Bus Operator Planning System Project

Phase III -- Final Report

Evaluation Of Operator-Assignment Ratios

Prepared for:

Southern California Rapid Transit District

Prepared by:

Schimpeler Corradino Associates

in association with

Curry Associates

The Cordoba Corporation

Myra L. Frank & Associates

July, 1986

TABLE OF CONTENTS

1. INTRODUCTION

In October, 1984, the Southern California Rapid Transit District engaged a consultant team headed by Schimpeler Corradino Associates to develop an efficient bus operator planning system that encompasses the hiring of new trainees, scheduling of bus assignments per operating division, and bus operator staffing needs. The project is one of five being funded under the Transit Operator Performance Improvement Fund (TOPIF) for the District. TOPIF was established by the Los Angeles County Transportation Commission (LACTC) to implement selected recommendations of the recently completed SB 759 performance audit of County transit operators that included the District. More specifically, the project has been designed in accordance with the following "Problem Statement" taken from the District's FY 1985-89 Five-Year Short-Range Transit Plan.

> "In pursuit of the goal of maximum efficiency, a system of integrated planning must be established at the front end of the manpower acquisition process which will enable the District to respond effectively and in a timely manner to service fluctuations - particularly those which take place after the planning and budgetary processes for a given fiscal year have been completed. A structural program is needed in which sufficient account is taken of budgetary, training, and staffing levels, throughout the process of planning and scheduling changes in service levels, locations or times."

Phases I and II have been completed and provided a series of recommendations to the District on manpower planning and allocation. These recommendations were contained in the Phase II report, submitted to the District in February, 1985.

In September, 1985, work was commenced on Phase III of the project. Specifically, this phase was designed to evaluate the District-wide setting of 1.27 as the operator-to-assignment ratio using available District data for a 26-week time period from April through September, 1985. For a few weeks in May and June, 1985, the District operated at an operator-to-assignment ratio of approximately 1.27. In August and September, the operator-to-assignment ratio has been below 1.30 due to operator attrition following the July 1 service reductions. In this phase of the study, available data has been analyzed to quantify the effects of reduced operator-to-assignment ratios.

To investigate the effects of a reduced operator-to-assignment ratio, data analysis was conducted using systemwide and division-level data although the analysis was necessarily limited for individual operating divisions due to limited project resources. Initially, various graphical displays, frequency tabulations, and cross-tabulations of the data for individual divisions and for the system as a whole were developed. Based upon the study team's analysis of these displays, statistical tests have been formulated to determine the nature and significance of observed associations in the data. This analysis has resulted in statistical models that are able to describe the results of operating under a range of operator-to-assignment ratios. The development and specification of these models are presented in chapters 2 and 3 of this report.

Two operating divisions were selected for an in-depth review of the daily markup, operator utilization, and dispatching results. This analysis was undertaken as the basis for identifying possible improvements in managing operator availability at lower operator-to-assignment ratios and to validate the results of the weekly data analysis and model development efforts. From this analysis, techniques used for managing operator availability under varying operator shortage conditions have been identified and are discussed in chapter 4.

1.1 KEY OPERATOR PLANNING ISSUES

The analysis carried out in this phase of the project has been directed to focus on key issues related to operator manpower planning at the District. More specifically, issues identified by the study from include the following.

- o Can the District's operations be maintained at an operator-to-assignment ratio of 1.27 without advirsely impacting service reliability and safety?

- o What is the "least cost" operator-to-assignment ratio for the District's operations?

- o Does operator absenteeism increase as the operator-to-assignment ratio is lowered?

- o Can operators be effectively employed for overtime work on days in order to reduce total manpower requirements for the District? Is there a limit on the amount of days off work that can be scheduled? What other methods may be employed to maintain scheduled operations under operator shortage conditions?

- o Do individual operating divisions respond differently as the operator-to-assignment ratio is lowered? Can the different responses be anticipated by examining the characteristics of the division's service operated and operator work force?

- o How can the District apply Phase III results to assist with its on-going operator planning requirements? Can Phase III results be applied to monitor and update operator-to-assignment ratios in the future, possibly as part of the TRANSMIS-II systems currently being designed and implemented?

For certain issue areas, no resolution has been possible although analysis results may provide further insights into the issue. Chapter 5 summarizes the study team's findings and conclusions related to each of the key issues listed above.

Where is Chapter 5?

1.2 OVERVIEW OF OPERATOR PLANNING AND ALLOCATION

The operator planning and allocation process is a complex one, particularly for a transit system as large as the SCRTD. Importantly, the results of this process can significantly impact both the cost and quality of services provided. If operator requirements are not anticipated in an effective manner resulting in a shortage of operators, the results may be:

- o higher costs due to increased operator overtime;
- o increased absenteeism related to the availability of additional overtime work; and
- o reduced service reliability from missed pullouts and trips.

On the other hand, a surplus of operators may ensure that absenteeism levels are controlled and that service reliability is maximized but may also result in higher costs due to increased operator guarantee time and fringe benefit costs. In May, 1985, the District employed approximately 4,200 full-time operators and 620 part-time operators. Expressed as full-time equivalent (FTE) operators, this 620 amounts to a total of 4,510 operators. Total operator requirements may be broken down as the following.

- o Sixty percent for scheduled five-day work runs which are usually bid and operated by operators for an extended time period.
- o Seventeen percent for scheduled service which has not been combined into work runs. Typically, this include spieces of work in the a.m. or p.m. peak periods that are 1-5 hours in length and are referred to as "trippers." This also included "extra service" scheduled on temporary change notices or "pink letters."
- o Twenty-three percent to protect for operators being absent and not available for driving work.

1.2.1 Scheduled Work Runs

Weekly work runs are developed by the Scheduling Department for bidding by operators. These work runs are built by combining weekday, Saturday, and Sunday work assignments into five-day work packages that provide for two consecutive days off. If it were assumed that no operator absence occurs and all service is scheduled into five-day work runs, operator manpower requirements would equal the number of scheduled five-day work runs. However, operators are absent for various reasons and not all service is scheduled into five-day work runs. Only about 60 percent of the required number of operators is based on the number of scheduled work assignments.

Daily work runs are built by the Scheduling Department in conformance with established work rules and practices which govern both the type of runs being constructed and the cost of these runs. Most of these rules and practices are specified in the District's contract with the United Transportation Union (UTU) which represents the District's operators. The cost of work runs is of particular importance, and the "least cost" set of runs should account for the following.

- o Operator pay costs for all scheduled work runs including pay allowances and premiums.
- o Operator pay costs for scheduled service which is not combined

into regular work runs, but which is assigned daily to operators or worked by part-time operators.

- o Indirect operator fringe benefit costs.

- o Other direct and indirect costs resulting from the operation of scheduled services.

At the SCRTD, the average pay hours for a daily work run is approximately eight hours, 40 minutes. Whether or not this average number of pay hours represents the least cost sizing for work runs is a complex problem that involves consideration of the interaction of diverse work rules and of the characteristics of service provided. Many of the optimization strategies which are available, including those considered in this report, address only part of this problem due to its complexity.

1.2.2 Scheduled Trippers

Not all scheduled service may be combined or broken up to form operator work runs. This may be due to limitations for the building of work runs or designed to obtain lower operating costs. Approximately 17 percent of the District's operator requirements are related to the operation of scheduled service in this manner, primarily for trippers in the a.m. and p.m. peak periods which may be operated in one of the following ways.

1. Trippers that contain between two and one-half and five hours of work time may be assigned to part-time operators, subject to the District's limitation than the number of part-time operators does not exceed fifteen percent of the number of full-time operators.

2. Trippers with less than three hours of work time may be designated as being "biddable." An operator may select a biddable tripper together with a regular work run provided that the total work time does not exceed 11 hours, 40 minutes. A minimum of two hours of pay time is guaranteed for working a biddable tripper.

3. Non-Biddable trippers not designated for part-time operators and"open" biddable trippers are "marked up" individually, paired, or combined with other available work runs for daily assignment to extra board operators or operators working on overtime.

Presently, the District operates approximately 1,750 scheduled trippers of which 600 are assigned for bidding by part-time operators, 500 are biddable for full-time operators, and 650 are non-biddable trippers marked up daily for extra board operators.

1.2.3 Protection for Operator Absences

Operators may be unavailable for work for a number of reasons governed by provisions of the UTU labor agreement. Additional operators must be retained to cover work assignments that are "open" because of operators being absent or not available for work. At the District, approximately 23 percent of operator staffing requirements are for this purpose.

Operators may be absent or unavailable for work for a number of reasons that include:

- vacation time which may be scheduled annually;
- sick leave for operator illness;
- other leave time provided for in the UTU labor agreement;
- discretionary leave requested by operators;
- assignment of operators to other positions (dispatching, supervision, radio dispatching, instruction, and traffic checking); and
- disciplinary leave required by District management.

What source?

In calendar year 1983, full-time operators at the District averaged over 55 days absent or not available for driving work. This total of lost time does not include regularly scheduled days off or time off for District holidays. Based on tabulations of 1985 operating data for this project, it appears that the number of days absent and not available may have declined since 1983. The recently-completed performance audit of the District's operations by the Los Angeles County Transportation Commission (LACTC) expressed considerable concern over the levels of operator days absent and not available for driving work at the District. Methods used by the District for managing operator availability need to account for potentially adverse effects on operator absenteeism rates.

For operator planning, absenteeism is particularly problematic due to daily variations in the number of operators absent or not available for work. In some cases, these absences may be known in advance so that appropriate action may be taken such as an extra board shakeup to change days off, "selling" open trippers, or calling in operators for days off work. For other absences, report operators are assigned when it is determined that an operator will not be working. For determining operator requirements, it is not immediately clear at what level operator staffing should be established -- at the "average" number of daily open runs, at the level equal to the lowest number of open runs, or at the level equal to the highest number of open runs? If the operator staffing level for protecting against open runs were set for the minimum number of daily open runs (or nearly so), open runs in excess of this number would be worked by operators on overtime. Otherwise, these runs would be cancelled. If worked on overtime, this will be done primarily by utilizing operators on their scheduled days off. Days off work may be done on either a voluntary basis (VCB) or be required by the District (OCB). With increased levels of operator staffing, the District would be required to pay guarantee time to extra board operators for whom no work is available. Since requirements to protect against operator absences represent 23 percent of the District's operator staffing, it represents an area where special attention is deserved.

2. SYSTEMWIDE DATA

2.1 VCBs/OCBs, SHINEOUTS, AND MISSED/LATE PULLOUTS

2.1.1 Prior Hypotheses

As the operator/assignment ratio decreases, there are fewer operators available to the dispatcher to operate the service. Therefore, it should be expected that the number of VCBs and OCBs would increase, to cover unscheduled absences by operators, or that missed and late pullouts would increase. If VCBs and OCBs increase sufficiently, no change should occur in missed and late pullouts. Alternatively, if VCBs and OCBs are not increased sufficiently to cover all unscheduled absence, then missed and late pullouts should increase.

The opposite relationship should be expected for shineouts. As the operator/assignment ratio decreases, the number of shineouts should decrease. This effect will be reduced or will disappear if too many VCBs and OCBs are called in, or if the number of late and missed pullouts is allowed to increase.

Given the interrelationships between these three variables, it should never be the case that VCBs, OCBs, and late and missed pullouts increase, shineouts decrease, and the operator/assignment ratio decreases all in the same week. Similarly, VCBs/OCBs, and late and missed pullouts should not both decrease at the same time that shineouts increase and the operator/assignment ratio increases. Why not?

2.1.2 Results of the Analysis

Analyzing the change between weeks, there are 25 week-to-week changes in the 26-week period under study. For 17 of these week-to-week changes, VCB/OCBs per assignment change in the opposite direction to the operator/assignment ratio; for 15, late/missed pullouts also change in the opposite direction to the operator/assignment ratio: while shineouts per assignment change in the same direction as the operator/assignment ratio only 9 out of 25 times. Taking VCB/OCBs and late/missed pullouts together, there is a change in one or both on 21 week-to-week changes that is in the expected direction. Adding the effects of shineouts, the correct composite change occurs on 23 of the 25 week-to-week changes. There are two occasions -- from week eleven to week twelve (week ending June 8 to week ending June 15) and from week eighteen to week nineteen (week ending July 27 to week ending August 3) when the exact reverse of the expected pattern of changes occurred.

Shineouts are examined in the following analysis. However, it is apparent that shineouts may be a poor measure of unscheduled overtime. Technically, there is very little distinction between 7-1/2 hours of shine and a half hour of duty and 8 hours of shine, the second of which defines a shineout. As a result, a second measure is examined in the following analysis, consisting of total report hours per assignment. This is a measure of the total amount of time not operated by operators on duty.

There is no strong evidence here that there is any lagged effect on the three variables from the operator/assignment ratio, nor is there any reason to expect that there will be such an effect. Within a day-to-day variation, some lagging of the effect of operator availability might occur, but this should not be evident on week-by-week data.

Examining trend plots of the three variables against the operator/assignment ratio as shown in Figure 2-1, the following conclusions appear:

a. Weeks 1 through 7 (ending 3/30 through 5/11):

The operator/assignment ratio decreases throughout this period, starting at 1.30 in the first week and declining to a level of 1.24 systemwide by the week ending May 11, a drop of 4.6 percent.

The VCBs/OCBs per assignment begin at 0.11 and increase to a high of 0.23 by the week ending May 4, as would be hypothesized. However, they drop slightly to 0.21 in the last week of the period. Overall, the VCBs/OCBs show about the expected relationship with the Operator/Assignment Ratio, with the exception of the last week of the period.

Late and missed pullouts per assignment increase throughout the period from an initial value of 0.010, reaching a maximum by week seven. This occurs at a value of .036 late and missed pullouts per assignment. The rise in late and missed pullouts as the Operator/Assignment Ratio drops is an expected result, and is indicative of the fact that the increase in VCBs/OCBs is not sufficient to allow maintenance of the low initial level of late and missed pullouts.

Shineouts per assignment decrease over the first four weeks, but show a slight increase in the sixth and seventh weeks. They begin the period at .005 per assignment, drop to .0019 by the fourth week and rise to .0038 in the seventh week. Report time per assignment is unavailable for the first four weeks. For the last three weeks, as shown in Figure 2-2, it increases from 1.475 hours per assignment to 1.589, following a similar pattern to shineouts. The increase in shine hours and shineouts as the Operator/Assignment Ratio decreases, VCBs/OCBs increase, and late and missed pullouts increase is not an expected result. It would appear to suggest that a scheduling problem has developed, where extraboard and VCBs/OCBs are not necessarily available when shortages of operators occur, while they are available at other times of the day when there is no shortage.

OPERATOR/ASSIGNMENT RATIO, VCB/OCBS, LATE/CANCELLED RUNS

AND SHINEOUTS PER ASSIGNMENT

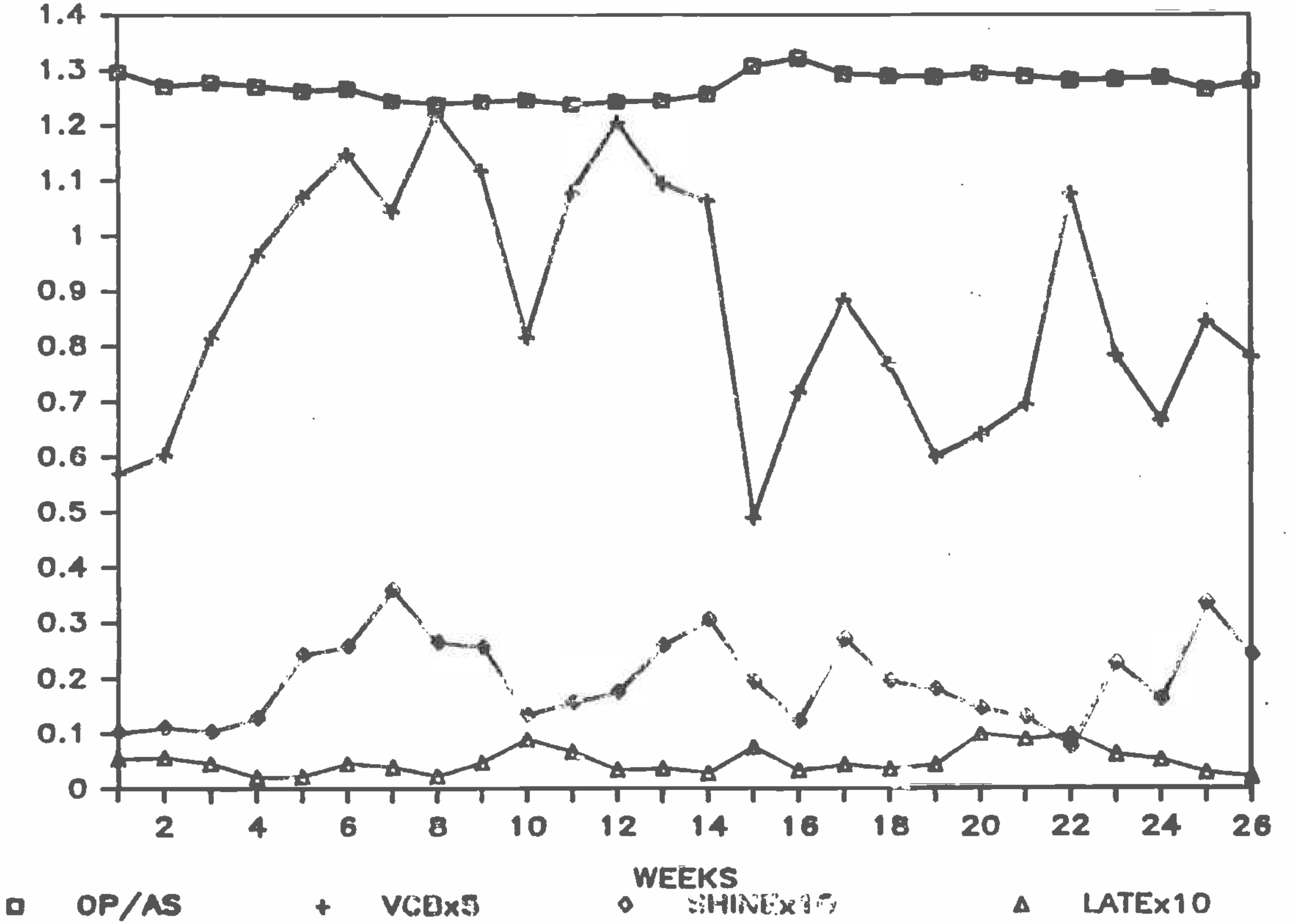


FIGURE 2-1

OPERATOR/ASSIGNMENT RATIO, VCB /REPORT/LATE PER ASSIGNMENT ALL DIVISIONS

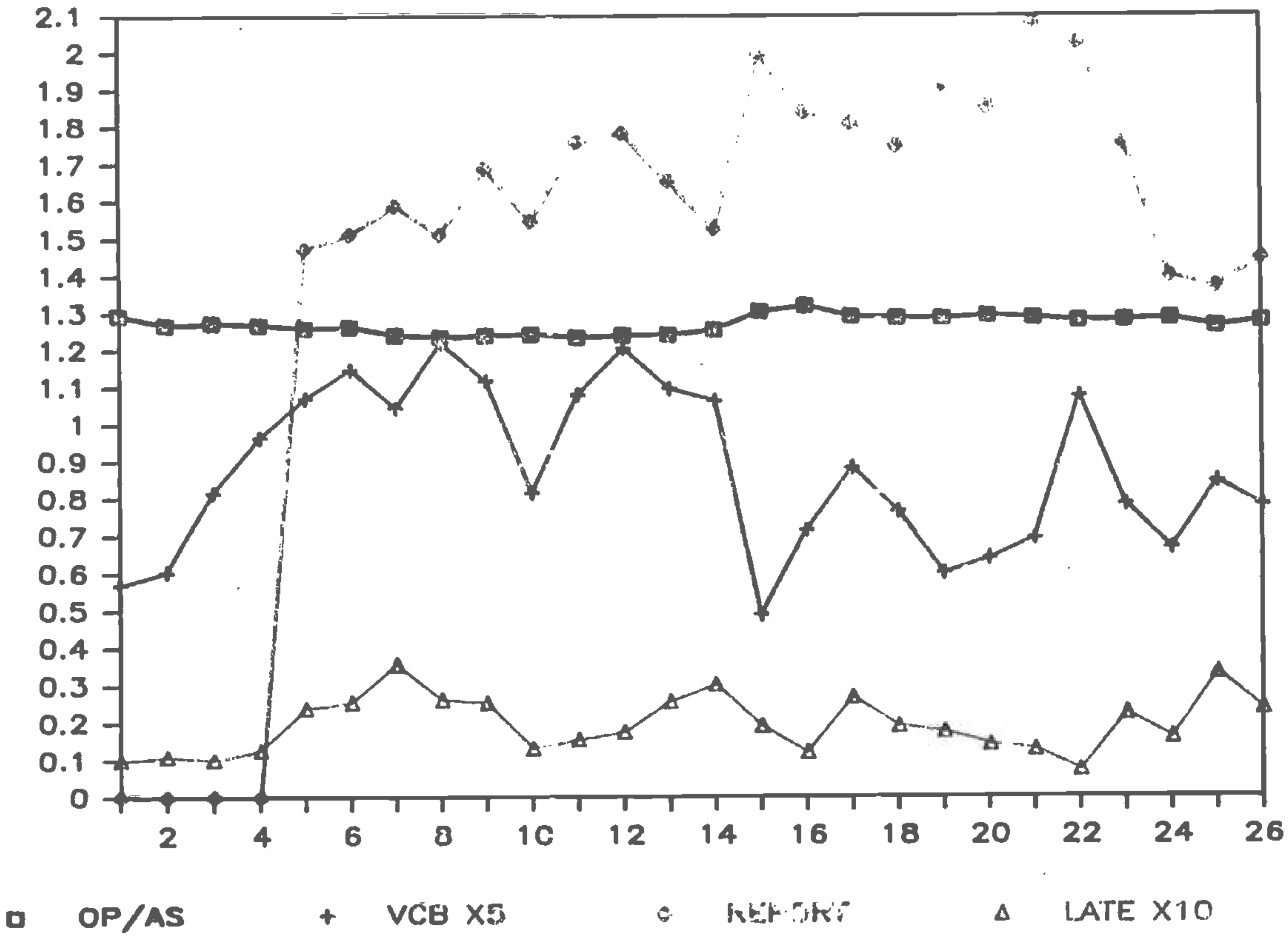


FIGURE 2-2

Overall, this period shows the expected relationships between Operator/Assignment Ratio and each of VCBs/OCBs and late and missed pullouts. However, changes in shineouts and report hours are not as expected and indicate that dispatchers may not have been able to anticipate changes in operator availability as effectively as would be hoped.

b. Weeks 8 through 14 (ending 5/18 through 6/29):

The operator/assignment ratio is essentially constant through this period at a value of 1.24, although a slight increase to 1.25 occurs in the week ending June 1, but drops back to 1.24 in the following week.

