.2

CITY "B"

	13/12	13/10	12/10
No part-time operators	95.7	100.0	103.6
10% part-time operators	95.9	100.0	101.3
20% part-time operators	96.5	100.0	100.0

CITY "C"

Table E-6

RELATIVE COSTS OF DIFFERENT SPREAD RULES (Cont'd.)

	13/12*	13/10	12/10
No part-time operators	96.1	100.0	101.7
10% part-time operators**	96.4	100.0	100.7
20% part-time operators	96.7	100.0	100.6

CITY "D"

	13/12	13/10	12/10
No part-time operators	97.2	100.0	100.0
10% part-time operators	97.8	100.0	100.0
20% part-time operators	97.5	100.0	100.2

CITY "E"

* 13/12 means 13 hours maximum spread time, and premium pay after 12 hours of spread.

** 10% & 20% part-time limits for one-tripper/day per part-timer.

APPENDIX F

HOW TO PROJECT THE SAVINGS FOR YOUR OWN TRANSIT DISTRICT

One of our purposes in doing this research was to produce some general guidance on the expected effect of work rule changes. That is, suppose the reader wanted to forecast the effect of a change in spread rules, or of the adoption of part-time labor, at his own transit district. How could these results be used to make predictions for a new district?

We show below how to do this, but first we want to offer a number of caveats about such projections. We point out, at the end of Chapter Seven, the dangers of beginning a labor negotiation under exaggerated notions of the savings possible from some work rule change: labor will expect too much compensation for making the change, and management will be too complacent about giving it, and the net result may actually end up as higher costs than under the old contract by the time the compensatory wage increases have compounded across the whole labor force, and the time period of the contract.

An additional problem is that seemingly idiosyncratic features in the contract can often make radical changes in how it is implemented, and may operate to prevent implementation of the features won in the negotiation. Anecdotes abound of such things. In our interviewing of operators with experience of part-time labor we found many who had negotiated a change to allow use of 10% part-time labor, but then had not been able to implement the full 10%. For example, one operator had agreed with the union's request that the loss of premium pay to the regular drivers, because of the use of part-time labor, should be shared equally among all the divisions in the system. So a provision was written that all divisions must utilize an equal percentage of part-time drivers. Unfortunately, though, when it came time to implement the contract and cut new runs it was discovered that one of the divisions was inherently not capable of using very much part-time labor, and so the entire system was limited to a use of part-time labor that was significantly below the 10% that had been negotiated. At other districts we have heard that limitations on the type of run allowed for part-timers (garage to garage trippers only, or runs of more than x hours but less than y hours only, etc.) have prevented the fully effective implementation of part-time labor provisions.

That is, the part-time estimates calculated below should be regarded as the best-case outcomes, and they may very well not be realized at some other transit district due to idiosyncratic variations in local work rules.

We give three methods of calculating the cost savings from use of part time labor, and the three methods become progressively more accurate, but also progressively more difficult to calculate.

Method 1. Given the peak/base ratio for some transit district of interest, decide which of the properties in our sample is closest to the district. Look up that property in Figure 6-8, or 6-9 (depending on whether you are evaluating a change to 10% single-peak part-time labor, or 20% single-peak part-time labor). If your peak/base ratio seems to be between two of the properties in the sample you may have to interpolate a bit between the two sets of columns in the Table. Now depending on whether your current maximum spread time allowed on the extraboard is 13 hours or 12 hours, pick the proper piece of the column and then read off the projected savings. If your spread time is between 12 and 13 hours you will have to interpolate.

Remember that this rough savings estimate is only the estimated savings in operator pay costs, not the estimated savings in total costs. (For most transit districts, operator pay costs come to about half of total costs.) And remember that the projection assumes full implementation, while actual results will be influenced by the kinds of contract implementation idiosyncrasies discussed above.

Method 1 can be applied very quickly and should give a reasonable approximation of expected savings. It is most suitable for use by policy analysts in government who are trying to calculate the effects of work rule changes, but is also useful to transit districts. The next two methods demand the kind of detailed information that is only available to individual districts.

Method 2. This method is based on counting up the number of unpairable trippers (see Appendix G: Glossary) and comparing it to the number of trippers that may be served using part-time labor under the assumed new contract. It takes account of the fringe benefit rates at your property and also some of the major details of the proposed new contract.

The first step is to make a rough calculation of the number of trippers that will be permitted by the proposed contract. For example if you are permitted 10% part-time, and each part-time driver is only permitted to work one tripper per day, the calculation is easy, i.e. it's just the number of part-time drivers permitted. If the part-timers are permitted to work two trippers per day then you cannot just double the number of part-time drivers: there will be some kind of restriction on the maximum daily platform time which part-timers may work, and also on the maximum spread time; and hence the total number of trippers that can be served will be somewhat less than twice the number of part-time drivers permitted. This number will be refined in a moment.

Next list all the unpairable trippers in order of increasing length. If your part-timers are only permitted to work one tripper per day, then you just go down this list, assigning one tripper to each part-timer available. Call this number of trippers T. The former cost of these trippers was

T x 8 x (hourly cost of wages plus fringe benefits)

That is, each of these unpairable trippers costs you a full day's wages and fringes. (See the analysis of extraboard costs in Appendix 3.) Now add up the total number of platform hours involved in these T trippers, call this number P. The new cost of serving these trippers will be

P x (hourly cost of wages + the fringe rate for part-timers)

The difference between the calculated old cost and the calculated new cost is your expected savings from part-time labor.