The VCBs/OCBs per assignment fluctuate quite widely over this period. After rising initially to 0.24, the VCBs/OCBs then decline over two weeks to 0.16, climb back to 0.24 over the next two weeks, and drop back to 0.21 by the fourteenth week. Given the steady Operator/Assignment Ratio through the period, these fluctuations in VCBs/OCBs are clearly generated by something other than the Operator/Assignment Ratio. An examination of absence, as shown in Figure 2-3, during the period shows that absence climbs from week seven to week eight and then declines quite sharply through weeks nine and ten. It appears, therefore, that the decline in absence generates the need for additional VCBs/OCBs in week eight and also generates the decrease in VCBs/OCBs over the next two weeks. Over weeks eleven through fourteen, absences rise again, and this generally parallels an overall rise in VCBs/OCBs. There are week-to-week fluctuations that do not create a parallel between VCBs/OCBs and absence, but the trends are similar.

Late and missed pullouts decline over the first three weeks of this period from the high at the end of the previous period. Starting from a high at the end of the previous period of 0.036 per assignment, they decline with the OCBs/VCBs to a low of 0.013 by week ten. They then rise gradually to 0.031 by the fourteenth week. During the first three weeks of the period, the decline is not consistent with the static Operator/Assignment Ratio and declining VCBs/OCBs, suggesting that the decline in absence provides sufficient operators to improve on-time pullouts. For the remainder of the period, given the changes in VCBs/OCBs and the changes discussed below in shineouts, the late and missed pullouts change consistently, indicating that shortages of operators generate increasing missed and late pullouts, as expected.

As shown in Figure 2-1, the shineouts per assignment are fairly steady at around 0.004 per assignment for the first two weeks of this period, then rise rapidly to 0.009 in the next two weeks. They then fall equally rapidly back to 0.0028 by the fourteenth week. The report hours per assignment show a slightly different picture. Over the first four weeks of the period, report hours per assignment vary significantly from 1.512 in week eight to

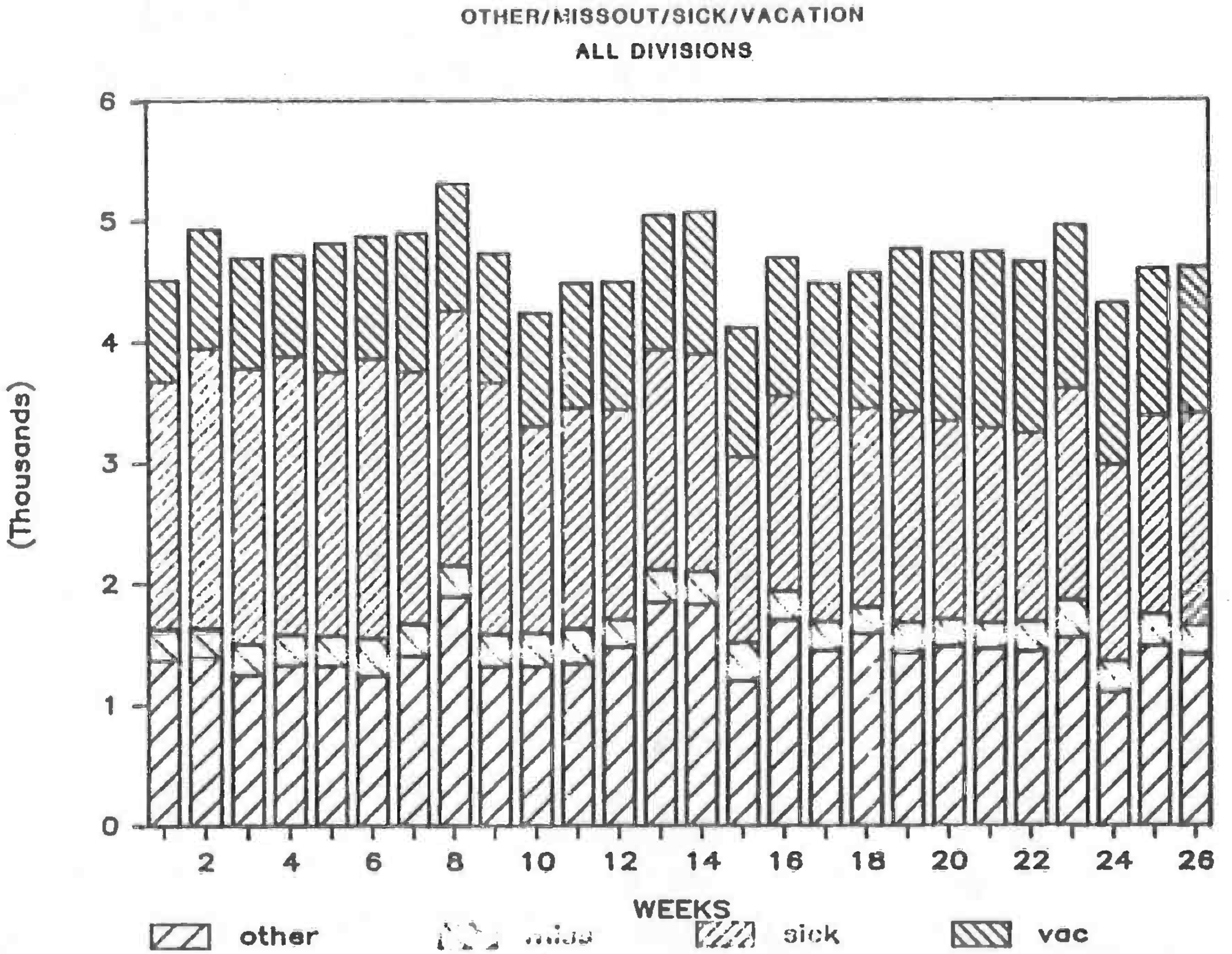

OTHER/MISSOUT/SICK/VACATION
ALL DIVISIONS
(Thousands)
0
1
2
3
4
5
6
2
4
6
8
10
12
14
16
18
20
22
24
26
WEEKS
other
sick
vac

FIGURE 2-3

1.689 in week nine, 1.548 in week ten, and 1.759 in week eleven. This pattern is quite unlike that of the shineouts. In the last three weeks of the period, the report hours decline from 1.783 to 1.525, paralleling a decline in VCBs/OCBs and a rise in late and missed pullouts. Except for week seven to week eight and week eight to week nine, the report hours per assignment change in the same direction as VCBs/OCBs, as would be expected. The decrease from week seven to week eight coincides with the increase in absence and presumably indicates that extraboard operators were used more effectively in week eight. The increase in report hours to week nine may indicate an insufficient cut in VCBs/OCBs, as absence, particularly unscheduled absence, declined significantly.

Overall, this period shows evidence of VCBs/OCBs responding to absence characteristics, when Operator/Assignment Ratio is static. The changes in late and missed pullouts and shineouts, shown in Figure 2-1, and report hours, shown in Figure 2-2, are as expected, given the changes in VCBs/OCBs.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, Figure 2-1 shows the operator/assignment ratio climbing from its steady state at 1.24 in the previous period, to 1.32 in week sixteen, and then declining slightly to 1.29 the following week. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers.

As expected, with the increases in available operators, the VCBs/OCBs per assignment decline markedly in the first week, but then begin climbing to the end of this period. Apart from the fact that the VCBs/OCBs start climbing sooner than expected (possibly due to an overcompensation in adjustment in week sixteen), the trends are as hypothesized.

Missed and late pullouts decline for the first two weeks and rise in the last week of this period, as the operator/assignment ratio begins to decline again. This pattern is what would be expected in terms of the operator/assignment ratio, with the number of missed and late pullouts declining as more operators become available from the increasing operator/assignment ratio, and increasing again as the operator/assignment ratio drops. However, in the last week of the period, the increase in VCBs/OCBs is apparently insufficient to compensate for the decrease in operator/assignment ratio, resulting in a peaking of the missed and late pullouts in week seventeen.

Shineouts per assignment increase at the beginning of the period (Figure 2-1), indicating that the sudden decrease in VCBs/OCBs was still insufficient against the increase in the operator/assignment ratio. The system appears to be quite unstable with respect to shineouts over the period, with a sharp increase in shineouts in the fifteenth week, even though the VCBs/OCBs drop significantly, then a decrease in shineouts, while VCBs/OCBs rise and the operator/assignment ratio rises in the sixteenth week. In the seventeenth week, shineouts rise again, as the operator/assignment ratio drops, VCBs/OCBs rise, and missed and late pullouts rise. The report hours per assignment (Figure 2-2) show a more stable pattern. The initial rise in shineouts is paralleled by a rise in report hours per assignment from week fourteen to week fifteen. Report hours then decline for the remainder of the period from a high of 2.0 to 1.81. Given that both VCBs/OCBs and late and missed pullouts rise in this period, the report hours should decline.

Overall, this period shows some instabilities as the operator/assignment ratio made some of its largest week-to-week changes, resulting from the June shake-up. Generally, the hypothesized relationships seem to hold, although there is evidence that the system takes two or three weeks to recover from the shake-up.

d. Weeks 18 through 24 (ending 7/27 through 9/7):

As shown in Figures 2-1 and 2-2, during this period the operator/assignment ratio is steady at 1.29 for the eighteenth through twenty-first weeks, then decreases to 1.28 for the next two weeks, and returns to about 1.29 for the last week of the period.

Despite the stability of the operator/assignment ratio, there are some significant changes in the VCBs/OCBs through the period. Initially, the VCBs/OCBs per assignment decline from the peak of 0.18 in week seventeen to a low of 0.12 in week nineteen. Over the next two weeks, the VCBs/OCBs rise slightly to 0.14, then peak in the twenty-third week at 0.22, dropping back to around 0.14 for the last two weeks of the period. The sudden rise occurs in the same week that the operator/assignment ratio declines from 1.29 to 1.28. The size of the increase seems, however, to be out of proportion to the change in operator/assignment ratio. Presumably this is why VCBs/OCBs immediately drop back to 0.155 the following week, and then to almost 0.13 in the final week, when the operator/assignment ratio increases back to 1.29. It is notable also that there is a marked increase in absences in the twenty-second and twenty-third weeks, the peak in week twenty-two being from requests off and the peak in week twenty-three being from missouts. These may be responsible for the extent of the peak in VCBs/OCBs in week twenty-three.

Missed and late pullouts decline from week eighteen through week twenty-two, dipping more sharply in week twenty-two, when the VCBs/OCBs peak. In week twenty-three, the missed and late pullouts jump sharply upwards from .007 to 0.023, but then decline to 0.016 for the last week in the period. Given the stability in operator/assignment ratios, the decline in missed and late pullouts appears to be primarily in response to changes in VCBs/OCBs, after the effects of the June shake-up have settled out of the system. Generally, the missed and late pullouts decline as VCBs/OCBs rise, and rise when VCBs/OCBs drops, as expected.

After declining from week seventeen to week eighteen, the shineouts (Figure 2-1) rise from a low in week eighteen of .003 to 0.01 in week twenty. This rise occurs as VCBs/OCBs rise, and as a slight upward movement in operator/assignment ratio occurs. Shineouts remain high over weeks twenty, twenty-one, and twenty-two, and then decline over the remaining two weeks of the period. The decline occurs as VCBs/OCBs also decline, as expected. Report hours (Figure 2-2) again show a significantly different pattern from shineouts. The report hours per assignment decline from 1.81 in week seventeen to 1.75 in week eighteen. The following week, report hours return to 1.91, then decline slightly to 1.85, and then peak at 2.08 in week twenty-one. For the remainder of the period they decline to 1.40 by week twenty four. Given that the Operator/Assignment Ratio is static through this period, the expected driving force on report hours will be the VCBs/OCBs. From week eighteen to week nineteen, VCBs/OCBs decline, but report hours increase and missed and late pullouts decrease. This is contrary to expectation, but is indicative of some change in the scheduling of extraboard operators (including VCBs/OCBs) that may be accommodating the pullout requirements better. Similarly, from week nineteen to week twenty, VCBs/OCBs rise and there is also a slight increase in Operator/Assignment Ratio, while report hours decrease and late and missed pullouts decrease. Again, the expectation would be that report hours should have risen in this period. From week twenty to week twenty-one, VCBs/OCBs rise further, Operator/Assignment Ratio decreases slightly, late and missed pullouts decrease again, and report hours increase. This is consistent with prior hypotheses. From weeks twenty-one to twenty-two, the Operator/Assignment Ratio decreases slightly, VCBs/OCBs rise sharply, late and missed pullouts drop, and report hours decrease slightly. Again, this is not as expected, but can be accounted for by changes in the time-of-day distribution of the VCBs/OCBs. For the remainder of the period, report hours drop sharply as VCBs/OCBs drop, as expected.

Throughout this period, the hypothesized relationships among these variables appear to hold quite well, with VCBs/OCBs and shineouts varying together, and missed and late pullouts changing in the opposite direction to these two variables. Figures 2-1 and 2-2 show that the operator/assignment ratio is fairly steady, so that there appear to be other factors, as in weeks 8 through 14, that are generating the changes in each of the other measures. The exception to the consistent pattern is about four weeks of report hours per assignment, but these can be accounted for largely on the assumption that there are variations in the times when VCBs/OCBs report, in relation to the schedule of pullouts.

e. Weeks 25 and 26 (ending 9/14 and 9/21):

A minor shake-up took place on September 8 that affects the performance in the last two weeks of the study period. Service was added back after the service cuts in June, resulting in a sharp drop in the operator/assignment ratio to 1.26 in week twenty-five, although it recovered to almost 1.28 in the following week.

As shown in Figure 2-1, as a result of the drop in the operator/assignment ratio, the VCBs/OCBs per assignment increases in week twenty-five, decreasing again in week twenty-six, as the operator/assignment ratio recovers. These changes are as expected.

Missed and late pullouts increase sharply in week twenty-five to 0.034, the highest value in the entire twenty-six weeks. This statistic then decreases quite sharply to 0.024 in the final week. Again, these changes occur in the expected direction, and appear to be a result of the changes in operator/assignment ratio.

Shineouts per assignment decline through both weeks. In the first week, this is expected, as the operator/assignment ratio drops and the VCBs/OCBs rises. However, one would expect that shineouts might have increased in the last week, as the operator/assignment ratio rose and VCBs/OCBs dropped. Report hours per assignment also decrease in the first week of the period, consistent with the drop in Operator/Assignment Ratio and the corresponding increase in VCBs/OCBs. In the second week, the report hours rise, as it would have been expected the shineouts should rise, but did not. Therefore, total report hours per assignment shows the expected relationship to the Operator/Assignment Ratio in both weeks.

Overall, these two weeks show the expected interrelationships between the Operator/Assignment Ratio, the VCBs/OCBs, late and missed pullouts, and report hours. Only shineouts is an exception to this.

2.2 SICK DAYS, MISSOUTS, REQUESTS OFF, AND OTHER POSITIONS

2.2.1 Prior Hypotheses

As the Operator/Assignment Ratio decreases, operators are effectively being asked to work more, with more opportunities for overtime work, and fewer opportunities to shine out. The demand for VCBs and OCBs is likely to increase, and this may be expected to generate some increase in the number of missouts and sick days. Therefore, under conditions of a decreasing operator/assignment ratio, it is expected that sick days and missouts will increase. Furthermore, one could anticipate that requests for a day off will increase, but the requests granted will decrease. As a result, there should be evidence of a declining number of requests off in the data (which relate to actual operator days off allowed from a request), and missouts or sick days should increase as operators use these as alternative methods to take time off that has not been granted from a request.

Generally, Vacation Days off will not be affected by the operator/assignment ratio and the responses to it. However, variations in the Vacation Days off affects the total pool of operators available in any given week, and is likely to have an effect on the other types of absenteeism. Higher numbers of Vacation Days will be likely to increase the effect of a decreasing Operator/Assignment Ratio, and lower numbers of Vacation Days Off will be likely to diminish the effect of a decreasing Operator/Assignment Ratio. In all these relationships, there is the possibility that there will be a lag effect that might be as much as two or three weeks. In the event that the number of Vacation Days Off rises to some significant peaks in the period, there should be a higher use of VCB/OCBs, fewer shine outs, and potentially more Missed and Late Pullouts, irrespective of the Operator/Assignment Ratio.

The reverse patterns should be expected when the Operator/Assignment Ratio is increasing, implying a growing pool of operators for the available assignments. In this case, there should be a need for fewer VCBs and OCBs, less overtime opportunities, and a resulting decline in unscheduled absences. Again, significant variations in Vacation Days Off will be likely to change the pattern, with a peak in Vacation Days Off diminishing the tendency for unscheduled absences to decline and a valley in Vacation Days Off tending to increase the declines in unscheduled absences.

Other Positions covers absence from driving duties by operators who are temporarily assigned to fill other positions, including dispatching, supervision, training, and traffic checks. Generally, these assignments are made to cover absence of personnel from such positions as dispatcher, to cover unusual increases in the need for training supervisors, and for situations where there is a need to undertake an unusually intensive ride check, or other monitoring activity. For the most part, variations in this absence category for the period under study should relate to coverage of regular staff vacation times. Assuming that such vacations will be spread through the period in a similar fashion to operator vacations, it would be expected that other positions will generally follow a similar pattern to vacation days off.

2.2.2 Results of the Analysis -- Unlagged Data

Analyzing the change between weeks, there are 25 week-to-week changes in the 26-week period under study. For 17 of these week-to-week changes, Requests Off per assignment change in the opposite direction to the operator/assignment ratio: for 13, Sick Days per operator also change in the opposite direction to the operator/assignment ratio; other positions per operator change in the opposite direction for 12 week-to-week changes: and missouts per operator change in the same direction as the operator/assignment ratio only 10 out of 25 times. Total unscheduled absences change in the expected direction on 14 of the 25 week-to-week periods. However, in 24 of the 25 week-to-week periods, at least one of the unscheduled absence categories -- sick, missout, request off, and other positions -- varies in the expected direction against operator/assignment ratio. There are peaks in vacation days per operator in the period. The first of these occurs around week seven (May 11), but is brief and the figure declines immediately after that week. There is a second, higher, and prolonged peak in weeks 19 through 24 (the month of August and first week of September). During that period, unscheduled absences maintain a somewhat lower level than during the remainder of the study period. Total absences, therefore, exhibit less variation and there is not a defined, prolonged peak during August. Overall, there is a peak that is maintained for four consecutive weeks from week six through week nine, and a second peak in week twenty-four, which includes the Labor Day weekend.

There is some evidence here that there is a lagged effect on some of the absenteeism variables from the operator/assignment ratio. In looking at the correlation of increases and decreases from week-to-week, it appears that missouts per operator are lagged about a week behind changes in the operator/assignment ratio. With a one week lag, the number of changes that have a sign opposite to the change in operator/assignment ratio increases from 10 out of 25 to 15 out of 24. Similarly, days off for sickness appear to correlate most highly with a two-week lag, where the percentage of occurrences of a change in value from week-to-week that is opposite to the operator/assignment ratio increases from 52 percent unlagged to 57 percent. Requests off correlate most highly without lagging at all, while other positions correlate most highly when lagged by two weeks (57 percent versus 48 percent unlagged), a finding which is not expected and is not obviously explicable.

Examining trend plots of the four absenteeism variables against the operator/assignment ratio, the following conclusions can be drawn for the unlagged effects:

a. Weeks 1 through 7 (ending 3/30 through 5/11):

The operator/assignment ratio decreases throughout this period, starting at 1.30 in the first week and declining to a level of 1.27 systemwide by the week ending May 11, a drop of 4.6 percent. Vacation days off start at their lowest value for the entire period and climb from the first to the second week, increasing from 0.183 days per operator to 0.217. Over the next three weeks, they decline to 0.185, then rise to 0.255 by the seventh week.

As shown in Figure 2-4, missouts per operator show generally an upward trend over this period, as would be hypothesized, increasing from 0.055 to 0.058 per operator. There is a sudden peak in week six to 0.068, which appears to be the result of a sharp decrease in operators rather than the result of a significant upward move in the number of days off. In fact, the total number of days off for missouts is identical in weeks five and six, while the full-time operators decline by 35 from 4264 to 4229, and part-time operators increase from 603 to 609. Full-time equivalent operators decline from 4565.5 to 4533.5.

Sick days off per operator rise between the first and second weeks from 0.447 to 0.507 and then remain fairly stable around 0.5 until the seventh week. At that time there is a significant drop back to the level of the first week. A small peak to 0.511 occurs in the sixth week that is similar to but much smaller than the peak in missouts. The expected increase in sick days off with decreasing Operator/Assignment Ratio is not evident in this period.

Requests off decline sharply during the first three weeks from 0.098 to 0.078 days per operator. In the next two weeks, they rise back to 0.098, decline in the sixth week to 0.090, while sick days and missouts peak, and rise again in the seventh week to 0.096. The initial drop in requests off appears to be a dispatcher response to the declining operator/assignment ratio, indicating fewer requests for a day off being approved. After the initial drop in the operator/assignment ratio, it appears that dispatchers found fewer problems than expected in getting service out and permitted more requests off to be taken after the third week. As a result, there is also little evidence of the expected decrease in request off resulting from a tighter labor situation.

Other positions per operator decline over the first three weeks from a value of 0.091 in the first week to 0.076 by the third week. For the balance of the period, other positions rise steadily to a value of 0.087 at the end of the period. Overall, other positions seems to parallel vacation days off as expected, but about a week ahead in this period, and also seems to parallel requests off. There appears to be little correlation, positive or negative, with the operator/assignment ratio, also as expected.

Overall, as shown in Figure 2-4, missouts per operator show the expected increase with decreasing Operator/Assignment Ratio, but the expected increase in sick days off and decrease in request off are not apparent from this period. The parallel between Vacation Days Off and other positions is apparent through most of the period.

OPERATOR/ASSIGNMENT RATIO MISSOUTS/REQUESTS OFF/OTHER/SICK/VACATION

PER OPERATOR ALL DIVISIONS

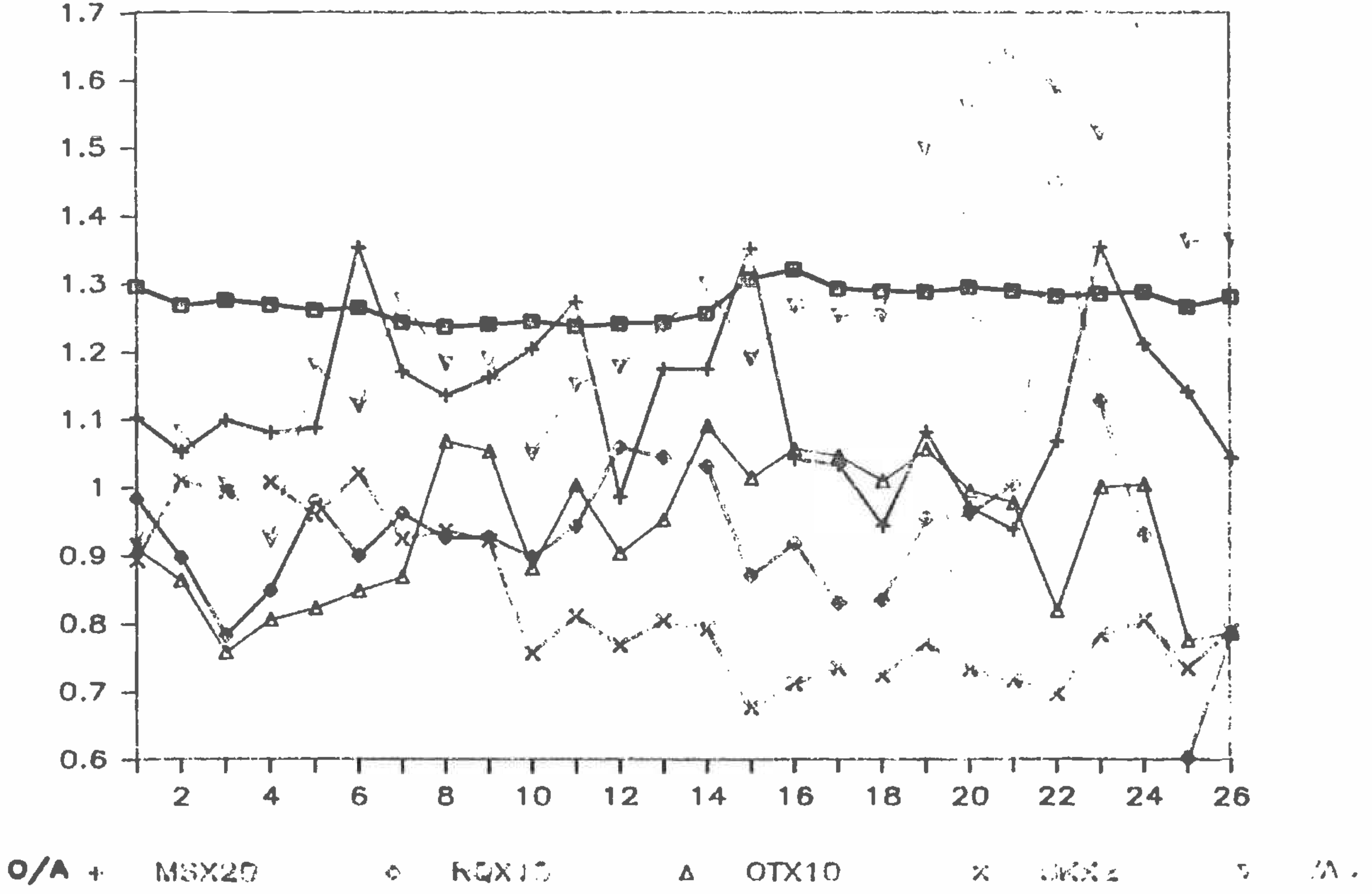


FIGURE 2-4

b. Weeks 8 through 14 (ending 5/18 through 6/29):

The operator/assignment ratio is essentially constant through this period at a value of 1.24, although a slight increase to 1.25 occurs in the week ending June 1, but drops back to 1.24 in the following week. Vacation days off fall initially from the high of 0.255 at the end of the previous period, reaching a low of 0.210 in the tenth week. From this point on, through the remainder of the period, vacation days off rise steadily to 0.260 by week fourteen. This same pattern is evident in total absences per operator, which fall from the eighth week to the tenth week, and then rise through the remainder of the period.

Missouts per operator decline slightly from the seventh to the eighth weeks, then climb for the next three weeks. From week eleven to week twelve, the missouts per operator drop sharply from 0.064 per operator to 0.049, but then rise again to about 0.059 for the next two weeks. Given that the operator/assignment ratio is stable through this period, it is apparent that this characteristic is not the one that influences the missouts per operator. For the first part of the period, as vacation days off fall, missouts increase, with missouts reaching a peak one week after the lowest level of vacation days off occurs. In the remaining weeks, however, after a sharp drop in missouts as vacation days off starts to increase, missouts also increase for the remainder of the period. There appears, therefore, to be only sporadic evidence of a relationship between missouts and each of the operator/assignment ratio and vacation days off.

Sick days off per operator decline generally throughout this period. They begin at 0.469 in the eighth week and decline to 0.397 by the fourteenth week. A significant dip occurs in week ten, with the value reaching a low of 0.379, coinciding with the low in vacation days off, and low points for the period in both other positions and requests off. A very small rise occurs in that week in the operator/assignment ratio, but this seems unlikely to explain the shifts in these other measures. The same week does show, however, a significant drop in the VCBs/OCBs, as might be expected, given a reasonably stable operator/assignment ratio and a low in most measures of scheduled and unscheduled absence. Overall, there is a decline in sick days off, which is not the pattern expected against a stable Operator/Assignment Ratio.

Figure 2-4 shows that requests off decline over the first three weeks of the period from 0.093 in the last week of the previous period to a low of 0.090 in the tenth week. In the next two weeks, there is a rise to 0.106, followed by a decline over the remaining three weeks to 0.103 in the fourteenth week. Contrary to what might be expected, the pattern in these changes matches the directional changes in operator/assignment ratio in reverse. That is, as the operator/assignment ratio falls, requests off rise, while small increases in the operator/assignment ratio are accompanied by decreases in requests off.

Other positions per operator generally parallel vacation days off and sick days off, declining from the end of the previous period to the tenth week, where a low for the period occurs, and then rising generally for the remainder of the period. A dip occurs in the other positions in the twelfth week, coinciding with a dip in sick days off and missouts. The parallel of this absence category to vacation days off is as expected.

Through this period, none of missouts, sick days, nor requests off show the expected relationships with the Operator/Assignment Ratio or Vacation Days Off. Only other positions shows the expected relationship to Vacation Days Off.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, the operator/assignment ratio climbs from its steady state at 1.24 in the previous period, to 1.32 in week sixteen, and then declines slightly to 1.29 the following week. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers. Although vacations are arranged well in advance, without prior knowledge of the consequences of a shake-up, it is noticeable from Figure 2-4 that vacations drop sharply in week fifteen (the week of the shake-up) and then return to a level close to that prior to the shake-up.

Missouts per operator rise sharply in week fifteen to a high of 0.068, then decline even more sharply to 0.052 and continue to fall over the balance of this period. This decline in missouts is expected, given the increase in the operator/assignment ratio.

Sick days off continue to decline from the fourteenth to the fifteenth week, and then rise slightly from the fifteenth through seventeenth weeks. Possibly the drop in sick days to the lowest value of the period at 0.339 days per operator in week fifteen is a result of operators wanting to be around to see the effects of the shake-up. The rise over the balance of the period appears to be lagged by one week from a rise in the operator/assignment ratio, which would be contrary to expectations (i.e., sick days off should increase when the operator/assignment ratio decreases). The rise is not large, however, and may be insignificant. The low value in week fifteen is 0.339 and rises to 0.368 in week seventeen.

Requests off per operator were declining in the last three weeks of the previous period and decline more steeply in the first week of this period from a value of 0.103 in week fourteen to 0.087 in week fifteen. After a slight increase in week sixteen, they end the period at 0.083 in week seventeen. The decline in value for week fifteen appears in all absence categories except missouts, but the continuing downward trend in requests off as the operator/assignment ratio starts to drop after the shake-up is as postulated.

Other positions per operator drop in week fifteen to 0.101 from 0.109 in the previous week. They rise slightly to week sixteen and then decline a little in week seventeen. The pattern of other positions parallels almost exactly the pattern in vacation days off, again, as expected.

Figure 2-4 shows that, overall, the primary effect that is observable over this period is a sharp decrease in all absence categories except missouts in the week following the June 30 shake-up. This seems to indicate an intention of operators to be around in that first week, possibly to make sure they know their new assignments, and possibly as protection against being laid off, given that service was cut on June 30. After the June 30 shake-up, requests off match the upward and downward movements of the operator/assignment ratio, as would generally be expected (i.e., the higher the operator/assignment ratio, the more operators are available and the more likely a dispatcher will grant requests off). However, trends in sick days off and missouts run contrary to expectation.

d. Weeks 18 through 24 (ending 7/27 through 9/7):

During this period, the operator/assignment ratio is steady at 1.29 for the eighteenth through twenty-first weeks, then decreases to 1.28 for the next two weeks, and returns to about 1.29 for the last week of the period. Vacation days off rise rapidly at the beginning of this period and remain high through all of August and the first week of September. This would be expected as operators attempt to take vacation during summer school vacations. Vacation days off per operator are at a low of 0.25 in week eighteen, but jump to 0.30 in the following week, and continue to climb to a peak of 0.327 in week twenty-one. A second, higher peak is reached in the last week of the period, in conjunction with the Labor Day weekend, with vacation days off reaching 0.334 in that week.

Missouts per operator continue to decline to week eighteen, rise briefly to 0.054 in week nineteen,and then decline to 0.047 by week twenty-one. A sharp rise occurs over the next two weeks as vacation days off start to fall from their first peak, and reach a peak of 0.068 in week twenty-three, when vacation days have dropped back to a valley at 0.304. As vacation days rise for the Labor Day weekend, missouts drop back to a value of 0.060 in the last week of the period. With the operator/assignment ratio remaining fairly steady throughout this period, the primary driving force on missouts seems to be vacation days off, against which it changes in the opposite direction.

Figure 2-4 shows that sick days off per operator decline after an initial small rise from weeks eighteen to nineteen. A second rise occurs in the last two weeks of the period, with sick days off peaking at 0.403 in the same week as the vacation days off peak for Labor Day. Apart from this coincidence in peaks, however, sick days off vary in the opposite direction to vacation days off, as might be expected. Correlation with the operator/assignment ratio is not evident.

Requests off per operator climb from a low in the eighteenth week of 0.083 (equal to the previous week) to a peak for the study period in week twenty-two at 0.145. The increase in requests off occurs in parallel with vacation days off, and in spite of a slight decline in operator/assignment ratio. The sharp peak in week twenty-two does not appear to correlate with any other variable, however, except for a peak in the VCBs/OCBs per assignment.

Other positions per operator show an overall decline over the period, from 0.105 at the end of the preceding period to 0.100 by the twenty-fourth week. Within that period, there is a slight increase to the nineteenth week to 0.106, followed by a drop over the next four weeks to 0.082. This drop is followed by an equally sharp rise to 0.100 in the twenty-third week, where it remains through the following week. Changes in other positions do not seem to correlate particularly strongly with any other variable in this period, although the direction of change is generally similar to that for sick days off.

Overall, none of the absence variables shows the expected correlations with Operator/Assignment Ratio or Vacation Days Off in this period, and exhibit a contrary correlation in most weeks of the period.

e. Weeks 25 and 26 (ending 9/14 and 9/21):

A minor shake-up took place on September 8 that affects the performance in the last two weeks of the study period. Service was added back after the service cuts in June, resulting in a sharp drop in the operator/assignment ratio to 1.26 in week twenty-five, although it recovered to almost 1.28 in the following week. Vacation days off per operator drop from their peak in week twenty-four to a level 0.272 in these two weeks.

Figure 2-4 shows that missouts per operator decline over these two weeks from 0.060 at the end of the previous period to 0.052 in the twenty-sixth week. A decline in the missouts per operator while the operator/assignment ratio increases is as would be hypothesized.

Sick days off per operator drop from week twenty-four to 0.367 from 0.403, and then rise to 0.395 in the final week. An increase in sick days off when the operator/assignment ratio increases is not as expected.

Requests off per operator drop to their lowest value in the 26-week study period in week twenty-five, completing a 3-week slide from 0.145 in week twenty-two to 0.060 in week twenty-five. There is then an upward adjustment to 0.079 in the final week of the study period. The very rapid fall in requests off per operator in the three weeks up through week twenty-five may be a result of the high number of vacation days off in late August and the beginning of September. It certainly does not appear to be driven by the operator/assignment ratio. The upward turn in the last week of the period is as expected for an increase in the operator/assignment ratio.

Other positions per operator show a marked fall from the end of the previous period, dropping from 0.100 in the twenty-fourth week to 0.077 in the twenty-fifth week. These absences then increase slightly to 0.079 in the last week. Again, the other positions parallel the vacation days off most closely, as expected.

In this last period of the study data, missouts and other positions show the expected relationships. For the last week only, requests off also show the expected relationship. However, sick days off do not exhibit the expected changes in relation to Operator/Assignment Ratio.

2.2.3 Results of the Analysis -- Lagged Data

Based on the interrelationships outlined previously, it should be expected that the following relationships might be found in the lagged data:

Decreases in the Operator/Assignment Ratio should give rise to increases in the demand for VCBs and OCBs, followed by lagged increases in the number of missouts and sick days. The reverse should also apply that increases in the Operator/Assignment Ratio should result in decreases in the lagged missouts and sick days.

Higher numbers of Vacation Days will be likely to increase the effect of a decreasing Operator/Assignment Ratio, and lower numbers of Vacation Days Off will be likely to diminish the effect of a decreasing Operator/Assignment Ratio. When the Operator/Assignment Ratio is constant, increases in Vacation Days Off should result in increases in VCBs/OCBs, followed by a lagged increase in sick and missout days per operator. Conversely, decreases in Vacation Days Off should be followed by a lagged decrease in sick and missed days.

Other positions should generally increase when the Vacation Days Off increases and decrease when Vacation Days Off decrease.

a. Weeks 1 through 7 (ending 3/30 through 5/11):

As noted previously, the operator/assignment ratio decreases throughout this period, starting at 1.30 in the first week and declining to a level of 1.27 systemwide by the week ending May 11, a drop of 4.6 percent. Vacation days off start at their lowest value for the entire period and climb from the first to the second week, increasing from 0.183 days per operator to 0.217. Over the next three weeks, they decline to 0.185, then rise to 0.255 by the seventh week.

Figure 2-5 shows that there is an overall trend for the missouts per operator to increase over this period, from the initial value of 0.055 to 0.058 at the end of the period. Within this overall increase, there is a sharp peak in the fourth week that coincides with a dip in vacation days off. The upward trend in missouts is what would be anticipated for a decreasing operator/assignment ratio, although the sudden peak in missouts does not correlate with the operator/assignment ratio. In this period, it appears that the missouts per operator trail the operator/assignment ratio and vacations by about two weeks.

Sick days off show a gradual decline over the period from 0.50 to 0.46. However, this includes as many increases week-to-week as decreases, indicating a degree of instability in this measure. Furthermore, the decline in sick days, lagged by two weeks, is contrary to the expected effect of an increase with decreasing operator/assignment ratio.

Other positions per operator rise through almost the entire seven weeks, with a sharper rise between weeks five and six, and a small decline to week seven. Overall, this rise correlates negatively with the Operator/Assignment Ratio, which falls throughout the period: and the other positions rise with the general upward trend in Vacation Days Off. These are the expected relationships. The sharp peak in other positions in week six (lagged) coincides with a drop in vacation days off, a slight rise in the Operator/Assignment Ratio, a slight drop in the missouts, a drop in requests off, and a rise in sick days off. There is no other time in this period when each of these variables move in the same directions as in week six. This appears to be an idiosyncratic change of little consequence.

Overall, this period shows the expected effects for missouts and other positions, but shows the opposite effect to that expected for sick days off. Given that the Operator/Assignment Ratio and Vacation Days Off are moving in opposite directions in this period, the period should exhibit a steady tightening of manpower and resulting increases in all categories of unscheduled absences, except request off. However, only two of the categories move in the expected direction.

b. Weeks 8 through 14 (ending 5/18 through 6/29):

The operator/assignment ratio is essentially constant through this period at a value of 1.24, although a slight increase to 1.25 occurs in the week ending June 1 (the tenth week), but drops back to 1.24 in the following week. Vacation days off fall initially from the high of 0.255 at the end of the previous period, reaching a low of 0.210 in the tenth week. From this point on, through the remainder of the period, vacation days off rise steadily to 0.260 by week fourteen. This same pattern is evident in total absences per operator, which fall from the eighth week to the tenth week, and then rise through the remainder of the period.

OPERATION/ASSIGNMENT MISSOUTS/REQUESTS OFF/OTHER/SICK DAYS OFF/VACATION

PER OPERATOR ALL DIVISIONS

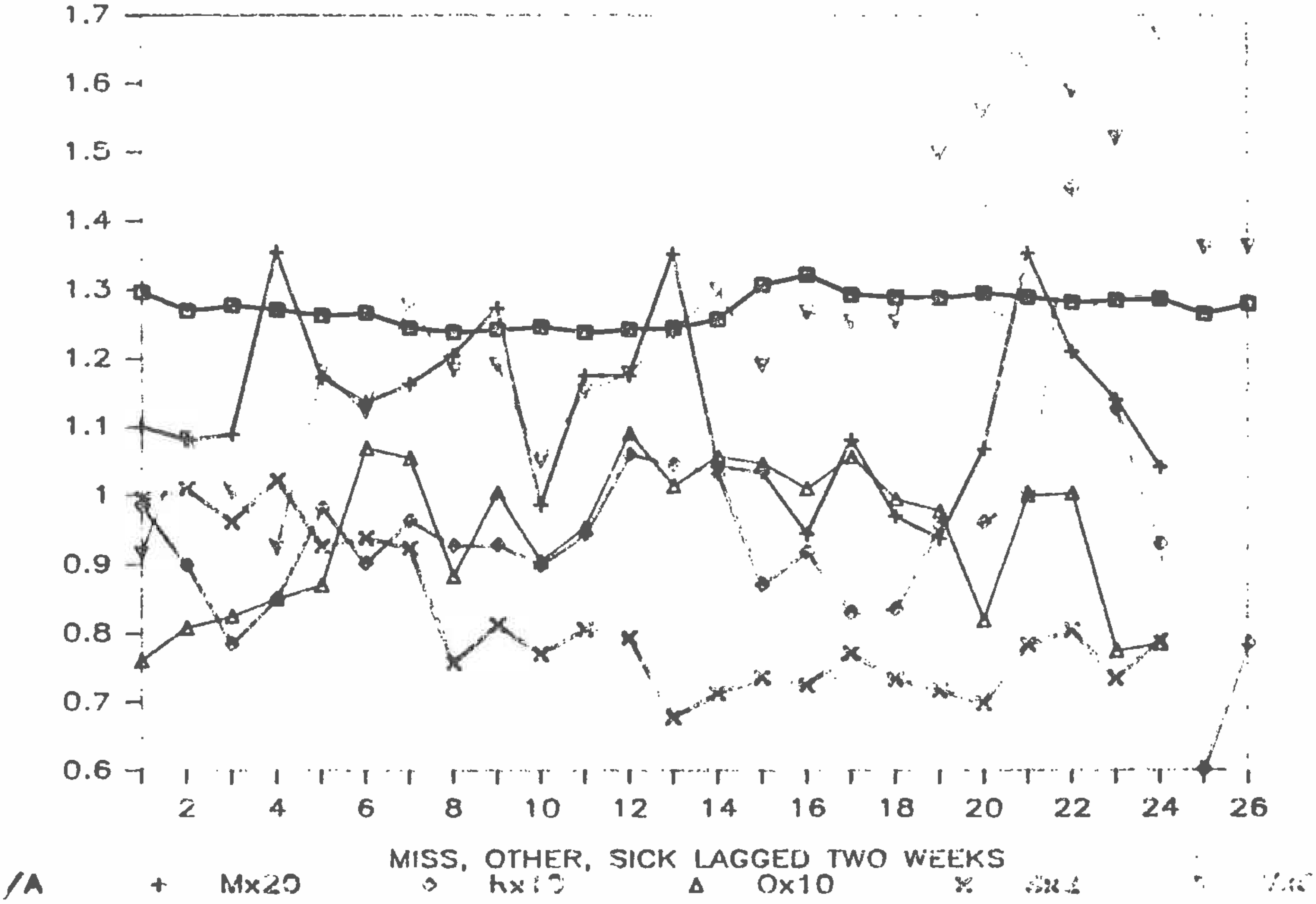


FIGURE 2-5

Missouts vary significantly over this period (Figure 2-5), rising initially from 0.058 in week seven to 0.064 in week nine, then falling sharply to 0.049 in week ten, rising over the next three weeks to 0.068 in week thirteen, and finally dropping to 0.052 in the fourteenth week. With the exception of the final week, the missouts parallel the vacation days off, while seeming largely unrelated to the operator/assignment ratio. This pattern is as expected for a constant Operator/Assignment Ratio and varying Vacation Days Off. Lagged changes in missouts should correlate with changes in Vacation Days Off when the Operator/Assignment Ratio is constant and Vacation Days Off are changing significantly.

Sick days off per operator generally decline through the period, from a high of 0.46 in the seventh week to a low of 0.106 in the fourteenth week. In the first four weeks of the period, sick days off parallel the changes in vacation days off and missouts, while reversing to an exact opposite set of changes in the last three weeks of the period. Again, there is no apparent relationship to the Operator/Assignment Ratio. The parallel changes between lagged sick days off and Vacation Days Off during the first four weeks are as expected. However, the contrary relationship in the latter three weeks is not expected.

Other positions per operator drop from week seven to week eight from 0.105 to 0.088, but then show an upward trend to 0.092 in the fourteenth week. Again, this absence variable parallels the changes in vacation days off, missouts, and sick days off for the first four weeks of the period. In week twelve, other positions per operator rise sharply, while vacation days off increase slightly, missouts are unchanged, and sick days off decline slightly. For the last two weeks of the period, other positions return to paralleling sick days off, but not Vacation Days Off. It is expected that other positions should parallel changes in the Vacation Days Off. For the first five weeks, this is reasonably the case, but is not so in the last two weeks.

Overall, this period shows the expected relationship between Vacation Days Off and missouts, and partially shows the expected relationship between Vacation Days Off and each of sick days and other positions, under circumstances of a reasonably constant Operator/Assignment Ratio. However, there are exceptions to the expected relationships, particularly in the last two to three weeks of the period, just preceding the June shake-up.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, the operator/assignment ratio climbs from its steady state at 1.24 in the previous period, to 1.32 in week sixteen, and then declines slightly to 1.29 the following week. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers. Although vacations are arranged well in advance, without prior knowledge of the consequences of a shake-up, it is noticeable that vacations drop sharply in week fifteen (the week of the shake-up) and then return to a level close to that prior to the shake-up.

Figure 2-5 shows that missouts per operator decline in the first two weeks of this period as the Operator/Assignment Ratio rises, and then jump sharply in week seventeen as the Operator/Assignment Ratio drops back to 1.29 from its high of 1.32 in the previous week. The changes in missouts per operator are precisely as postulated, changing in the reverse direction to the Operator/Assignment Ratio.

Sick days off per operator trend upwards during this period of three weeks, from 0.37 in week fifteen to 0.39 in week seventeen. From week fifteen to week sixteen, while the Operator/Assignment Ratio is rising sharply, there is a slight drop in sick days off, but so small as to be of little consequence. Between week sixteen and week seventeen, the Operator/Assignment Ratio drops and sick days off rise. As for missouts, it appears as though lagged sick days off change in the opposite direction to the Operator/Assignment Ratio, as hypothesized.

Other positions per operator parallel exactly the changes in missouts, declining in weeks fifteen and sixteen and rising in week seventeen. In this period, the changes in other positions (lagged by two weeks) shows an inverse correlation with the Operator/Assignment Ratio, but does not follow the pattern of Vacation Days Off, as would have been expected. It could be speculated, however, that the relationship to Operator/Assignment Ratio is more plausible around a shake-up than would be a relationship to Vacation Days Off. In this case, in the two weeks following the shake-up, which created a surplus of operators, the number of other positions per operator declines, rising again as the system begins to settle back into a more stable manpower condition.

Overall, this short period around the June shake-up shows the expected relationships between Operator/Assignment Ratio and each of lagged missouts and lagged sick days off, but does not support the expected changes in other positions related to vacations.

d. Weeks 18 through 24 (ending 7/27 through 9/7):

During this period, the operator/assignment ratio is steady at 1.29 for the eighteenth through twenty-first weeks, then decreases to 1.28 for the next two weeks, and returns to about 1.29 for the last week of the period. Vacation days off rise rapidly at the beginning of this period and remain high through all of August and the first week of September. This would be expected as operators attempt to take vacation during summer school vacations. Vacation days off per operator are at a low of 0.25 in week eighteen, but jump to 0.30 in the following week, and continue to climb to a peak of 0.327 in week twenty-one. A second, higher peak is reached in the last week of the period, in conjunction with the Labor Day weekend, with vacation days off reaching 0.334 in that week.