If your part-timers are permitted to work 2 trippers per day, then the initial step becomes more complex. You want to get the maximum number of short trippers paired up within the total platform limit of the part-time drivers, then give the shortest remaining trippers to the remaining part-time drivers until you have run out of part-timers. Then just repeat the before/after cost calculations as above.

Method 3. Here the basic idea is to do an actual runcut in accordance with the work rules in the new contract, and then cost-out the result. This is a much more complicated procedure, and essentially duplicates the work we did on the properties in the sample. It has the advantage that it can be customized to your own work rules, and indeed this is the only method of the three which is capable of giving reasonable estimates for multiple rule changes, i.e. what happens if we simultaneously decrease maximum spread by half an hour, reduce spread premium by one hour, and allow 10% part-time drivers. We detail the calculation methods we used in our costing in Appendices A - C, and these should provide reasonable guidance for duplicating our process.

APPENDIX G
GLOSSARY AND KEY TERMS ILLUSTRATED*

APTA -- American Public Transit Association. A voluntary organization of transit operators in the U.S.

BLOCK -- the sequence of all trips, including deadheading, made by a bus between pull-in and pull-out. The corresponding concept for drivers in the RUN: a BLOCK may consist of many driver runs.

CLEAR (TIME) -- paid time for vehicle stowing, fare accounting, etc., subsequent to pull-in; usually five or ten minutes.

CLOCK-IN -- the time when a driver reports for assignment at the start of the working day.

CLOCK-OUT -- the time when a driver leaves his job at the end of the working day.

DEADHEADING -- The portion of a route where a bus is moving, but out-of-service. For example, the trip from the garage to the starting point of a run.

DIVISION -- the collection of blocks (bus runs) based at a single garage. The district will be split into several garages to reduct deadheading time.

EXTRABOARD -- The group of operators responsible for covering runs left open by sick or absent regular drivers. In addition the extraboard covers runs left open by vacationing drivers at most districts; and covers; scheduled trippers and charter runs.

Key terms and concepts, indicated by an "", are illustrated in Figure G-1.

GARAGE -- see DIVISION.

HEADWAY -- The time between successive buses along a route. See also POLICY HEADWAY.

INTER-PEAK TIME -- The time between the morning and evening peak service points (the two highest points on the daily buses-in-service curve).

LOAD-SHEDDING -- Reducing the amount of conventional public transit service at peak hours by encouraging the use of paratransit operations (van pools, bus pools, jitneys, shared ride taxis, etc.) to take on the burden of carrying some of the peak-period passengers.

*MAKEUP TIME -- the bonus paid to meet a driver's daily guaranteed minimum pay hours.

MAXIMUM SPREAD -- longest permissible spread time for an operator.

*PAY HOUR -- a unit of money equivalent to one hour of straight-time wage.

PEAK-BASE RATIO -- Total buses in service during the peak commuting period divided by the number of buses in service during the midday period.

PIECE -- an unbroken driver assignment of trips.

*PLATFORM TIME -- actual time in a day's assignment during which an operator is in charge of the vehicle, whether it is in motion or not: the time between pull-out and pull-in, plus clear time and report time.

*PLATFORM OVERTIME -- wage bonus paid for platform time in excess of some daily limit.

POLICY-HEADWAY -- The transit district's policy as to the maximum permissible time between buses, even in the areas with low demand. See HEADWAYS.

PULL-IN -- the time at which a bus returns to the garage from a regularly scheduled trip.

PULL-IN TIME -- see CLEAR.

PULL-OUT -- the time at which a bus leaves the garage for a regularly scheduled trip.

PULL-OUT TIME -- see REPORT.

REGULAR OPERATORS -- operators assigned to regular runs, as opposed to extraboard operators.

*REGULAR RUN -- the combination of regularly scheduled trips making up an operator's daily assignment. If the combined platform times exceed a certain amount, say 6 hours, it is a full-time run. Unless otherwise specified, the term refers to a full-time operator's run.

REPORT (TIME) -- paid time for vehicle preparation prior to pull-out; usually five or ten minutes.

RUN -- see REGULAR RUN.

SPAREBOARD -- see EXTRABOARD.

SPLIT RUN -- a run split into several pieces, containing an unpaid break.

*SPREAD TIME -- total elapsed time from the beginning to the end of a day's assignment including all breaks.

SPREAD PENALTY -- penalty pay to drivers for work performed in excess of a specified SPREAD PREMIUM TIME. For example, under a contract with a spread penalty time of 10 hours, a driver typically receives time-and-a-half for the period longer than the spread penalty time. Thus a driver with 12 hours of spread between clock-in and clock-out, would receive an extra hour of premium pay.

SPREAD PREMIUM -- spread penalty from labor's viewpoint.

MAXIMUM SPREAD -- largest permissible spread time for an operator.

STRAIGHT RUN -- a run without an unpaid break.

SWING TIME -- elapsed time between the end of the first piece and the beginning of the second piece of a two-piece run.

TRIPPER -- short operator assignment. Typically a tripper begins and ends in the garage.

TWO PIECE RUN -- a run containing a break; if the break is unpaid, the run is a split run.

UNPAIRABLE TRIPPERS -- See TRIPPERS. A tripper which cannot be paired with another piece of work, because of its timing and the work rules at the district in question. For example a tripper beginning at 6am could not be paired with a tripper ending at 7pm if the property had a 12 hour maximum spread rule. Very expensive trippers because they must be handled as the sole work of a driver in most situations.

APPENDIX H

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