As shown in Figure 2-5, missouts per operator decline in the first two weeks of this period, accompanying a small decline in the Operator/Assignment Ratio and a major surge in Vacation Days Off. In the next two weeks, Vacation Days Off rises while the Operator/Assignment Ratio moves up and then back down to the same level as week nineteen. In these two weeks, the missouts per operator increase sharply from 0.047 to 0.068. From week twenty to week twenty-four, the missouts per operator fall steadily back to 0.052, while the Operator/Assignment Ratio remains stable around 1.28, and the Vacation Days Off remains high but declines from a peak in week twenty-one, returning to a second, higher peak in week twenty-four. Overall, given the increases in Vacation Days Off and the maintenance of a high level of Vacation Days Off, it would be expected that missouts per operator would trend upwards, particularly because there is little significant change in the Operator/Assignment Ratio in this period (beginning and ending at 1.29, and with no more than a 0.012 difference between highest and lowest values).

Sick days off per operator decline over the first three weeks, then rise for two weeks. In the last two weeks of the period, sick days off drop sharply and then rise again. Against the Operator/Assignment Ratio alone, one would have expected sick days off per operator (lagged) to remain fairly static in the first four weeks, rise in the next two weeks and decline in the last week. With the added effect of the increase in Vacation Days Off during the first part of this period, there is more reason to expect an increase in sick days off than the decrease actually observed. Overall, sick days off in this period do not exhibit the dependencies expected with either Operator/Assignment Ratio or Vacation Days Off.

Other positions decline quite sharply in the first three weeks, as Vacation Days Off rise. An sharp increase in other positions occurs in week twenty-one, while Vacation Days Off are still rising, and coincident with the sharp peak in missouts. Although there are minor contrary movements, the overall trend in the last three weeks of the period is for a decline in the other positions from 0.100 in week twenty-one to 0.079 in the twenty-fourth week. This decline follows a decline in Vacation Days Off, except for the last week of the period. In the first three weeks of the period, other positions vary inversely with Vacation Days Off, which is not the expected pattern, and does not seem to be a function of changes in the Operator/Assignment Ratio, which is reasonably static. In the remainder of the period, the expected relationship between other positions and Vacation Days Off appears, although the magnitude of week-to-week changes show little relationship between the two variables.

Overall, this period shows significant departures from the expected relationships, with none of the unscheduled absence measures showing an expected directional change for more than half the weeks in the period.

2.2.4 Results of the Analysis -- Unlagged Data Against VCBs/OCBs

The original hypotheses have all referenced VCBs/OCBs as being the intermediary variable between Operator/Assignment Ratio and the variations in the unscheduled absence categories. It seems useful, therefore, to examine the variations in unscheduled absences in relation to changes in VCBs/OCBs. Generally, increases in VCBs/OCBs should cause increases in sick days off and missouts. Furthermore, increases in Vacation Days Off should cause increases in the VCBs/OCBs. Conversely, decreases in VCBs/OCBs should produce decreases in missouts and sick days off, and decreases in Vacation Days Off should cause decreases in VCBs/OCBs. Requests off per operator should decline as VCBs/OCBs rise, because of the shortage of manpower that increases in VCBs/OCBs indicate. Likewise, requests off should increase when VCBs/OCBs decrease. As before, the only postulated relationship for other positions should be with Vacation Days Off, and should be in the same direction as changes in the Vacation Days Off.

a. Weeks 1 through 6 (ending 3/30 through 5/4):

From Figure 2-6, it can be seen that the VCBs/OCBs increase throughout this period from a low of 0.114 per assignment in the first week to 0.230 in the sixth week. Vacation Days Off start at a low value of 0.183, climb to the second week, then fall for the next two weeks to 0.185, climb to 0.236 and then fall slightly to 0.224. Increases in the VCBs/OCBs is caused in this period primarily by decreases in the Operator/Assignment Ratio, and not by changes in the Vacation Days Off.

Missouts per operator increase over the period from an initial value of 0.055 to a high of 0.068 in the sixth week. There are minor drops in value in the second and fourth weeks, but the overall trend is upwards. This conforms with the expected direction of change that should coincide with the change in VCBs/OCBs. Significant increases in the number of Vacation Days Off from week one to week two and from week four to week five do not show any significant effect on the missouts.

VCB/OCB MISSOUTS/REQUESTS OFF/OTHER/SICK DAYS OFF/VACATIONS

PER OPERATOR ALL DIVISIONS

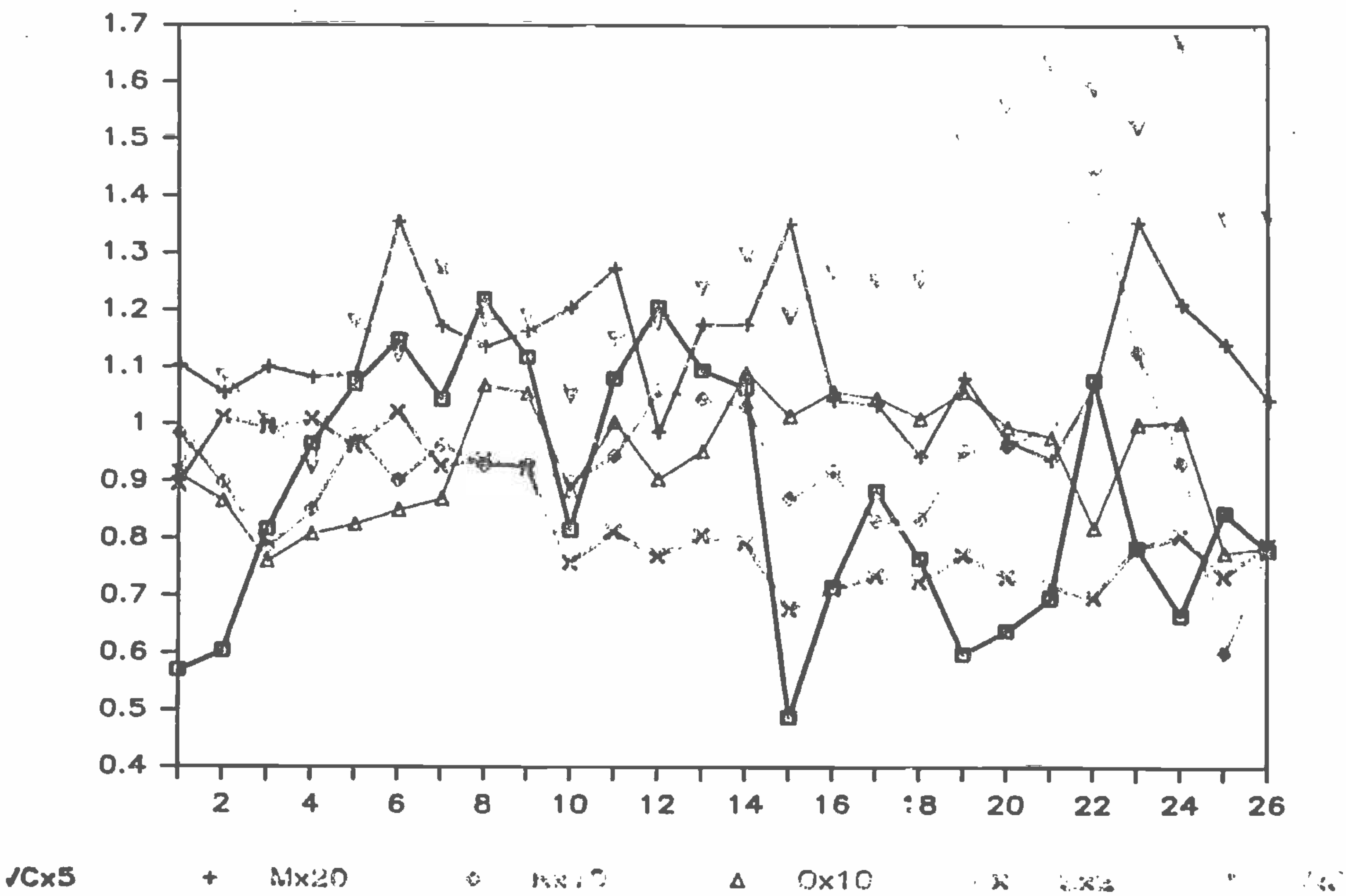


FIGURE 2-8

Sick days off per operator rise from the first to the second week, from 0.447 to 0.507, and then remain fairly stable through the sixth week at around 0.5. Apart from the initial rise, the sick days off do not increase with the increasing VCBs/OCBs in this period. There is also no apparent correlation of this measure with the Vacation Days Off.

Figure 2-6 shows that the requests off per operator decline during the first two weeks from 0.098 to 0.078. This change is as expected, responding to the increase in VCBs/OCBs over the same period. However, while it would be expected that requests off would continue to decline, from the third week through the fifth week, they rise to 0.098 and decline only a little in the sixth week to 0.090. The three weeks of increasing requests off follow by a week a decline in the number of Vacation Days Off. Possibly, in this period, the declining Vacation Days Off have more effect on the requests off than the rise in VCBs/OCBs.

Other positions decline in the first two weeks from 0.091 to 0.076, then rise slowly through the remaining four weeks to 0.085. This pattern is not at all consistent with the Vacation Days Off, with which this absence category is hypothesized to be related, nor does it follow changes in the VCBs/OCBs in any regular fashion.

Overall, only missouts per operator exhibit consistently the expected relationship to VCBs/OCBs or Vacation Days Off. Each of the other variables exhibits the changes expected for half or less of this six-week period.

b. Weeks 7 through 14 (weeks ending 5/11 through 6/29):

Week 10 includes the Memorial Day Holiday and there is an expected significant drop in the VCBs/OCBs per assignment for that week, as shown in Figure 2-6. Apart from that, the VCBs/OCBs fluctuate between about 0.219 and 0.244, but are generally around 0.22 through much of the period. For the first four weeks, Vacation Days Off fall from 0.255 to 0.210. From week ten, there is a steady climb back up to a value of 0.260.

Missouts per operator start and end the period at about the same level. Between the seventh and fourteenth weeks, however, the number of missouts per operator fluctuate from a low of 0.050 to a high of 0.064. Except for week ten to week eleven, each week's change in missouts runs in exactly the opposite direction to the change in VCBs/OCBs. For example, from week seven to week eight, VCBs/OCBs rise and missouts fall; from week eight to week nine, VCBs/OCBs fall and missouts rise; etc. Therefore, the changes in missouts all run precisely counter to what would be expected in this period. Only from week ten (with the Memorial Day weekend) to week 11 does missouts change in the same direction as VCBs/OCBs.

Sick Days Off per operator decline throughout this period from a high of 0.46 in the weeks seven and eight to 0.40 in the fourteenth week. During this period, there is a small increase from week seven to week eight, from week ten to week eleven, and another from week twelve to week thirteen. All other week-to-week changes are downwards. While much less marked, the changes are in the same direction as VCBs/OCBs except from week eleven to week twelve and week twelve to week thirteen. With the exception of these two consecutive weeks, the changes are as hypothesized.

As shown in Figure 2-6, requests off per operator decline slightly over the first four weeks of the period, from 0.096 to 0.090, then rise over the next two weeks to 0.106, and decline for the last three weeks to 0.103. It is hypothesized that requests off per operator should change in the opposite direction to VCBs/OCBs. However, throughout this period the changes in requests off are in the same direction as changes in VCBs/OCBs, except from week seven to week eight. The changes also parallel those in Vacation Days Off, except in the last two weeks of the period. Unexpectedly, it appears as though fewer requests off are being granted (and possibly fewer are being requested) as VCBs/OCBs and Vacation Days Off both decline, and more are being granted when VCBs/OCBs and Vacation Days Off rise. These are counterintuitive results.

Other positions per operator rise from 0.087 in week seven to 0.107 in week eight, then fall for the next three weeks, including a sharp drop to week ten, similar to that shown for VCBs/OCBs and Vacation Days Off. Other positions rise again to week eleven to 0.100 after a low in week ten of 0.089, then fall to 0.090 in week twelve, and rise over the last three weeks of the period to 0.109. Changes in the same direction as Vacation Days Off are evident in weeks nine through eleven, and weeks twelve through fourteen. For weeks seven through nine, and eleven to twelve, changes run counter to those in Vacation Days Off.

Overall, sick days off and other positions exhibit changes that are generally as hypothesized. Missouts and requests off generally show changes that run counter to those expected against both VCBs/OCBs and Vacation Days Off.

c. Weeks 15 through 17 (weeks ending 7/6 through 7/20):

This period includes the June shake-up which is evident from the sharp drop in VCBs/OCBs from week fourteen to week fifteen, followed by a rise over the remaining two weeks. The initial drop is precipitate from 0.213 to 0.098, (the minimum value shown by VCBs/OCBs throughout the twenty-six week study period), following which the VCBs/OCBs climbs back to 0.177. Vacation Days Off also drop from week fourteen to week fifteen, rise again to week sixteen and decline slightly to week seventeen.

From Figure 2-6, missouts per operator run in exactly the opposite direction to VCBs/OCBs throughout this period, with a sharp rise from week fourteen to week fifteen, from 0.059 to 0.068, then fall back to 0.052 and drop slightly in the seventeenth week. Again, these changes in missouts per operator run exactly counter to what would be hypothesized with respect to both VCBs/OCBs and Vacation Days Off.

Sick Days Off per operator fall from week fourteen to week fifteen, and then rise from week fifteen through week seventeen. While the changes are not as sharp as for VCBs/OCBs, the changes are all in the expected direction.

Requests Off per operator fall from week fourteen to week fifteen, from 0.103 to 0.087. From week fifteen to week sixteen, they rise to 0.092 and then fall the following week to 0.083. It is postulated that requests off should generally run counter to VCBs/OCBs and also to Vacation Days Off. However, in this period, they run in the same direction, except from weeks sixteen to seventeen, when requests off decline while VCBs/OCBs rise.

Other positions per operator follow exactly the change pattern in Vacation Days Off, as hypothesized, declining from week fourteen to week fifteen (0.103 to 0.087), rising to week sixteen (0.092) and falling again to week seventeen (0.083).

Overall, this period shows the expected changes for sick days off and other positions, but show counterintuitive changes in requests off and missouts per operator. Because of the instability caused by the shake-up, the unexpected changes in two variables may not be significant.

d. Weeks 18 through 23 (weeks ending 7/27 through 8/31):

Figure 2-6 shows that VCBs/OCBs decline in this period from 0.177 in week seventeen to 0.120 in week nineteen, then rise slowly for the next three weeks and sharply from week twenty-one to week twenty-two (0.215) before dropping back to 0.157 in the twenty-third week. Vacation Days Off are high throughout the period, climbing from 0.25 in weeks seventeen and eighteen to 0.30 in week nineteen and to 0.33 in week twenty-one. There is then a slight decline in the last two weeks of the period, with Vacation Days Off ending at 0.30 in week twenty-three.

Missouts per operator fall initially from 0.052 in week seventeen to 0.047 in week eighteen, then rise to 0.054 in week nineteen. Missouts decline for the next three weeks to 0.047 in week twenty-one, then rise sharply to 0.068 in week twenty-three. Except for week seventeen to week eighteen and week twenty-one to week twenty-two, the changes are in the opposite direction to changes in VCBs/OCBs. This is not the expected pattern. Because changes in Vacation Days Off parallel changes in VCBs/OCBs through most of the period, it would be expected that the hypothesized relationship of changes in the same direction as VCBs/OCBs would be more strongly exhibited, contrary to what actually happens.

Sick Days Off per operator decline slightly from week seventeen to week eighteen, then rise to week nineteen. Over the next four weeks, sick days off decline gradually from the high of 0.386 to 0.349 in week twenty-two, before rising in the twenty-third week to 0.392. Except for week seventeen to week eighteen, the changes in sick days off are opposite to those of VCBs/OCBs and Vacation Days Off, contrary to expectation.

As shown in Figure 2-6, requests off per operator rise for all but the last week of the period, starting at 0.083 in week seventeen and rising to 0.145 in week twenty-two. In the last week, requests off per operator drop to 0.113. Except for weeks eighteen to nineteen, increases and decreases in requests off parallel those for VCBs/OCBs, contrary to what would be expected.

Other positions per operator decline through most of the period from 0.105 in week seventeen to 0.082 in week twenty-two. There is a sharp rise in week twenty-three to 0.100. There is also a small increase in other positions per operator from week eighteen to week nineteen. The parallel of changes in this variable with Vacation Days Off is not apparent except in the small increase from week eighteen to week nineteen, and in the drop from week twenty-one to week twenty-two.

Overall, none of the measures of unscheduled absence change in the expected direction during this period, but all change counter to the expected direction, in relation both to VCBs/OCBs and Vacation Days Off. Based on this period, none of the hypotheses of interrelationships could be held substantiated.

e. Weeks 24 through 26 (weeks ending 9/7 through 9/21):

From Figure 2-6, VCBs/OCBs decline in the first week of the period from 0.157 in week twenty-three to 0.133 in week twenty-four, then rise to 0.169 in week twenty-five and decline to 0.156 in week twenty-six. Vacation Days Off climb to a peak in week twenty-four (0.344 -- Labor Day weekend) and then decline to 0.272 for the last two weeks. A mini-shake-up in this period can be expected to cause some instability in the figures.

Missouts per operator decline throughout the period from 0.068 in week twenty-three to 0.052 in week twenty-six. For weeks twenty-three to twenty-four and twenty-five to twenty-six, the changes in missouts per operator are in the same direction as those in VCBs/OCBs, as expected. The sudden drop in Vacation Days Off from week twenty-four to week twenty-five may account for the drop in missouts, even though VCBs/OCBs rise slightly between these two weeks.

Sick Days Off per operator rise initially from 0.392 to 0.403, then drop to 0.367, then rise again to 0.395, exactly opposite to changes in VCBs/OCBs, and contrary to expectation. However, the pattern does parallel changes in Vacation Days Off.

Requests Off per operator drop from 0.113 in week twenty-three to 0.060 in week twenty-five, and then rise to 0.079 in the last week. For weeks twenty-four through twenty-six, requests off run opposite in change to VCBs/OCBs, as hypothesized. The sharp drop from week twenty-three to week twenty-four is almost certainly a result of the sharp rise in Vacation Days Off.

Other positions per operator drop between weeks twenty-four and twenty-five from 0.100 to 0.077. Elsewhere in the period, there are small rises from one week to the next. Apart from the small size of the increase from week twenty-three to week twenty-four, the changes parallel Vacation Days Off, as expected.

Overall, missouts, requests off, and other positions exhibit the expected relationships, while sick days off run counter to expectation in this period.

2.2.5 Results of the Analysis -- Lagged Data Against VCBs/OCBs

Based on the earlier results for the Operator/Assignment Ratio, where three of the unscheduled absence variables showed stronger relationships when lagged, the following analysis examines the lag effects against VCBs/OCBs. Given that most of the periods examined in the earlier analysis with VCBs/OCBs showed results that were not as hypothesized, it might be anticipated that better correlation may be found with the lagging of sick days off and missouts per operator, in particular. As before, for unlagged data, it is expected that missouts and sick days off will change in the same direction as VCBs/OCBs, and that other positions will change in the same direction as Vacation Days Off.

a. Weeks 1 through 6 (ending 3/30 through 5/4):

Figure 2-7 shows that the VCBs/OCBs increase throughout this period from a low of 0.114 per assignment in the first week to 0.230 in the sixth week. Vacation Days Off start at a low value of 0.183, climb to the second week, then fall for the next two weeks to 0.185, climb to 0.236 and then fall slightly to 0.224. Increases in the VCBs/OCBs is caused in this period primarily by decreases in the Operator/Assignment Ratio, and not by changes in the Vacation Days Off.

Lagged missouts per operator decline slightly from week one to week two (0.055 to 0.054) and then rise to 0.068 in week four. Missouts then decline for the last two weeks of the period, ending at 0.057. Thus, for approximately half of this period, the changes in missouts parallel those for VCBs/OCBs, while running counter to them for the balance of the period.

MISSING

FIGURE 2-7

Lagged sick days off per operator rise from week one to week two, then drop to week three, rise to week four, drop to week five, and rise slightly to week six. The total change over the period is relatively small, from 0.201 in week one to 0.237 in week six. Over this period, prior hypotheses would suggest that sick days off per operator should rise, and there is an overall increase, but this is not sustained on a week-by-week basis.

Other positions per operator, lagged by the same two weeks, show an increase over the period from 0.076 to 0.107, paralleling the changes in VCBs/OCBs rather than the changes in Vacation Days Off.

Overall, the trend in sick days off is as expected, although week-to-week changes run counter to the expected direction at times. Missouts per operator and other positions generally do not change as expected for much of the period. Unlagged (see 2.2.4 above), missouts changed as expected, and lagging has not improved the correlation for the other two variables in this period.

b. Weeks 7 through 14 (weeks ending 5/11 through 6/29):

Week 10 includes the Memorial Day Holiday and there is an expected significant drop in the VCBs/OCBs per assignment for that week. Apart from that, the VCBs/OCBs fluctuates between about 0.219 and 0.244, but is generally around 0.22 through much of the period. For the first four weeks, Vacation Days Off fall from 0.255 to 0.210. From week ten, there is a steady climb back up to a value of 0.260.

As shown in Figure 2-7, lagged missouts per operator parallel changes in VCBs/OCBs from weeks nine through twelve, and change in the same direction from week seven to week eight and from week thirteen to week fourteen. Thus, for most of the period, lagged missouts correlate fairly well with VCBs/OCBs, as hypothesized. Given that the unlagged variable changed contrary to hypothesis through this period, lagging has clearly improved the association between these measures.

Lagged sick days off per operator decline from 0.469 in week six to 0.357 in week fourteen. As for the previous period, there are a number of variations in the direction of change of this measure, with changes paralleling those in VCBs/OCBs for half the week-to-week periods and running counter in the other half. Unlagged sick days off showed a higher correlation in this period.

Lagged other positions per operator are expected to match changes in Vacation Days Off, which they do from week seven through week twelve, while running counter to Vacation Days Off from week six to week seven, and week twelve to week thirteen. Overall, Vacation Days Off begin and end the period at about the same level (0.255 and 0.260) and other positions do the same (0.107

and 0.106). By a small margin, changes are more consistent with Vacation Days Off when other positions are lagged in this period than unlagged.

Overall, lagged missouts and other positions show a higher correlation with changes in VCBs/OCBs and Vacation Days Off than unlagged, while the reverse is true for sick days off.

c. Weeks 15 through 17 (weeks ending 7/6 through 7/20):

This period includes the June shake-up which is evident from the sharp drop in VCBs/OCBs from week fourteen to week fifteen, followed by a rise over the remaining two weeks. The initial drop is precipitate from 0.213 to 0.098, (the minimum value shown by VCBs/OCBs throughout the 26-week study period), following which the VCBs/OCBs climbs back to 0.177. Vacation Days Off also drop from week fourteen to week fifteen, rise again to week sixteen and decline slightly to week seventeen.

Lagged missouts per operator decline slightly from week fourteen to week fifteen (Figure 2-7), while VCBs/OCBs drop dramatically; then lagged missouts continue to decline while VCBs/OCBs rises. In the remaining week, lagged missouts again change in the same direction as VCBs/OCBs. This correlation is significantly higher than for unlagged missouts.

Lagged sick days off per operator trend upwards from 0.357 in week fourteen to 0.386 in week seventeen through this period. There is a slight drop from week fifteen to week sixteen, but changes in lagged sick days move in the same direction as VCBs/OCBs in the other two week-to-week periods. Correlation is not as good for the lagged variable as unlagged.

Lagged other positions per operator follow the pattern of lagged sick days off, but do not correlate well with Vacation Days Off. The unlagged variable correlated well with Vacation Days Off, however.

Overall, lagged missouts correlate better than unlagged, while sick days off and other positions show better correlations in this period when not lagged.

d. Weeks 18 through 23 (weeks ending 7/27 through 8/31):

Figure 2-7 shows that VCBs/OCBs decline in this period from 0.177 in week seventeen to 0.120 in week nineteen, then rise slowly for the next three weeks and sharply from week twenty-one to week twenty-two (0.215) before dropping back to 0.157 in the twenty-third week. Vacation Days Off are high throughout the period, climbing from 0.25 in weeks seventeen and eighteen to 0.30 in week nineteen and to 0.33 in week twenty-one. There is then a slight decline in the last two weeks of the period, with Vacation Days Off ending at 0.30 in week twenty-three.

Lagged missouts per operator decline over the first two weeks, from 0.048 to 0.047, paralleling VCBs/OCBs, then rise for the next three weeks to 0.068, peaking one week before the peak in VCBs/OCBs. For the remainder of the period, lagged missouts decline to 0.057, following the pattern of VCBs/OCBs for all but one week. This is a much higher correlation than for the unlagged measure.

Lagged sick days off per operator decline for the first three weeks, then increase for the next two, and decline to the last week of the period. Four of the five week-to-week changes are in the same direction as the changes in VCBs/OCBs, which is a much closer correlation than for the unlagged measure. Furthermore, VCBs/OCBs shows little total change from the beginning to the end of the period, from 0.153 to 0.157, and lagged sick days off also show little change, beginning and ending at 0.367.

Other positions per operator decline for the first three weeks, then increase for the next three weeks, and decline significantly in the last week. Overall there is a downward trend from 0.099 to 0.077, while Vacation Days Off show an upward trend from 0.25 to 0.30. In only two weeks are the changes in Vacation Days Off and other positions in the same direction. However, the measure performed no better unlagged for this period.

Overall, lagged missouts and sick days performed better in this period than the unlagged measures, while other positions showed little correlation either lagged or unlagged.

2.3 CONCLUSIONS ON SYSTEMWIDE DATA

2.3.1 Unscheduled Overtime Measures

The measures of unscheduled overtime are VCBs/OCBs, late and missed pullouts, and shineouts or report hours, each per assignment to remove the extraneous effects of variations in numbers of assignments from week to week. Overall, VCBs/OCBs show evidence of the expected relationship to Operator/Assignment Ratio, increasing as Operator/Assignment Ratio decreases and decreasing when Operator/Assignment Ratio increases. However, there is considerably more variation apparent in VCBs/OCBs than in Operator/Assignment Ratio over the twenty-six week period studied, and considerable variations in VCBs/OCBs occur when Operator/Assignment Ratio is predominantly static. Missed and late pullouts also show evidence of the expected changes in relation to Operator/Assignment Ratio, decreasing as Operator/Assignment Ratio increases and increasing as Operator/Assignment Ratio decreases. When Operator/Assignment Ratio is static and VCBs/OCBs are varying, it appears that the VCBs/OCBs dictate the direction of change in missed and late pullouts, with increases occurring when VCBs/OCBs decrease and Operator/Assignment Ratio is static. and vice versa.

Shineouts appear to be a somewhat less reliable measure and do not necessarily correlate well with report hours per assignment. as they should. This indicates that, on a systemwide basis, there are differences from week to week in the proportion of report operators that work some amount of time, compared to those that shine out. In the case of either shineouts or report hours per assignment, the relationship to Operator/Assignment Ratio or VCBs/OCBs is significantly weaker than the relationships discussed in the preceding paragraph. Nevertheless, it would appear that report hours per assignment may be predictable to a reasonable extent from Operator/Assignment Ratio and VCBs/OCBs together.

2.3.2 Unscheduled Absence Measures

Unscheduled absence appears to be a more complex characteristic to predict for the systemwide data. Missouts show a reasonable correlation with each of the Operator/Assignment Ratio and the VCBs/OCBs, when lagged by two weeks, indicating that two weeks following a change in either the Operator/Assignment Ratio or the VCBs/OCBs, missouts will tend to change in the opposite direction to Operator/Assignment Ratio and the same direction as VCBs/OCBs. When unlagged, the correlation is significantly weaker. Sick days off do not correlate well with Operator/Assignment Ratio, even when lagged by two weeks. The strongest relationship found for sick days off appears to be for the VCBs/OCBs, without sick days off being lagged. Against the Operator/Assignment Ratio, sick days off show a stronger relationship when lagged than unlagged, but the extent of the relationship does not suggest that this variable will be predicted at all easily. In addition, there appears to be some evidence of an inverse relationship to Vacation Days Off, although this appears only when the Operator/Assignment Ratio is largely static.

Requests off show little relationship to either VCBs/OCBs or Operator/Assignment Ratio, and there is no evidence to support the idea that a stronger relationship would result if the variable was lagged by one or more weeks. It seems likely that operators are more likely to request days off following decreases in the Operator/Assignment Ratio, or increases in the VCBs/OCBs, but that the number of requests that are permitted will decrease with decreasing Operator/Assignment Ratio and increasing VCBs/OCBs. In a statistical analysis, it may be worthwhile to investigate the effects of Operator/Assignment Ratio and VCBs/OCBs on the sum of missouts, sick days, and requests off. Other positions should correlate most highly with vacation days off, from among the variables examined in this study. Such a relationship seems to hold fairly well, without lagging. A strong relationship to Operator/Assignment Ratio or VCBs/OCBs is not apparent in any of the data studied.

2.4 STATISTICAL TESTS OF RELATIONSHIP ON SYSTEMWIDE DATA

2.4.1 Outline of the Analysis

Based on the findings reported in section 2.3 of this report, a series of relationships were hypothesized. These relationships center on attempting to estimate the various measures of unscheduled overtime and unscheduled absence from the independent variables of the operator/assignment ratio and vacation days off. These two variables can be considered to be independent in the sense that they are under the District's control and can be set by policy. Other variables, such as the number of VCBs/OCBs are a response on a day-by-day basis to the actual manpower position that is anticipated for the following day. Such variables are, therefore, dependent variables.

The analyses reported this far in the chapter have sought to identify the extent to which a relationship might exist between the two independent variables and the various measures of unscheduled overtime and unscheduled absence. The analyses have also been aimed at determining whether there is a lag of time between changes in a policy variable and changes in unscheduled absence or overtime, and at identifying if there is strong evidence of a particular form of relationship.

The analyses have established that there is evidence of relationships of various strengths between the independent variables of operator/assignment ratio and vacation days off, and the dependent variables of VCBs/OCBs, Late and Missed Pullouts, Report Hours or Shineouts, Missouts, Sick Days Off, Request Off, and Other Positions. These relationships vary from strong to weak, and there is evidence that some of the relationships may be stronger if the data are lagged by two weeks than related week-by-week. No evidence was uncovered that would indicate specifically that a relationship exists in a particular functional form. As a result, initial statistical hypotheses are based on the simplest form of relationship, i.e. a linear (straight-line) relationship.

In addition, after establishing which relationships are potentially useful, scatter plots were made of the data for each pair of dependent and independent variables, to determine if evidence supported a linear or nonlinear relationship. Based on the scatter plots, some nonlinear relationships were postulated and tested. Table 2-1 shows the various hypotheses that have been tested.

2.4.2 Results of the Analysis

Table 2-2 summarizes by model number the results of the regression analyses that are shown in Table 2-1. Initially, all regressions were performed using the full twenty-six weeks of data. However, repeatedly, weeks ten, fifteen, and twenty-four showed up as outliers. These weeks contained Memorial Day, Independence Day, and Labor Day, respectively, and were therefore weeks with four weekdays, one Saturday, and two Sundays for service purposes. As a result, all regressions were re-run to exclude these three weeks.

TABLE 2-1

TESTED HYPOTHESES FOR UNSCHEDULED OVERTIME AND ABSENCE CHARACTERISTICS

MODEL NUMBER	UNSCHEDULED ABSENCE OR OVERTIME MEASURE	TYPE	INDEPENDENT VARIABLES
1	VCBS/OCBS per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
2	Missed and Late Pullouts per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
3	Missed and Late Pullouts per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
4	Report Hours per Assignment	Unlagged	Shineouts per Assignment
5	Report Hours per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
6	Report Hours per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
7	Shineouts per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
8	Shineouts per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
9	Missouts per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator
10	Missouts per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
11	Missouts per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment

MODEL NUMBER	UNSCHEDULED ABSENCE OR OVERTIME MEASURE	TYPE	INDEPENDENT VARIABLES
12	Missouts per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
13	Missouts per Operator	Lagged	Log(Operator/Assignment Ratio)
14	Sick Days Off per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
15	Sick Days Off per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
16	Sick Days Off per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment
17	Sick Days Off per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
18	Sick Days Off per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator
19	Sick Days Off per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
20	Sick Days Off per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment
21	Sick Days Off per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
22	Requests Off per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
23	Requests Off per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
24	Requests Off per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment

MODEL NUMBER	UNSCHEDULED ABSENCE OR OVERTIME MEASURE	TYPE	INDEPENDENT VARIABLES
25	Requests Off per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
26	Requests Off per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
27	Requests Off per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
28	Requests Off per Operator	Unlagged	Log(Operator/Assignment Ratio) Log(Vacation Days Off per Operator)
29	Other Positions per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
30	Other Positions per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
31	Other Positions per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment
32	Other Positions per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
33	(Missouts + Sick + Request) per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
34	(Missouts + Sick + Request) per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
35	(Missouts + Sick + Request) per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment
36	(Missouts + Sick + Request) per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
37	(Missouts + Sick + Request) per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator

MODEL NUMBER	UNSCHEDULED ABSENCE OR OVERTIME MEASURE	TYPE	INDEPENDENT VARIABLES
38	(Missouts + Sick + Request) per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
39	(Missouts + Sick + Request) per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment
40	(Missouts + Sick + Request) per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
41	(Missouts + Request) per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator
42	(Missouts + Request) per Operator	Unlagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
43	(Missouts + Request) per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment
44	(Missouts + Request) per Assignment	Unlagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment
45	(Missouts + Request) per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator
46	(Missouts + Request) per Operator	Lagged	Operator/Assignment Ratio Vacation Days Off per Operator VCBs/OCBs per Assignment
47	(Missouts + Request) per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment
48	(Missouts + Request) per Assignment	Lagged	Operator/Assignment Ratio Vacation Days Off per Assignment VCBs/OCBs per Assignment

In all cases, the relationships were either improved or remained the same. Therefore, Table 2-2 reports only on the relationships for the remaining 23 weeks, with holiday weeks excluded. To interpret the results reported in Table 2-2, a few evaluation criteria are useful to keep in mind.

1. A t-score (in parentheses beneath the coefficient value) of less than about 1.96 indicates an unreliable coefficient estimate. If the coefficient has the expected sign and magnitude, however, a low score is not necessarily a fatal flaw.

2. The closer the R-Square value is to 1.00, the better is the regression, while the closer it is to 0.00, the worse is the regression.

3. The significance of the regression (reported in the last column of the table) is the probability of random occurrence of the F statistic computed from the regression. Generally, the smaller this value, the better is the regression, and a value greater than 0.1 indicates a very poor fit of the data to the reported equation. Thus, models 4, 26, 27, 29, 30, 31, 32, 41, 43, 44, 45, 46, 47, and 48 must be considered to be very poor, and to provide no evidence that a linear model in these variables exists.

First, it appears that the VCBs/OCBs per assignment can be predicted quite well from the operator/assignment ratio, as is shown by equation 1. In fact, this equation indicates that the rate of increase in VCBs/OCBs is 1.45 times the rate of decrease in operator/assignment ratio. Based on this model, we would expect that an operator/assignment ratio of 1.30 would be associated, on average, with 0.137 VCBs/OCBs per assignment, while an operator/assignment ratio of 1.27 should be associated with 0.181 VCBs/OCBs per assignment. All of the statistics of this regression indicate a very significant relationship, and an examination of the residuals shows no evidence that the relationship is anything other than linear. There is also no clear evidence of a missing independent variable. Regressions were run that permitted vacation days off per operator to be considered for the regression, but this variable showed no relationship whatsoever with VCBs/OCBs per assignment.

A fairly good predictive model was found for Missed and Late Pullouts per assignment, as shown by model 2. This model is also based on the operator/assignment ratio and shows that decreases in the operator/assignment ratio will produce increases in the late and missed pullouts. Again, it can be noted that an operator/assignment ratio of 1.30 will produce 0.015 late and missed pullouts per assignment, while an operator/assignment ratio of 1.27 should produce 0.020 late and missed pullouts per assignment. This could be restated to say that, all other things being equal and based on actual performance during the period for which data have been analyzed in this phase of the project, an operator/assignment ratio of 1.3 will generate about 1.5 percent missed and late pullouts, which should increase to 2 percent if the operator/assignment ratio is decreased to 1.27.

TABLE 2-2

RESULTS OF THE REGRESSION ANALYSES SPECIFIED IN TABLE 2-1

MODEL NUMBER	DEPENDENT VARIABLE	COEFFICIENTS (t-SCORE) OP/AS	VACATION DAYS	VCBs/OCBs	CONSTANT	R-SQUARE	SIG.
1	VCBs/OCBs	-1.45 (5.72)	-	-	2.025 (6.28)	.61	.0000
2	Missed and Late Pullouts	-0.174 (2.56)	-	-	0.241 (2.80)	.24	.018
3	Missed and Late Pullouts	same as model 2					
4	Report Hours	70.46*Shineouts (1.13)			1.083 (3.39)	.06	.272
5	Report Hours	-7.689 (1.80)	14.080 (5.79)	-	7.620 (1.44)	.63	.0001
6	Report Hours	-	14.38 (7.24)	6.964 (3.71)	-3.484 (5.26)	.74	.0000
7	Shineouts	-	0.031 (2.91)		-0.003 (1.21)	.29	.0084
8	Shineouts	no model obtained that is intuitively plausible					
9	Lagged Missouts per Operator	-0.133 (2.58)	-	-	0.226 (3.45)	.26	.018
10	Lagged Missouts per Operator	same as model 9					
11	Lagged Missouts per Assignment	-0.126 (1.98)	-	-	0.233 (2.86)	.17	.063
12	Lagged Missouts per Assignment	-	-	0.055 (1.75)	0.062 (10.79)	.12	.094
13	Lagged Missouts per Operator	-0.168* (2.57)	-	-	0.098 (6.20)	.26	.019

MODEL NUMBER	DEPENDENT VARIABLE	COEFFICIENTS (t-SCORE)				R-SQUARE	SIG.
		OP/AS	VACATION DAYS	VCBs/OCBs	CONSTANT		
14	Sick Days Off per Operator	-0.519 (1.38)	-0.945 (4.43)	-	1.317 (2.83)	.57	.0002
15	Sick Days Off per Operator	-0.800 (1.34)	-0.943 (4.35)	-0.193 (0.61)	1.708 (2.14)	.58	.0008
16	Sick Days Off per Assignment	-	-0.942 (4.90)	-	0.835 (13.35)	.53	.0001
17	Sick Days Off per Assignment	-0.398 (0.52)	-0.936 (4.37)	-0.255 (0.64)	1.384 (1.36)	.54	.0016
18	Lagged Sick Days Off per Operator	0.275 (0.65)	-0.966 (4.00)	-	0.305 (0.58)	.47	.0032
19	Lagged Sick Days Off per Operator	-0.118 (0.17)	-0.957 (3.91)	-0.267 (0.74)	0.851 (0.94)	.49	.0084
20	Lagged Sick Days Off per Assignment	0.932 (1.79)	-1.020 (4.54)	-	-0.339 (0.53)	.53	.0010
21	Lagged Sick Days Off per Assignment	-	-0.993 (4.76)	-0.580 (2.22)	0.942 (10.26)	.57	.0005
22	Requests Off per Operator	-	0.149 (1.88)	-	0.057 (2.83)	.14	.0738
23	Requests Off per Operator	0.197 (0.90)	0.161 (2.04)	0.201 (1.75)	-0.232 (0.80)	.26	.0957
24	Requests Off per Assignment	-	0.152 (2.02)	-	0.071 (2.91)	.16	.0561
25	Requests Off per Assignment	0.305 (1.08)	0.161 (2.05)	0.256 (1.74)	-0.366 (0.98)	.28	.0915
26	Lagged Requests Off per Operator	-0.180 (0.71)	0.102 (1.46)	-0.070 (0.53)	0.303 (0.91)	.12	.5186
27	Lagged Requests Off per Assignment	-0.204 (0.62)	0.118 (1.31)	0.127 (0.75)	0.364 (0.84)	.12	.5214
28	Requests Off per Operator	-	0.035* (1.74)	-	0.143 (5.12)	.13	.0965

* This variable is entered as the natural logarithm of the raw variable

MODEL NUMBER	DEPENDENT VARIABLE	COEFFICIENTS (t-SCORE) OP/AS	VACATION DAYS	VCBs/OCBs	CONSTANT	R-SQUARE	SIG.
29	Other Positions per Operator	-0.008 (0.08)	0.069 (1.14)	-	0.086 (0.65)	.06	.5221
30	Other Positions per Operator	0.007 (0.04)	0.069 (1.11)	0.011 (0.12)	0.065 (0.28)	.06	.7338
31	Other Positions per Assignment	0.072 (0.51)	0.069 (1.15)	-	0.005 (0.03)	.10	.3383
32	Other Positions per Assignment	0.093 (0.42)	0.069 (1.12)	0.014 (0.12)	-0.024 (0.08)	.10	.5465
33	Missout + Sick + Request per Operator	-0.712 (1.67)	-0.792 (3.27)	-	1.673 (3.16)	.47	.0019
34	Missout + Sick + Request per Operator	-0.659 (0.96)	-0.793 (3.19)	0.036 (0.10)	1.600 (1.75)	.47	.0066
35	Missout + Sick + Request per Assignment	-0.158 (0.28)	-0.787 (3.27)	-	1.176 (1.71)	.40	.0065
36	Missout + Sick + Request per Assignment	-0.106 (0.12)	-0.787 (3.19)	0.036 (0.08)	1.103 (0.94)	.40	.0201
37	Lagged Missout+Sick+ Request per Operator	-	-0.907 (3.80)	-	0.787 (12.99)	.43	.0012
38	Lagged Missout+Sick+ Request per Operator	-0.686 (0.99)	-0.894 (3.58)	-0.482 (1.31)	1.743 (1.89)	.48	.0092
39	Lagged Missout+Sick+ Request per Assignment	-	-0.781 (3.25)	-	0.960 (12.36)	.36	.0042
40	Lagged Missout+Sick+ Request per Assignment	-	-0.897 (3.87)	-0.570 (1.96)	1.101 (10.79)	.47	.0033
41	Missout+Request per Operator	-0.193 (1.67)	0.152 (1.20)	-	0.357 (1.79)	.15	.2079
42	Missout+Request per Operator	-	0.159 (1.90)	0.172 (2.16)	0.079 (2.81)	.26	.0509

MODEL NUMBER	DEPENDENT VARIABLE	COEFFICIENTS (t-SCORE)				R-SQUARE	SIG.
		OP/AS	VACATION DAYS	VCBs/OCBs	CONSTANT		
43	Missout+Request per Assignment	-0.132 (0.62)	0.152 (1.67)	-	0.310 (1.19)	.12	.2717
44	Missout+Request per Assignment	0.292 (0.94)	0.149 (1.73)	0.291 (1.80)	-0.281 (0.68)	.25	.1331
45	Lagged Missout+ Request per Operator	-0.207 (1.26)	0.113 (1.21)	-	0.385 (1.89)	.12	.3222
46	Lagged Missout+ Request per Operator	-0.338 (1.27)	0.116 (1.22)	-0.090 (0.64)	0.568 (1.60)	.14	.4557
47	Lagged Missout+ Request per Assignment	-0.144 (0.66)	0.117 (1.24)	-	0.337 (1.25)	.08	.4660
48	Lagged Missout+ Request per Assignment	-0.318 (0.92)	0.120 (1.25)	-0.118 (0.65)	0.579 (1.26)	.10	.5906

As reported in the earlier analysis, there is no clear relationship between shineouts and report hours. Model 4, which attempted to quantify a relationship, shows a very poor regression that has an R-square of 0.06 and a significance of 0.272, which is indicative of no significant relationship between the two variables. About all the attempted regression shows is that there is one shineout for approximately every 70 hours of report time. However, this is not a reliable relationship.

Two good models are found for predicting report hours per assignment, while a significantly less good model is obtained for predicting shineouts per assignment. The only variable that shows a significant correlation with the shineouts per assignment is vacation days off. This is not the expected relationship, and it is an implausible one. It indicates that shineouts per assignment increase as vacation days off increase, whereas the inverse of this relationship would be expected, if vacation days off were causally related. Therefore, it is concluded that no useful relationship can be found for shineouts per assignment. Report hours per assignment shows a relationship either to vacation days off and the operator/assignment ratio, or to vacation days off and VCBs/OCBs. Although the latter relationship is the stronger one, it is also less desirable, because VCBs/OCBs is itself predicted from the operator/assignment ratio. Therefore, model 5 is the recommended model for report hours per assignment.

The analysis of the graphical displays showed that missouts per operator should be lagged by two weeks to give the strongest relationship. Using missouts lagged by two weeks from vacation days off, VCBs/OCBs, and the operator/assignment ratio, two models were attempted using missouts per operator, two with missouts per assignment, and one using the logarithm of the operator/assignment ratio, because of the shape of the scatter plot and the residuals from the initial models. Despite the appearance of the plots, the logarithmic model performed no better than the straight linear model. Using assignments as the base, instead of operators, the model was statistically less reliable. The best model is one that relates the missouts to the operator/assignment ratio, and shows that decreases in the operator/assignment ratio result in increases in the missouts two weeks later, as would be expected. At 1.30 for the operator/assignment ratio, there should be 0.053 missouts per operator, which should increase to 0.057 when the operator/assignment ratio decreases to 1.27. The model shows a fairly flat response to changes in the operator/assignment ratio, with responses running at only about 10 percent of the change in the operator/assignment ratio.

Sick days off were examined in several different ways, including as a direct variable per operator, a direct variable per assignment, and lagged by two weeks both by operator and by assignment. In some models, VCBs/OCBs were allowed to enter as an independent variable, while VCBs/OCBs were not permitted in other versions. Reviewing the results of these models (models 14 through 21 in Table 2-2), models 14, 16, and 20 are the best from statistical measures. The overall best model is model 16, which relates sick days off per assignment to vacation days off, with an inverse relationship, meaning that sick days off increase as vacation days off decrease. Because both vacation days off and sick days off are calculated in model 16 as per assignment figures, and the coefficient of vacation days off is close to 1.0 (0.942), this implies that the combination of vacation and sick days per assignment remains more or less constant. In addition, the intercept for the relationship (the constant) is also near to 1.0 (0.835). The effect of this is to limit the range of the relationship (given that both vacation days off and sick days off must be non-negative) to a range of between 0 and 0.886 vacation days off, which will generate a range of between 0.835 and 0 sick days off, respectively. There is an unclear causality in this relationship, that seems to imply that the total of vacation and sick leave will generally be about constant, and also implies that operators will take sick days off more often when they have no vacation time available.

Model 14 shows that sick days off per operator are a function of the operator/assignment ratio and vacation days off. For both variables, the relationship is an inverse one, as expected. This indicates that decreases in either the operator/assignment ratio or vacation days off will result in increases in sick days off. This model will not be limited to the same range of applicability as the previous one, because it is a function of both the operator/assignment ratio and vacation days off, so that the maximum value of vacation days off for which the relationship will hold will depend on the value of the operator/assignment ratio.

The best relationship found for sick days off lagged by two weeks is not as strong, statistically, as either of models 14 and 16. Also, it shows a positive sign on the operator/assignment ratio, which is intuitively troublesome. Overall, the lagged models all show less strong relationships than the unlagged models, and several of the lagged models contain problems such as counter-intuitive signs. As a result, it is recommended that the model for sick days off should be model 14.

For requests off, a number of different models were tried, none of which were particularly strong, statistically. Regressions were run both for lagged requests off and unlagged requests off, and using both operators and assignments in the denominator. One model was also run with the log of vacation days off and the operator/assignment ratio, because there appeared to be some evidence that such a relationship would be an improvement. However, the resulting regression was no better than the one in which a simple linear relationship was specified. Overall, the lagged models performed worse than unlagged, with none of the coefficients being statistically significant. Among the unlagged models, model 24, using requests off per assignment, is the best model statistically, and shows requests off to be a function of vacation days off. On the basis of operators, model 22, with an identical specification, is the best model. Both models indicate that requests off increase with vacation days off, which seems an unlikely result. Worse, however, is the result of models 23 and 25, each of which indicates requests off increasing with all of vacation days off, VCBs/OCBs, and the operator/assignment ratio. As noted in section 2.3, requests off should increase with decreasing operator/assignment ratio and increasing VCBs/OCBs. A relationship to vacation days off is unexpected and does not seem to be causally valid. Nevertheless, for this stage of the analysis, this relationship is reported and used.

Other positions was also analyzed using both operators and assignments as the base. In no case was a significant model found, although the highest correlation was found with vacation days off, as postulated. It is not recommended that any of the relationships derived from the regression be used, and this variable remains unpredictable from the analysis performed here.

In section 2.3, it was suggested that the sum of missouts, sick, and requests off be analyzed. The resulting models are shown as models 33 through 40 in Table 2-2. None of these models performed as well, statistically, as the model for sick days off alone, so models were also tried with missouts and requests off alone. These models are shown as models 41 through 48 in Table 2-2. All of these models are inferior to the models that use missouts alone or requests off alone. Therefore, it is concluded that sums of unscheduled absence categories do not provide a means to obtain more meaningful relationships.

2.4.3 Test of the Final Models

As a summary of the preceding section, the following models have been identified as the best, intuitively and statistically, for predicting unscheduled overtime variables and unscheduled absences from the operator/assignment ratio and the vacation days off:

a. VCBs/OCBs per Assignment = -1.45*Oper/Assign. + 2.025

b. Missed & Canc. Pullouts per Assignment = -0.174*Oper/Assign. + 0.241

c. Report Hours per Assignment = -7.689*O/A + 14.08*VDO + 7.62

[d. Shineouts per Assignment = 0.031*Vacation Days - 0.003]

e. Lagged Missouts per Operator = -0.133*Oper/Assign. + 0.226

f. Sick days off per Operator = -0.519*O/A - 0.945*VDO + 1.317

g. Requests off per Operator = 0.149*Vacation Days + 0.057

The implications of these formulas can be seen in two ways. First, suppose that the operator/assignment ratio is currently 1.30 and the average vacation days off per operator is 0.2. Assuming that there are 3550 assignments and 4615 FTE operators (as generated by applying the 1.30 operator/assignment ratio), then this scenario would lead to the following weekly results from these formulas:

VCBs/OCBs = 497

Late and Cancelled Runs = 53

Report Hours = 1563

Shineouts = 11

Missouts = 245

Sick Days = 2092

Requests off = 401

The figure for missouts assumes that the operator/assignment ratio was steady at 1.30 two weeks prior to the scenario created here. Similarly, if one were to look at another week in which the vacations days off were to increase to 0.22, but no other change occurred, only report hours, shineouts, sick days, and requests off will change. The new values of these will be:

Report Hours = 2563

Shineouts = 14

Sick Days = 2005

Requests off = 414

If the operator/assignment ratio is changed to 1.27, then all the values except shineouts and requests off will change. For a week in which vacation days off is 0.2, the following values will pertain:

VCBs/OCBs = 651

Late and Cancelled Runs = 71

Report Hours = 2382

Shineouts = 11

Missouts = 257

Sick Days = 2114

Requests off = 401

While there are some questionable aspects to these relationships, they indicate that there is some possibility that unscheduled overtime and unscheduled absence can be predicted from the policy variables of operator/assignment ratio and vacation days off. Many additional questions would be appropriate to raise on these relationships that this project is unable to address, but which could be a fruitful exercise in the future.

3. DIVISION DATA

Selected data elements were tabulated and analyzed for the District's Operating Divisions 1 and 9, using techniques similar to those described in the preceding chapter for systemwide data. The results of this analysis are only partially described in this version of the report, but will be completed for the final report.

3.1 DIVISION 1 VCBs/OCBs, SHINE HOURS, AND MISSED/LATE PULLOUTS

3.1.1 Prior Hypotheses

As the operator/assignment ratio decreases, there are fewer operators available to the dispatcher to operate the service. Therefore, it should be expected that the number of VCBs and OCBs would increase, to cover unscheduled absences by operators, or that missed and late pullouts would increase. If VCBs and OCBs increase sufficiently, no change should occur in missed and late pullouts. Alternatively, if VCBs and OCBs are not increased sufficiently to cover all unscheduled absence, then missed and late pullouts should increase.

The opposite relationship should be expected for shine hours. As the operator/assignment ratio decreases, the number of shine hours should decrease. This effect will be reduced or will disappear if too many VCBs and OCBs are called in, or if the number of late and missed pullouts is allowed to increase.

Given the interrelationships between these three variables, it should never be the case that VCBs, OCBs, and late and missed pullouts increase, shine hours decrease, and the operator/assignment ratio decreases all in the same week. Similarly, VCBs/OCBs, and late and missed pullouts should not both decrease at the same time that shine hours increase and the operator/assignment ratio increases.

3.1.2 Results of the Analysis

Analyzing the change between weeks, there are 25 week-to-week changes in the 26-week period under study. For 14 of these week-to-week changes, VCBs/OCBs per assignment change in the opposite direction to the operator/assignment ratio: for 13, late/missed pullouts also change in the opposite direction to the operator/assignment ratio: while shine hours per assignment change in the same direction as the operator/assignment ratio 10 out of 25 times. Taking VCBs/OCBs and late/missed pullouts together, there is a change in one or both on 19 week-to-week changes that is in the expected direction. Adding the effects of shine hours, the correct composite change occurs on 23 of the 25 week-to-week changes. There are two occasions -- from week 5 to 6 and from week 11 to 12, when the exact reverse of the expected pattern of changes occurred.

There is no strong evidence here that there is any lagged effect on the three variables from the operator/assignment ratio, nor is there any reason to expect that there will be such an effect. Within a day-to-day variation, some lagging of the effect of operator availability might occur, but this should not be evident on week-by-week data.

Examining trend plots of the three variables against the operator/assignment ratio, the following conclusions appear:

a. Weeks 1 through 5:

The operator/assignment ratio decreases throughout this period, starting at 1.27 in the first week and declining to a level of 1.22 for Division 1 by week 5, a drop of 3.9 percent.

The VCBs/OCBs per assignment begin at 0.06 and hover at low levels (twice hitting lows of zero) to end at .05 in week 5.

Late and missed pullouts per assignment decline from an initial value of 0.022 to zero in the following three weeks, and end the period at 0.003.

Shine hours per assignment are not available for most of this period. Shineouts generally decline from the initial value of 0.022 to a low of 0.003. and end at 0.007.

b. Weeks 6 through 14:

The operator/assignment ratio is essentially constant through this period at a value of 1.25, although a slight increase to 1.27 occurs in weeks 8 and 9, then a drop to 1.24 in week 10 before returning to 1.25 for the remainder of the period.

The VCBs/OCBs per assignment fluctuates quite widely over this period. Beginning at 0.11 they rise to a high of 0.30 in week 8, plunge to 0.02 in week 10, then climb steeply again to end at a high of 0.40. Memorial Day occurred in week 10, which may have been responsible for the low. The highs may reflect the dispatcher's efforts to push down rising late and missed pullouts.

Late and missed pullouts generally rise slightly over the period. Starting from an initial value of 0.007 per assignment, they fluctuate for the next six weeks between a low of zero in week 10 and a high of 0.011 in week 12. Week 13 reaches a peak of 0.026 and the period ends at 0.007.

The shine hours per assignment fluctuate during the period, generally in inverse proportion to OCBs/VCBs.

Because the operator/assignment ratio is steady through the period, the variations in the VCBs/OCBs, late and missed pullouts, and shine hours are arising from other factors. During the first two weeks of the period, the directions of change are counter-intuitive and we have no explanation for them: the VCBs/OCBs are increasing, the late and missed pullouts are increasing, and the shine hours are holding fairly steady. However, absenteeism for excused or unexcused reasons throughout the period fluctuates similarly to VCBs/OCBs, which may account for those changes.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, the operator/assignment ratio climbs from its steady state at 1.25 in the previous period, to 1.32 in week 16, and then declines slightly to 1.30 the following week. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers.

As expected, with the increases in available operators, the VCBs/OCBs per assignment declines markedly in the first week, but then begins climbing to the end of this period. Apart from the fact that the VCBs/OCBs start climbing sooner than expected (possibly due to an overcompensation in adjustment in week 16), the trends are as hypothesized.

Missed and late pullouts decline for the first week, then rise in the last two weeks of this period, as the operator/assignment ratio begins to decline again. This pattern is what would be expected in terms of the operator/assignment ratio, with the number of missed and late pullouts declining as more operators become available from the increasing operator/assignment ratio, and increasing again as the operator/assignment ratio drops. However, in the last week of the period, the increase in VCBs/OCBs is apparently insufficient to compensate for the decrease in operator/assignment ratio, resulting in a peaking of the missed and late pullouts in week 17.

Shine hours per assignment increase at the beginning of the period, indicating that the sudden decrease in VCBs/OCBs was still insufficient against the increase in the operator/assignment ratio. The system appears to be quite unstable with respect to shine hours over the period, with an increase in shine hours in the fifteenth week, even though the VCBs/OCBs drop significantly. In week 16 shine hours rise more slowly as VCBs/OCBs also rise, although apparently not fast enough. In the seventeenth week, shine hours drop again, as the operator/assignment ratio drops, VCBs/OCBs rise, and missed and late pullouts rise.

Overall, this period shows some instabilities as the operator/assignment ratio made some of its largest week-to-week changes, resulting from the June shake-up. Generally, the hypothesized relationships seem to hold, although there is evidence that the system takes two or three weeks to recover from the shake-up.

d. Weeks 18 through 24 (ending 7/27 through 9/7):

During this period, the operator/assignment ratio is steady at 1.28 for the eighteenth through twenty-first weeks, then decreases to 1.26 one week, and returns to about 1.27 for the last week of the period.

Despite the stability of the operator/assignment ratio, there are some significant changes in the VCBs/OCBs through the period. Initially, the VCBs/OCBs per assignment continue to decline from the peak of 0.34 in week 16 to a low of 0.10 in week 19. Over the next four weeks the VCBs/OCBs rises to a peak in the twenty-third week at 0.0.32, dropping slightly to 0.31 to end the period. The sudden rise occurs in the same week that the operator/assignment ratio declines from 1.28 to 1.26. It is notable that there is a marked increase in absences in the twenty-second and twenty-third weeks, the peak in week 22 being from missouts and the peak in week 23 being from the "other" category. These absences may be responsible for the extent of the peak in VCBs/OCBs in week 23.

Missed and late pullouts reach a peak of 0.07 in week20, then decline to 0.02 by week24. Given the stability in operator/assignment ratios, the decline in missed and late pullouts appears to be primarily in response to changes in VCBs/OCBs, after the effects of the June shake-up have settled out of the system. Generally, the missed and late pullouts decline as VCBs/OCBs rise, and rise when VCBs/OCBs drops, as expected.

Shine hours generally decline over the period - with some steep peaks and valleys along the way. The first three weeks show a consistent decline in shine hours - as VCBs/OCBs also decline and late and missed pullouts increase. Shine hours remain high over weeks 20, 21, and 22, and then decline over the remaining two weeks of the period. The decline occurs as VCBs/OCBs also declines, as expected.

Throughout this period, the hypothesized relationships among these variables appear to hold quite well, with VCBs/OCBs and shine hours varying together, and missed and late pullouts changing in the opposite direction to these two variables. The operator/assignment ratio is fairly steady, so that there appear to be other factors, probably changes in absenteeism, that are generating the changes in each of the other measures.

e. Weeks 25 and 26 (ending 9/14 and 9/21):

A minor shake-up took place on September 8 that affects the performance in the last two weeks of the study period. Service was added back after the service cuts in June, resulting in a sharp drop in the operator/assignment ratio to 1.24 in week 25, although it recovered to almost 1.30 in the following week.

Despite the drop in the operator/assignment ratio, the VCBs/OCBs per assignment decrease in week25 and increase in week26. These changes result in a sharp increase in missed and late pullouts in week 25 and another, smaller increase in week 26.

As noted above, missed and late pullouts increase sharply in week 25 to 0.08, and continue to climb to 0.09 in week 26, the highest value in the entire 26 weeks. These changes occur in the expected direction, and appear to be a result of the changes in operator/assignment ratio.

Shine hours per assignment increase slightly then decline. Both shine hours and VCBs/OCBs are working counter-intuitively in this period, as missed and late pullouts rise sharply.

3.2 DIVISION 1 SICK DAYS, MISSOUTS, REQUESTS OFF, AND OTHER POSITIONS

3.2.1 Prior Hypotheses

As the Operator/Assignment Ratio decreases, operators are effectively being asked to work more, with more opportunities for overtime work, and fewer opportunities to shine out. The demand for VCBs and OCBs is likely to increase, and this may be expected to generate some increase in the number of missouts and sick days. Therefore, under conditions of a decreasing operator/assignment ratio, it is expected that sick days and missouts will increase. Furthermore, one could anticipate that requests for a day off will increase, but the requests granted will decrease. As a result, there should be evidence of a declining number of requests off in the data (which relate to actual operator days off allowed from a request), and missouts or sick days should increase as operators use these as alternative methods to take time off that has not been granted from a request.

Generally, Vacation Days off will not be affected by the operator/assignment ratio and the responses to it. However, variations in the Vacation Days off affects the total pool of operators available in any given week, and is likely to have an effect on the other types of absenteeism. Higher numbers of Vacation Days will be likely to increase the effect of a decreasing Operator/Assignment Ratio, and lower numbers of Vacation Days Off will be likely to diminish the effect of a decreasing Operator/Assignment Ratio. In all these relationships, there is the possibility that there will be a lag effect that might be as much as two or three weeks. In the event that the number of Vacation Days Off rises to some significant peaks in the period, there should be a higher use of VCBs/OCBs, fewer shine outs, and potentially more Missed and Late Pullouts, irrespective of the Operator/Assignment Ratio.

The reverse patterns should be expected when the Operator/Assignment Ratio is increasing, implying a growing pool of operators for the available assignments. In this case, there should be a need for fewer VCBs and OCBs, less overtime opportunities, and a resulting decline in unscheduled absences. Again, significant variations in Vacation Days Off will be likely to change the pattern, with a peak in Vacation Days Off diminishing the tendency for unscheduled absences to decline and a valley in Vacation Days Off tending to increase the declines in unscheduled absences.

3.2.2 Results of the Analysis -- Unlagged Data

Analyzing the change between weeks, there are 25 week-to-week changes in the 26-week period under study. For 5 of these week-to-week changes, Requests Off per assignment change in the opposite direction to the operator/assignment ratio; for 20, Sick Days per operator also change in the opposite direction to the operator/assignment ratio; other absences per operator change in the opposite direction for 16 week-to-week changes; and missouts per operator change in the same direction as the operator/assignment ratio only 11 out of 25 times. Total unscheduled absences change in the expected direction on 14 of the 25 week-to-week periods. However, in 24 of the 25 week-to-week periods, at least one of the unscheduled absence categories -- sick, missout, request off, and other -- varies in the expected direction against operator/assignment ratio. There are peaks in vacation days per operator in the period. The first of these occurs around week 5, but is brief and the figure declines immediately after that week. There is a second, higher, and prolonged peak in weeks 12 through 24 (the summer months). Total absences drop at the beginning of the period and remain rather low relative to later periods.

There is some evidence here that there is a lagged effect on some of the absenteeism variables from the operator/assignment ratio. In looking at the correlation of increases and decreases from week-to-week, it appears that missouts per operator are lagged about two weeks behind changes in the operator/assignment ratio. With a two week lag, the number of changes that have a sign opposite to the change in operator/assignment ratio increases from 11 out of 25 to 13 out of 24. Similarly, days off for sickness appear to correlate most highly with a two-week lag, where the percentage of occurrences of a change in value from week-to-week that is opposite to the operator/assignment ratio increases from 80 percent unlagged to 92 percent. Requests off correlate most highly without lagging at all, while a lagging does not effect other absences, as expected.

Examining trend plots of the four absenteeism variables against the operator/assignment ratio, the following conclusions can be drawn for the unlagged effects:

a. Weeks 1 through 5:

The operator/assignment ratio decreases throughout this period, starting at 1.27 in the first week and declining to a level of 1.22. Vacation days off decline, then climb back toward to the period starting point, beginning at 0.34 and ending at 0.31.

Missouts per operator fluctuate during the period, but end where they began, at 0.05 per operator. A peak of 0.07 occurs in week 4, at a point where requests off are quite low. In fact, the total number of days off for missouts is identical in weeks 6 and 7, while the full-time operators increases by 3 from 305 to 308 and part-time operators decrease from 47 to 46. Full-time equivalent operators increase from 328.5 to 331.

Sick days off per operator fluctuate then end higher, moving form 0.37 to 0.40 per operator. A small peak to 0.41 occurs in the third week, similar to but much smaller than the peak in missouts.

Requests off reach a 26-week high in week 4 of 0.21 per operator, up from 0.13 the previous week. The high in requests off coincides with a low in missouts and sick days, and comes at a time when vacation days are also quite low. For the remainder of the period requests off cluster around 0.15 per operator. The initial drop in requests off appears to be a dispatcher response to the declining operator/assignment ratio, indicating fewer requests for a day off being approved. After the initial drop in the operator/assignment ratio, it appears that dispatchers found fewer problems than expected in getting service out and permitted more requests off to be taken after the third week.

Other positions per operator decline sharply from a starting value of 0.16 to a low of 0.09 in the third week. In the last week other positions increase to 0.11. Overall, other positions seems to parallel vacation days off, and to run counter to requests off.

b. Weeks 6 through 14:

The operator/assignment ratio is essentially constant through this period at a value of 1.25, although a slight increase to 1.27 occurs in the weeks 8 and 9, but drops back to 1.25 by the end of the period. Vacation days off fluctuate but trend upward, reaching the start of the summer season by the end of the period. From a beginning point of 0.24 they reach an ending point of 0.40. The exception is a sharp drop in week 10 to 0.27.

Missouts per operator drop sharply in week 8, then climb as sharply, dip again, then end higher. Missouts start at 0.06, hit a low of 0.03 then end at 0.07. Given that the operator/assignment ratio is stable through this period, it is apparent that this characteristic is not the one that influences the missouts per operator. In the later part of the period missouts parallel vacations days. There appears to be only sporadic evidence of a relationship between missouts and the operator/assignment ratio and sick and other positions.

Sick days off per operator rise and fall smoothly throughout this period with peaks in weeks 8 and 12-13. They begin at 0.474 in the eighth week and decline to 0.388 by the fourteenth week. A dip occurs in weeks 10-11 with the value reaching a low of 0.382 coinciding with the low in vacation days off, and low points for the period in other absences and a high in requests off.

Requests off fluctuate beginning at 0.127, reach a high of 0.202

in week 10, and decline to end at 0.109. Contrary to what might be expected, the pattern in these changes usually matches the directional changes in operator/assignment ratio in reverse. That is, as the operator/assignment ratio falls, requests off rise, while small increases in the operator/assignment ratio are accompanied by decreases in requests off.

Other positions per operator roughly parallels vacation days off and sick days off, declining from the end of the previous period to the tenth week, where a low for the period occurs, and then rising generally for the remainder of the period. A dip occurs in the other positions in the tenth week, coinciding with a dip in sick days off. The parallel of this absence category to sick days off and vacation days off is not expected.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, the operator/assignment ratio climbs from its steady state at 1.25 in the previous period, to 1.32 in week 16, and then declines slightly to 1.30 the following week. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers. Although vacations are arranged well in advance, without prior knowledge of the consequences of a shake-up, it is noticeable that vacations drop in week 15 (the week of the shake-up) and then return to a level close to that prior to the shake-up.

Missouts per operator decline throughout the period, starting at 0.049 and ending at 0.040. This decline in missouts is expected, given the increase in the operator/assignment ratio.

Sick days off continue to decline from the fourteenth to the fifteenth week, and then rise slightly from the fifteenth through seventeenth weeks. Possibly the drop in sick days to the lowest value of the period at 0.327 days per operator in week fifteen is a result of operators wanting to be around to see the effects of the shake-up. The rise over the balance of the period appears to be lagged by one week from a rise in the operator/assignment ratio, which would be contrary to expectations (i.e., sick days off should increase when the operator/assignment ratio decreases). The rise is not large, however, and may be insignificant.

Requests off per operator were declining in the last three weeks of the previous period but now rise sharply in the first week and continue climbing to a high of 0.174 in week 16 then declines somewhat in week 17. The decline in value for week 15 appears in all absence categories except requests off, as the operator/assignment ratio starts to drop after the shake-up is as postulated.

Other positions per operator drop in week 15 to 0.116 from 0.137 in the previous week. They rise to week 16 and then drop sharply in week 17. The pattern of other positions parallels the pattern in missouts and requests off.

Overall, the primary effect that is observable over this period is a sharp decrease in all absence categories except requests off in the week following the June 30 shake-up. This seems to indicate an intention of operators to be around in that first week, possibly to make sure they know their new assignments, and possibly as protection against being laid off, given that service was cut on June 30. After the June 30 shake-up, trends run counter to what would generally be expected.

d. Weeks 18 through 24 (ending 7/27 through 9/7):

During this period, the operator/assignment ratio is steady at 1.28 for the eighteenth through twenty-first weeks, then decreases to 1.26 for one week, and returns to about 1.27 for the remainder of the period. Vacation days off are high through this period, period and remain high through week 24. This would be expected as operators attempt to take vacation during summer school vacations. Vacation days off per operator climb to a peak of 0.400 in week 20.

Missouts per operator fluctuate extremely widely between weeks 18 and 22. Overall, they show an upward trend. Week 18 shows a low of 0.021, week 20 shows the high of 0.095, and at week 24 the period ends at 0.057. The peak coincides with vacations days off and runs contrary to trends in requests off. With the operator/assignment ratio remaining fairly steady throughout this period, the primary driving force on missouts seems to be vacation days off and requests off.

Sick days off per operator rise steadily throughout the period. Sick days off vary in the opposite direction to vacation days off, as might be expected. Correlation with the operator/assignment ratio is not evident.

Requests off per operator fall to a 26-week low of 0.054 in week 21 then climb to end the period at 0.098 in week 24. The decrease in requests off occurs opposite to vacation days off, and in spite of a slight decline in operator/assignment ratio.

Other positions per operator decline sharply over the period, from 0.090 at the end of the preceding period to 0.006 by the twenty-fourth week. Within that period, there is some fluctuation, but it is clear that the general trend is downwards. Changes in other positions do not seem to correlate particularly strongly with any other variable, although the direction of change is generally similar to that for requests off.

e. Weeks 25 and 26 (ending 9/14 and 9/21):

A minor shake-up took place on September 8 that affects the performance in the last two weeks of the study period. Service was added back after the service cuts in June, resulting in a sharp drop in the operator/assignment ratio to 1.24 in week 25, although it recovered to almost 1.30 in the following week. Vacation days off drop sharply, then climb back to 0.035 in these two weeks.

Missouts per operator decline slightly then rise sharply over these two weeks. Missouts parallel vacations and requests, as would be expected.

Sick days off per operator rise then drop slightly . As the operator/assignment ratio increases sick days drop, as would be hypothesized.

Requests off per operator drop sharply then rise to end the period near where they began. These movements are opposite to what would be expected relative to the operator/assignment ratio. Requests off in this period closely parallel vacation days off and run opposite to other positions and sick days.

Other positions per operator rise than fall sharply over the period. In this period the other correlate well with the operator/assignment ratio but run opposite to vacation days off, requests off, and to some extent, missouts.

3.2.3 Results of the Analysis -- Lagged Data

As noted in section 3.2.2, there is some evidence that there is a lagged effect on sick leave and missouts from the operator/assignment ratio. These lagged effects appear to be on the order of two weeks, suggesting that changes in the operator/assignment ratio trigger changes in these categories of absence after two weeks have elapsed. Examining trend plots of the four lagged absenteeism variables against the operator/assignment ratio, the following conclusions can be drawn:

Decreases in the Operator/Assignment Ratio should give rise to increases in the demand for VCBs and OCBs, followed by lagged increases in the number of missouts and sick days. The reverse should also apply that increases in the Operator/Assignment Ratio should result in decreases in the lagged missouts and sick days.

Higher numbers of Vacation Days will be likely to increase the effect of a decreasing Operator/Assignment Ratio, and lower numbers of Vacation Days Off will be likely to diminish the effect of a decreasing Operator/Assignment Ratio. When the Operator/Assignment Ratio is constant, increases in Vacation Days Off should result in increases in VCBs/OCBs, followed by a lagged increase in sick and missout days per operator. Conversely, decreases in Vacation Days Off should be followed by a lagged decrease in sick and missed days.

Other positions should generally increase when the Vacation Days Off increases and decrease when Vacation Days Off decrease.

a. Weeks 1 through 5:

As noted previously, the operator/assignment ratio decreases throughout this period, starting at 1.27 in the first week and declining to a level of 1.22. Vacation days off decline, then climb back toward to the period starting point, beginning at 0.34 and ending at 0.31.

There is an overall trend for the missouts per operator to decrease over this period. Within this overall decrease, there is a sharp decrease in the second week that coincides with a dip in vacation days off. The downward trend in missouts is not what would be anticipated for a decreasing operator/assignment ratio. In this period, it appears that the missouts per operator trail vacations by about two weeks.

Sick days off initially dip then increase over the period. The increase in sick days, lagged by two weeks, is the expected effect of an increase with decreasing operator/assignment ratio.

Other positions per operator is fairly stable except for a sharp peak in week 3. This sharp peak in other positions (lagged) coincides with a low in vacation and request days off.

b. Weeks 6 through 14:

The operator/assignment ratio is essentially constant through this period at a value of 1.25, although a slight increase to 1.27 occurs in the weeks 8 and 9, but drops back to 1.25 by the end of the period. Vacation days off fluctuate but trend upward, reaching the start of the summer season by the end of the period. From a beginning point of 0.24 they reach an ending point of 0.40. The exception is a sharp drop in week 10 to 0.27.

Missouts vary significantly over this period, initially falling sharply from week five to week six, then rising for the remainder of the period. Missouts approximately parallel requests off and sick days and in all but one week move opposite to the operator/assignment ratio. This pattern is as expected for a fairly constant Operator/Assignment Ratio and varying Vacation Days Off.

Sick days off per operator generally decline through the period, although they do so in a gentle roller-coaster pattern with highs in weeks 10 and 11. This pattern is roughly a mirror image of Vacation Days Off and Missouts. There is no apparent relationship to the Operator/Assignment Ratio. The parallel changes between lagged sick days off and Vacation Days Off are as expected.

Other positions per operator trend generally upward during the period, with the exception of weeks 8 and 10. Again, this absence variable parallels the changes in vacation days off and missouts. It is expected that other positions should parallel changes in the Vacation Days Off.

Overall, this period shows the expected relationship between Vacation Days Off and missouts, and partially shows the opposite relationship between Vacation Days Off and each of sick days and other positions, under circumstances of a reasonably constant Operator/Assignment Ratio.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, the operator/assignment ratio climbs from its steady state at 1.25 in the previous period, to 1.32 in week 16, and then declines slightly to 1.30 the following week. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers. Although vacations are arranged well in advance, without prior knowledge of the consequences of a shake-up, it is noticeable that vacations drop in week 15 (the week of the shake-up) and then return to a level close to that prior to the shake-up.

Missouts per operator decline in the first two weeks of this period as the Operator/Assignment Ratio rises, and then jump sharply in week seventeen as the Operator/Assignment Ratio drops back from its high in the previous week. The changes in missouts per operator are precisely as postulated, changing in the reverse direction to the Operator/Assignment Ratio.

Sick days off per operator hold constant during this period of three weeks, and they do not appear to be effected by any other variable.

Other positions per operator somewhat parallel the changes in missouts. In this period, the changes in other positions (lagged by two weeks) shows an inverse correlation with the Operator/Assignment Ratio, but does not follow the pattern of Vacation Days Off, as would have been expected. It could be speculated, however, that the relationship to Operator/Assignment Ratio is more plausible around a shake-up than would be a relationship to Vacation Days Off. In this case, in the two weeks following the shake-up, which created a surplus of operators, the number of other positions per operator declines, rising again as the system begins to settle back into a more stable manpower condition.

Overall, this short period around the June shake-up shows the expected relationships between Operator/Assignment Ratio and each of lagged missouts and lagged sick days off, but does not support the expected changes in other positions related to vacations.

d. Weeks 18 through 24 (ending 7/27 through 9/7):

During this period, the operator/assignment ratio is steady at 1.28 for the eighteenth through twenty-first weeks, then decreases to 1.26 for one week, and returns to about 1.27 for the remainder of the period. Vacation days off are high through this period, period and remain high through week 24. This would be expected as operators attempt to take vacation during summer school vacations. Vacation days off per operator climb to a peak of 0.400 in week 20.

Missouts per operator fluctuate widely, then end near their beginning point. Between weeks 20 and 24 they follow a pattern similar to vacation days off. Otherwise their is little correlation with any other variable.

Sick days off per operator rise steadily over the period with the exceptions of the last week when they decline somewhat. This downward trend is as expected against the Operator/Assignment Ratio, which overall declines slightly. In the latter part of the period, they also move as expected against Vacation Days Off, which are declining.

Other positions fluctuate widely but generally decline overall in the period. In the early part of the period they somewhat follow the same pattern as requests off. Otherwise, there is little correlation between other positions and any other variable.

Overall, this period shows significant departures from the expected relationships. The strongest relationship seems to be between sick days and the operator/assignment ratio.

3.3 DIVISION 9 VCBs/OCBs, SHINEOUTS, AND MISSED/LATE PULLOUTS

3.3.1 Prior Hypotheses

As the operator/assignment ratio decreases, there are fewer operators available to the dispatcher to operate the service. Therefore, it should be expected that the number of VCBs and OCBs would increase, to cover unscheduled absences by operators, or that missed and late pullouts would increase. If VCBs and OCBs increase sufficiently, no change should occur in missed and late pullouts. Alternatively, if VCBs and OCBs are not increased sufficiently to cover all unscheduled absence, then missed and late pullouts should increase.

The opposite relationship should be expected for shine hours. As the operator/assignment ratio decreases, the number of shine hours should decrease. This effect will be reduced or will disappear if too many VCBs and OCBs are called in, or if the number of late and missed pullouts is allowed to increase.

Given the interrelationships between these three variables, it should never be the case that VCBs, OCBs, and late and missed pullouts increase, shine hours decrease, and the operator/assignment ratio decreases all in the same week. Similarly, VCBs/OCBs, and late and missed pullouts should not both decrease at the same time that shine hours increase and the operator/assignment ratio increases.

3.3.2 Results of the Analysis

Analyzing the change between weeks, there are 25 week-to-week changes in the 26-week period under study. For 15 of these week-to-week changes, VCBs/OCBs per assignment change in the opposite direction to the operator/assignment ratio: for 11, late/missed pullouts also change in the opposite direction to the operator/assignment ratio: while shine hours per assignment change in the same direction as the operator/assignment ratio 9 out of 25 times. Taking VCBs/OCBs and late/missed pullouts together, there is a change in one or both on 18 week-to-week changes that is in the expected direction. Adding the effects of shine hours, the correct composite change occurs on 22 of the 25 week-to-week changes. There are three occasions -- from week 6 to 7 and from weeks 9 to 11, when the exact reverse of the expected pattern of changes occurred.

There is no strong evidence here that there is any lagged effect on the three variables from the operator/assignment ratio, nor is there any reason to expect that there will be such an effect. Within a day-to-day variation, some lagging of the effect of operator availability might occur, but this should not be evident on week-by-week data.

Examining trend plots of the three variables against the operator/assignment ratio, the following conclusions appear:

a. Weeks 1 through 6:

The operator/assignment ratio increases throughout this period, starting at 1.30 in the first week and rising to a level of 1.34 for Division 9 by week 6, a rise of 3.0 percent.

The VCBs/OCBs per assignment begin at 0.21 and after some fluctuation increase to a high of 0.23 by the week ending May 4, as would be hypothesized. However, they then drop sharply to end at a low of 0.08 in the last week of the period.

Late and missed pullouts per assignment hit an early peak then a sharp decline and finally end near the starting level. The initial value of 0.02 peaked at 0.06 in week 2, dropped to zero in week 4, then climbed back to end at 0.02. The high in week 2 and drop in week 3 coincide with a similar rise and drop in absenteeism in those weeks.

Shine hours per assignment data is not available for most of this period. Shineouts decrease over the first four weeks, but show a slight increase in the sixth and seventh weeks. They begin the period at .005 per assignment, drop to .0019 by the fourth week and rise to .0038 in the seventh week.

b. Weeks 7 through 14 (ending 5/18 through 6/29):

The operator/assignment ratio is essentially constant through this period, beginning at 1.32, increasing to 1.34 in week 10, then edging off to 1.33 for the remainder of the period.

The VCBs/OCBs per assignment rise gradually over the period with the exception of a plunge in week 12. The plunge coincides with a sharp decrease in absenteeism. After beginning at 0.07 VCBs/OCBs rise to 0.12, plunge to 0.005, then end at a high of 0.15.

Late and missed pullouts decline over this period from the high at the end of the previous period. Starting from a high at the end of the previous period of 0.015 per assignment, they decline with the OCBs/VCBs to a low of zero twice in the period, in weeks 9 and 11. They end the period at 0.007.

Shine hours per assignment fluctuate during the period but generally trend up from a total of 610 hours to 650 hours. Peaks and valleys in total shine hours tend to vary inversely with OCBs/VCBs, as is expected.

Because the operator/assignment ratio is steady through the period, the variations in the VCBs/OCBs, late and missed pullouts, and shine hours are arising from other factors. On three occasions the directions of change are counter-intuitive and we have no explanation for them: the VCBs/OCBs are declining, the late and missed pullouts are declining, and the shine hours are holding fairly steady. In the remainder of the period, the combined changes in these measures are a little more logical, showing generally increasing shine hours with increasing VCBs/OCBs, and missed and late pullouts increasing as VCBs/OCBs decrease.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, the operator/assignment ratio climbs from its steady state at about 1.30 in the previous period, to 1.39 in week 15, declines slightly to 1.38 the following week, and then declines sharply to 1.28 in week 17. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers.

As expected, with the increases in available operators, the VCBs/OCBs per assignment declines markedly in the first week, but then begins climbing to the end of this period. Apart from the fact that the VCBs/OCBs start climbing sooner than expected (possibly due to an overcompensation in adjustment in week 16), the trends are as hypothesized.

Missed and late pullouts rise slightly in the first week then decline for the remainder of the period.

Shine hours per assignment increase at the beginning of the period, indicating that the sudden decrease in VCBs/OCBs was still insufficient against the increase in the operator/assignment ratio. The system appears to be quite unstable with respect to shine hours over the period, with a sharp increase in shine hours in the fifteenth week, even though the VCBs/OCBs drop significantly, then a decrease in shine hours, while VCBs/OCBs rise and the operator/assignment ratio rises in the sixteenth week. In the seventeenth week, shine hours drop as the operator/assignment ratio drops, VCBs/OCBs rise, and missed and late pullouts remain at zero.

Overall, this period shows some instabilities as the operator/assignment ratio made some of its largest week-to-week changes, resulting from the June shake-up. Generally, the hypothesized relationships seem to hold, although there is evidence that the system takes two or three weeks to recover from the shake-up.

d. Weeks 18 through 24 (ending 7/27 through 9/7):

During this period, the operator/assignment ratio gradually edges down from 1.25 to 1.23.

Despite the consistent decline in the operator/assignment ratio, there are some significant fluctuations in the VCBs/OCBs through the period. Initially, the VCBs/OCBs per assignment rise to of 0.27 in week 17 then decline to 0.28 in week 18. Over the next two weeks, the VCBs/OCBs rises to a high of 0.39 in week 22 then plunge to end at 0.19 in week 24. These fluctuations cannot be explained by changes in absenteeism as they run counter to absenteeism trends.

Missed and late pullouts rise slightly over the period. A dramatic jump from 0.01 to 0.05 occurs in week 23, but a correction in week 24 brings missed and late pullouts immediately back down to 0.07. As the operator/assignment ratios decline slightly, the missed and late pullouts rise slightly, as would be expected.

After declining from week 17 to week 18, the shine hours rise to their 26-week high in week 19. This rise occurs as VCBs/OCBs rises, and as a slight upward movement in operator/assignment ratio occurs. Shine hours generally descend for the remainder of the period to finish at their 26-week low in week 24. This decline occurs as VCBs/OCBs also declines, as would be expected.

Throughout this period, the hypothesized relationships among these variables appear to hold quite well, with VCBs/OCBs and shine hours varying together, and missed and late pullouts changing in the opposite direction to these two variables. The operator/assignment ratio is fairly steady, so that there appear to be other factors, as in weeks 8 through 14, that are generating the changes in each of the other measures.

e. Weeks 25 and 26 (ending 9/14 and 9/21):

A minor shake-up took place on September 8 that affects the performance in the last two weeks of the study period. Service was added back after the service cuts in June, resulting in a sharp drop in the operator/assignment ratio to 1.19 in week 25, recovering to 1.20 in the following week.

The VCBs/OCBs per assignment increase steadily throughout the period from 0.19 to 0.25.

Missed and late pullouts increase sharply in week 25 from 0.07 to 0.40 as the operator/assignment ratio plunges.

Shine hours per assignment move counter to what would be expected from changes in the operator/assignment ratio. Instead they seem to respond to changes in VCBs/OCBs.

3.4 DIVISION 9 SICK DAYS, MISSOUTS, REQUESTS OFF, AND OTHER POSITIONS

3.4.1 Prior Hypotheses

As the Operator/Assignment Ratio decreases, operators are effectively being asked to work more, with more opportunities for overtime work, and fewer opportunities to shine out. The demand for VCBs and OCBs is likely to increase, and this may be expected to generate some increase in the number of missouts and sick days. Therefore, under conditions of a decreasing operator/assignment ratio, it is expected that sick days and missouts will increase. Furthermore, one could anticipate that requests for a day off will increase, but the requests granted will decrease. As a result, there should be evidence of a declining number of requests off in the data (which relate to actual operator days off allowed from a request), and missouts or sick days should increase as operators use these as alternative methods to take time off that has not been granted from a request.

Generally, Vacation Days off will not be affected by the operator/assignment ratio and the responses to it. However, variations in the Vacation Days off affects the total pool of operators available in any given week, and is likely to have an effect on the other types of absenteeism. Higher numbers of Vacation Days will be likely to increase the effect of a decreasing Operator/Assignment Ratio, and lower numbers of Vacation Days Off will be likely to diminish the effect of a decreasing Operator/Assignment Ratio. In all these relationships, there is the possibility that there will be a lag effect that might be as much as two or three weeks. In the event that the number of Vacation Days Off rises to some significant peaks in the period, there should be a higher use of VCBs/OCBs, fewer shine outs, and potentially more Missed and Late Pullouts, irrespective of the Operator/Assignment Ratio.

The reverse patterns should be expected when the Operator/Assignment Ratio is increasing, implying a growing pool of operators for the available assignments. In this case, there should be a need for fewer VCBs and

OCBs, less overtime opportunities, and a resulting decline in unscheduled absences. Again, significant variations in Vacation Days Off will be likely to change the pattern, with a peak in Vacation Days Off diminishing the tendency for unscheduled absences to decline and a valley in Vacation Days Off tending to increase the declines in unscheduled absences.

3.4.2 Results of the Analysis -- Unlagged Data

Analyzing the change between weeks, there are 25 week-to-week changes in the 26-week period under study. For 15 of these week-to-week changes, Requests Off per assignment change in the opposite direction to the operator/assignment ratio; for 14, Sick Days per operator also change in the opposite direction to the operator/assignment ratio; other positions per operator change in the opposite direction for 14 week-to-week changes; and missouts per operator change in the same direction as the operator/assignment ratio only 5 out of 25 times. In all of the 25 week-to-week periods, at least one of the unscheduled absence categories -- sick, missout, request off, and other -- varies in the expected direction against operator/assignment ratio. Vacation Days fluctuate quite widely at a lower level for the first 15 weeks, then fluctuate more narrowly at a higher level for the summer months.

Unlike Division 1, there is no evidence here that there is a lagged effect on some of the absenteeism variables from the operator/assignment ratio, with the exception of other positions. In looking at the correlation of increases and decreases from week-to-week, it appears that other positions per operator are lagged about two weeks behind changes in the operator/assignment ratio. With a two week lag, the number of changes that have a sign opposite to the change in operator/assignment ratio increases from 13 out of 25 to 16 out of 24.

Examining trend plots of the four absenteeism variables against the operator/assignment ratio, the following conclusions can be drawn for the unlagged effects:

a. Weeks 1 through 6:

The operator/assignment ratio increases throughout this period, starting at 1.30 in the first week and rising to a level of 1.34 for Division 9 by week 6, a rise of 3.0 percent. Vacation days off rise initially and stay at a plateau for two weeks, then drop sharply, only to rebound almost as sharply in the next week, and finally finish higher.

Missouts per operator show generally an upward trend over this period, as would be hypothesized. The exception is a sharp decline in week 5 which reaches a 26-week low. Week 6, however, shows and even sharper increase, to end the period at the 26-week high. These peaks and valleys, and all other changes during the period run counter to the operator/assignment ratio, as would be expected.

Sick days off per operator decline fairly steadily throughout the period with the exception of an increase in week 5. The first five weeks change in opposition to the operator/assignment ratio, as would be expected. The final week changes in the same direction as the operator/assignment ratio, which is not expected. In the first four weeks of the period changes in sick days follow the same pattern of changes as other positions.

Requests off rise moderately, then decline sharply in week 3, only to rebound on a sharp upward trend which ends in a 26-week high in week 6. All but one of these changes are in opposition to the operator/assignment ratio, as would be expected. Moreover, the pattern of changes for requests off is quite similar to the pattern of changes for missouts, with the exception of week 5, where missouts plunge sharply while requests off continue to rise.

Other positions per operator rise then decline sharply in week 3, then stabilize at a level somewhat lower than week 1. In all but the last week of this period other positions change in the opposite direction to the operator/assignment ratio. The pattern of changes for other positions is most similar to the pattern of changes for sick days off.

b. Weeks 7 through 14 (ending 5/18 through 6/29):

The operator/assignment ratio is essentially constant through this period, beginning at 1.32, increasing to 1.34 in week 10, then edging off to 1.33 for the remainder of the period. Vacation Days Off plunge steadily until week 9, then generally trend upward to end lower overall.

Missouts per operator decline sharply from the seventh to the eighth weeks, increase about half the previous decline, decrease for two weeks to low in week 10, then fluctuate to end low. Given that the operator/assignment ratio is stable through this period, it is apparent that this characteristic is not the one that influences the missouts per operator. Moreover, Missouts seems to parallel vacation days, the opposite relationship that would be expected.

Sick days off per operator fluctuate during this period, but end very close to their beginning point. A high occurs in week 8 and the 26-week low occurs in week 12. That significant dip occurs in week 10, which coincides with the low in vacation days off, and low points for the period in both other positions and requests off. A very small rise occurs in that week in the operator/assignment ratio, but this seems unlikely to explain the shifts in these other measures. The same week does show, however, a drop in the VCBs/OCBs, as might be expected, given a reasonably stable operator/assignment ratio and a low in most measures of scheduled and unscheduled absence.

Requests off decline sharply until week 9, then gradually increase to regain about half that initial drop. The only exception to the upward trend in the latter part of the period occurs in week 12 with a minor drop which is corrected in the following week. Contrary to what might be expected, the majority of these changes match the directional changes in operator/assignment ratio in reverse. That is, as the operator/assignment ratio falls, requests off rise, while small increases in the operator/assignment ratio are accompanied by decreases in requests off. There are also some similarities apparent between the pattern of changes for requests off and for the pattern for missouts, as might be expected.

Other positions per operator somewhat parallel the patterns for missouts and sick days off. Other positions increase for the first two weeks, decline back almost to the beginning level by week 12, then increase to end the period somewhat higher than the beginning level. The dip in week 12 coincides with the dip in sick days off and missouts. The parallel of this absence category to sick days off and vacation days off is not expected.

c. Weeks 15 through 17 (ending 7/6 through 7/20):

Over this period, which includes the effects of the June shake-up, the operator/assignment ratio climbs from its steady state at about 1.30 in the previous period, to 1.39 in week 15, declines slightly to 1.38 the following week, and then declines sharply to 1.28 in week 17. The rise is almost certainly a result of the service cuts instituted at the end of June, without any significant lay-offs of drivers. Although vacations are arranged well in advance, without prior knowledge of the consequences of a shake-up, it is noticeable that vacations drop sharply in week 15 (the week of the shake-up) and then return to a level close to that prior to the shake-up.

Missouts per operator rise sharply in week 15, then decline even more sharply, then rise back to end somewhat lower than their beginning point. This decline in missouts is expected, given the increase in the operator/assignment ratio. During this period missouts generally move in opposition to vacations days off and request days off.

Sick days off decline then rise in the final week to end the period higher. During this period sick days seem to be lagged by one week from a rise in the operator/assignment ratio, which would be contrary to expectations (i.e., sick days off should increase when the operator/assignment ratio decreases). The pattern of sick days off for this period most closely follows the pattern of other positions.

Requests off per operator steeply in the first week of this period, then continue to decline moderately in week 16 and slightly increase in week 17 to end the period quite low. The decline in value for week 15 appears in all absence categories except missouts and other, but the continuing downward trend in requests off as the operator/assignment ratio starts to drop after the shake-up is as likely to be the result of the

dispatcher's unwillingness to grant requests with a declining operator/assignment ratio.

Other positions per operator remain fairly steady then increase sharply in the final week of this period. The pattern of other positions most closely resembles the pattern observed in sick days off.

Overall, the primary effect that is observable over this period is a sharp decrease in all absence categories except missouts in the week following the June 30 shake-up. This seems to indicate an intention of operators to be around in that first week, possibly to make sure they know their new assignments, and possibly as protection against being laid off, given that service was cut on June 30. After the June 30 shake-up, requests off match the upward and downward movements of the operator/assignment ratio, as would generally be expected (i.e., the higher the operator/assignment ratio, the more operators are available and the more likely a dispatcher will grant requests off). However, trends in sick days off and missouts run contrary to expectatior

d. Weeks 18 through 24 (ending 7/27 through 9/7):

During this period, the operator/assignment ratio gradually edges down from 1.25 to 1.23. Vacation days off remain very high throughout this period with minor dips in week 19 and 23. This high level of vacation days off would be expected as operators attempt to take vacation during summer school vacations.

Missouts per operator continue to rise for the first two weeks, then decline for two weeks, then increase sharply for a period high in week 23, the decline back to end the period very close to the starting point. The two period highs both coincide with lows in vacation days. On the whole, the pattern for missouts is nearly the inverse of the pattern for vacations days. With the operator/assignment ratio remaining fairly steady throughout this period, the primary driving force on missouts seems to be vacation days off.

Sick days off per operator remain fairly constant for two weeks, drop rather sharply, then regain about half the previous drop and remain fairly constant for the final four weeks. The sharp drop coincides with the peak in request days off. Otherwise, sick days off tend to vary in the opposite direction to vacation days off, as might be expected. Correlation with the operator/assignment ratio is not evident.

Requests off per operator decline modestly then increase rapidly for two period, then fluctuate sharply for the rest of the period. The sharp fluctuations do not appear to correlate with any other variable.

Other positions per operator alternately move up then down throughout the period, then end down. Changes in other positions do not seem to correlate particularly strongly with any other variable.

e. Weeks 25 and 26 (ending 9/14 and 9/21):

A minor shake-up took place on September 8 that affects the performance in the last two weeks of the study period. Service was added back after the service cuts in June, resulting in a sharp drop in the operator/assignment ratio to 1.19 in week 25, recovering to 1.20 in the following week. Vacation days off per operator drop from their peak in week 24 to a level 0.34 in these two weeks.

Missouts per operator decline then increase to end higher over these two weeks. Missouts do not appear to correlate with any other variable during this period.

Sick days off per operator rise throughout this period. Sick days off parallel other positions most closely, but they do not correlate well with the operator/assignment ratio.

Requests off per operator drop sharply in both weeks of this period, ending near the 26-week low. Requests off do not correlate well with any other variable during this period.

Other positions per operator hold steady then increase over the period. Again, the other positions parallel the sick days off most closely, but do not appear to correlate particularly with the operator/assignment ratio.

4. DETAILED OPERATING DIVISION ANALYSIS

As part of the Phase III work program, the study team conducted a detailed analysis of selected operating data for the District's divisions 1 and 9 in order to identify and investigate factors affecting the ability of operating divisions to function efficiently and effectively at lower operator/assignment ratios specifically ratios at roughly 1.27 as recommended by the study team's Phase II Report. Daily operating statistics were obtained for divisions 1 and 9 for eight weeks from the week ending January 11 through the week ending March 1, 1986. In early April, interviews were held with selected division management and supervisory personnel to discuss manpower planning and utilization at divisions 1 and 9. The findings and conclusions from this analysis for the District's divisions 1 and 9 are presented in this chapter.

4.1 DAILY OPERATOR REQUIREMENTS

Operator requirements are projected each day for the next day's operations by each division. At the same time, the number of operators available for the next day's work is determined. The difference between the number of operators available and the projected operator requirements, which may be plus or minus for any day, is referred to as the "manpower condition." Manpower condition is a variable reported daily by each operating division. More specifically, it is computed as the number of extra board operators available for filling open assignments on the next day less the number of assignments projected to be filled on the next day. It is calculated at 11:00 a.m. at which time work is commenced to mark up extra board work assignments for the following day. If the manpower condition is reported as (-10), the division is reporting a shortage of ten operators for the next day's work.

4.1.1 Work Assignments for Extra Board Operators

The number of work assignments to be filled by extra board operators includes the following:

- Open regular assignments;
- Open a.m. biddable trippers;
- Non-biddable trippers; and
- Reports to protect against missouts and other operator absences not known at 11:00 a.m.

Regular run assignments may be open because of an operator being sick, on vacation or other leave, or not available for driving work for other reasons. If the operator holding the regular run also held a biddable tripper, the combined regular run and biddable tripper is considered as one open work assignment for manpower planning purposes and is also marked up as a single work assignment. If the regular run will be vacant for one week or longer (except where the regular operator is sick or injured), it may be posted for hold-down bidding by extra board operators. The open regular run is then worked by the successful extra board operator until the regular operator returns to work.

Open biddable trippers starting in the a.m. are counted as assignments to filled for manpower planning purposes. It is assumed that open biddable trippers starting in the p.m. may be paired with open trippers starting in the a.m., open regular runs that end in the midday hours, or other regular runs worked by regular and extra board operators. When combined with a regular run, the total work time for the combined assignment must not exceed eleven hours, forty minutes and the total driving time for the combined assignment must not exceed ten hours.

Non-biddable trippers are typically between approximately two hours and five hours in length. They may be worked individually by part-time operators (provided that they are not shorter than two and one-half hours or longer than five hours), individually or in pairs by extra board operators, or in conjunction with a work run by a regular or extra board operators. Since non-biddable trippers are typically two and one-half hours or longer in length, the maximum work time limitation of eleven hours, forty minutes restricts the working of non-biddable trippers in conjunction with regular work run assignments. For manpower planning calculations, it is assumed that the number of operators required for open non-biddable trippers is equal to the largest of the a.m or p.m. number of open non-biddable trippers. For example, if 25 non-biddable trippers starting in the a.m. are open and thirty non-biddable trippers starting in the p.m. are open, it is assumed for manpower planning purposes that thirty operators are required. Of this total, 25 operators would be assigned to tripper combination work assignments and five would be assigned to p.m. trippers combined with report work.

Report assignments are designed to provide operators for work that becomes open after 11:00 a.m. on the preceding day. Start times for report assignments are specified so that one or more operators will be available at times when work runs are scheduled to start throughout the day. Each of the District's operating divisions has determined its report operator requirements based on its past operating experience and related factors.

Data for one of the District's operating divisions illustrates a typical breakdown of extra board operator requirements.

Open regular assignments	38
Open non-biddable trippers	20
Open a.m. biddable trippers	14
Reports	32
Total Extra Board Operator Work Assignments	104

In this example, extra board operator requirements are roughly split on a equal basis among requirements for open regular assignments, open biddable and non-biddable trippers, and report assignments.

Study analysis results indicate that the estimation of extra board operator requirements used for the calculation of the daily manpower condition does not accurately reflect actual manpower requirements. More specifically, the projected requirements exceed actual requirements by a significant amount which will be examined in the following sections of this chapter. In examining the determination of operator requirements, it should be kept in mind that there may not be 'one' answer to the question.

of establishing operator requirements but rather separate answers for questions such as:

- What are the minimum operator requirements at which a division can operate without resulting in unacceptable levels of service reliability? or
- What is the least cost operator requirements at which a division's operating costs are minimized?

4.1.2 Systemwide Operator Requirements

Figure 4-1 illustrates the range of weekly manpower conditions for the District's operating divisions for the 26 weeks being studied in the Phase III work program. For nearly all weeks, the system was operating with 'negative' manpower condition levels ranging as high as (-2,100) per week. A negative manpower condition level of (-2,100) corresponds roughly to a systemwide requirement for 420 operators.

In order to operate with a negative manpower condition level, at least four actions may be invoked by division management and supervisory personnel.

- Operators may be called to work on their days off, referred to as VCB for "voluntary call back" or OCB for "off, called back" for operators who have not volunteered for work on their day off. Over the 26 week time period, the number of VCB/OCBS per week ranged from 332 to 875.
- Service may be cancelled when there are an insufficient number of bus operators available to operate scheduled services. For the 26 week time period, the number of weekly late and cancelled bus pullouts ranged from 26 to 130 per week. At the maximum number, this represents only a fraction of one percent of the total weekly pullouts for the District.
- Open biddable and non-biddable trippers may be combined together and with regular run assignments to the maximum possible extent, reducing the requirement for extra board operators to work open biddable and non-biddable trippers.
- The number of report assignments may be reduced, increasing the risk that it may be necessary to cancel service on the following day due to operators not being available.

MKTG 9
REV 8/84

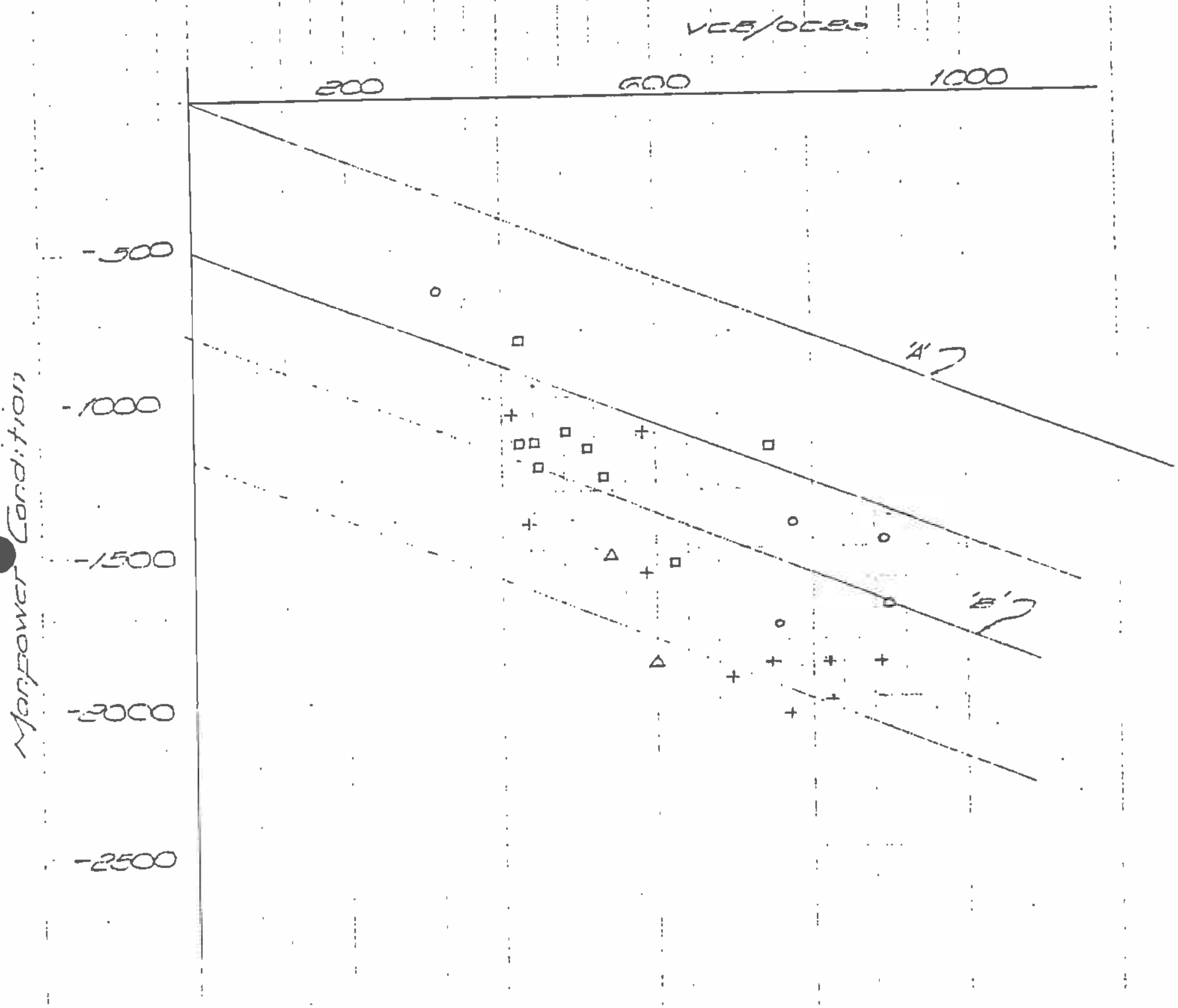
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

RTD

Figure 4-1

Subtask	Systemwide	Date 7-10-86	Page of
Subject			Preparer



From Figure 4-1, it may be concluded that the District employs a variety of actions in order to satisfy operator requirements with a projected manpower shortage. If the projected shortage were fully covered by VCB/OCB operators, the number of VCB/OCB operators used would correspond with the magnitude of the negative manpower condition on a one-to-one basis. In other words, 100 VCB/OCB operators would be employed for a week with a negative manpower manpower condition of (-100). The upper line (labeled "A") in Figure 4-1 corresponds to a one-to-one relationship between the number of VCBs/OCBs and negative manpower condition. Note that all of the plotted data points fall significantly below this line, meaning that projected operator shortages are being accommodated in part without the need for providing the projected number of operators. The second line (labeled "B") in Figure 4-1 has been drawn parallel to the upper line with an approximate one-to-one slope. It is intended as a rough best fit through the data points plotted with a one-to-one slope. From this this line in Figure 4-1, the following may be concluded.

- Operator shortages totaling between 500 and 1,200 per week systemwide can be absorbed without the need for utilizing operators working on their day off. This corresponds to a requirement for between 100 and 240 bus operators systemwide (assuming approximately 3550 assignments, this corresponds to between 0.03 and 0.07 in the operator/assignment ratio).

- At smaller negative manpower condition levels, the clustering of data points above the line appears to suggest that there is an increased tendency to utilize VCB/OCB operators to make up for small operator shortages. These data points also correspond to weeks with national holidays where regular weekday schedules were operated for only four days and to six out of the eight weeks in which the District's summer schedules were in effect.

- At the higher negative manpower condition levels, there appears to be a clustering of points below the line possible suggesting that the availability of VCBs/OCBs has been exhausted and that other means for meeting minimum operator requirements must be invoked.

4.1.3 Division Operator Requirements

Figure 4-2 shows the weekly number of VCBs/OCBs plotted against the weekly negative manpower condition levels for the District's division 1. An approximate best fit line with a one-to-one slope is drawn in Figure 4-2. For the 26 week time period, the division operated with daily operator shortages totaling approximately 80 operator days per week before VCBs/OCBs were employed. This estimate is based on the best fit line's intercept with the negative manpower condition as is shown in Figure 4-2.

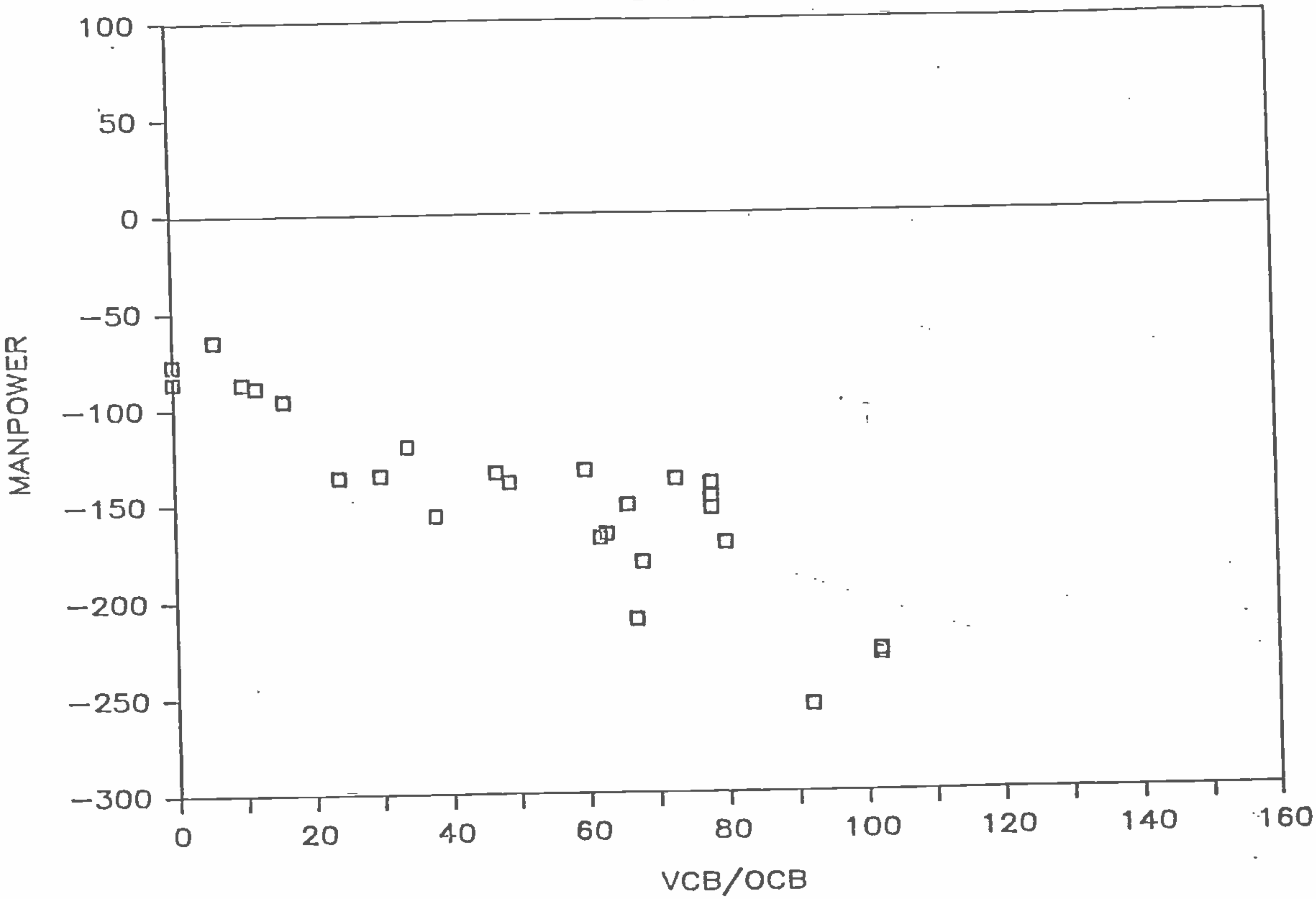
Figures 4-3 through 4-5 are similar plots of the daily manpower condition and of the number of VCBs/OCBs for division 1. These plots are for three separate eight week periods, specifically:

1. Week ending April 20 through week ending June 8, 1985 (weeks 4 through 11 of the 26-week study time period);

Figure 4-2

MANPOWER COND. VCB/OCB

DIVISION 1



MKTG 9
REV 8/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

RTD

Task 4-3

Subtask

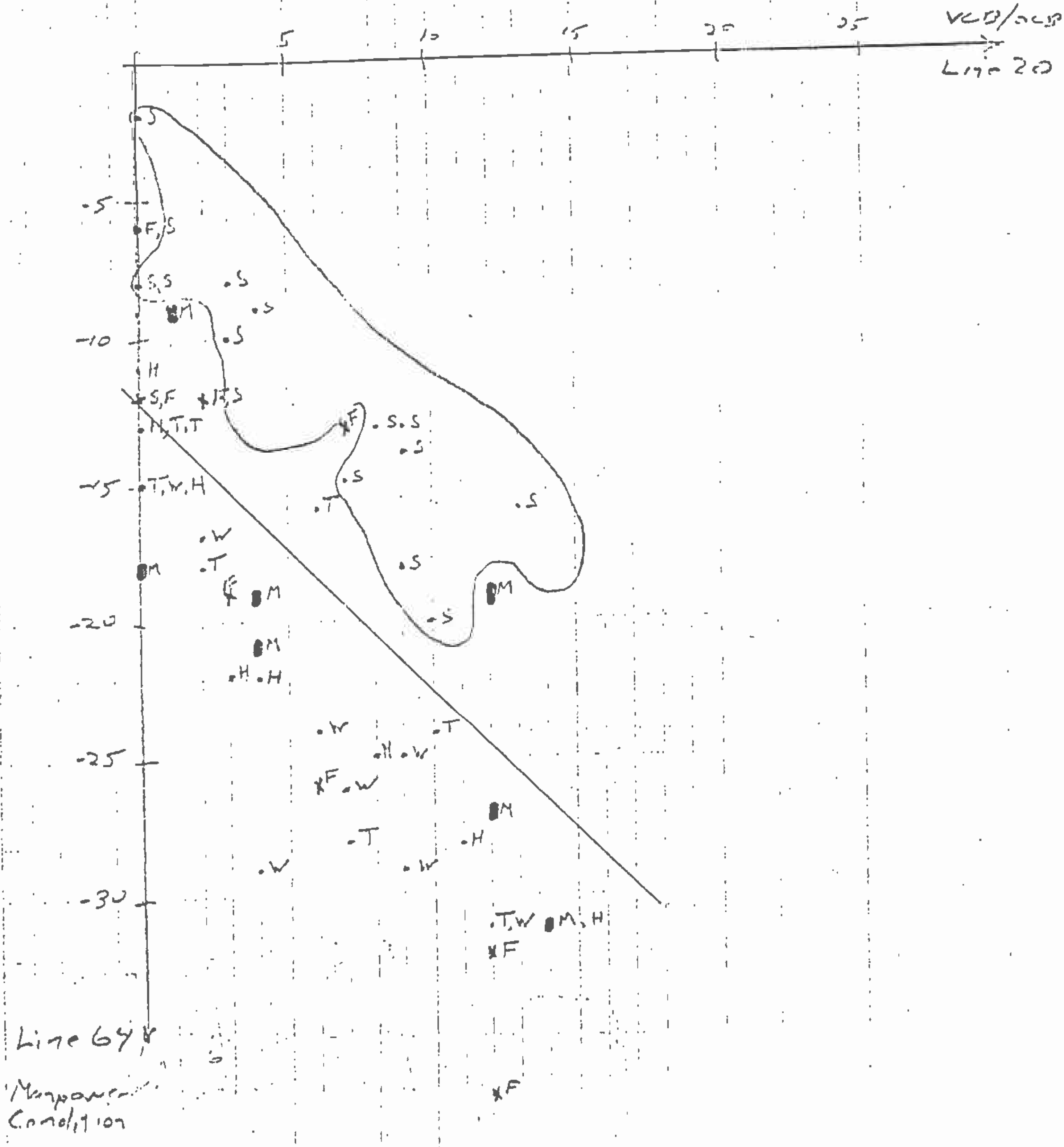
Date

Page of

Preparer

Subject Division 1

Weeks 4 thru 11



MKTG 9
REV 8/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

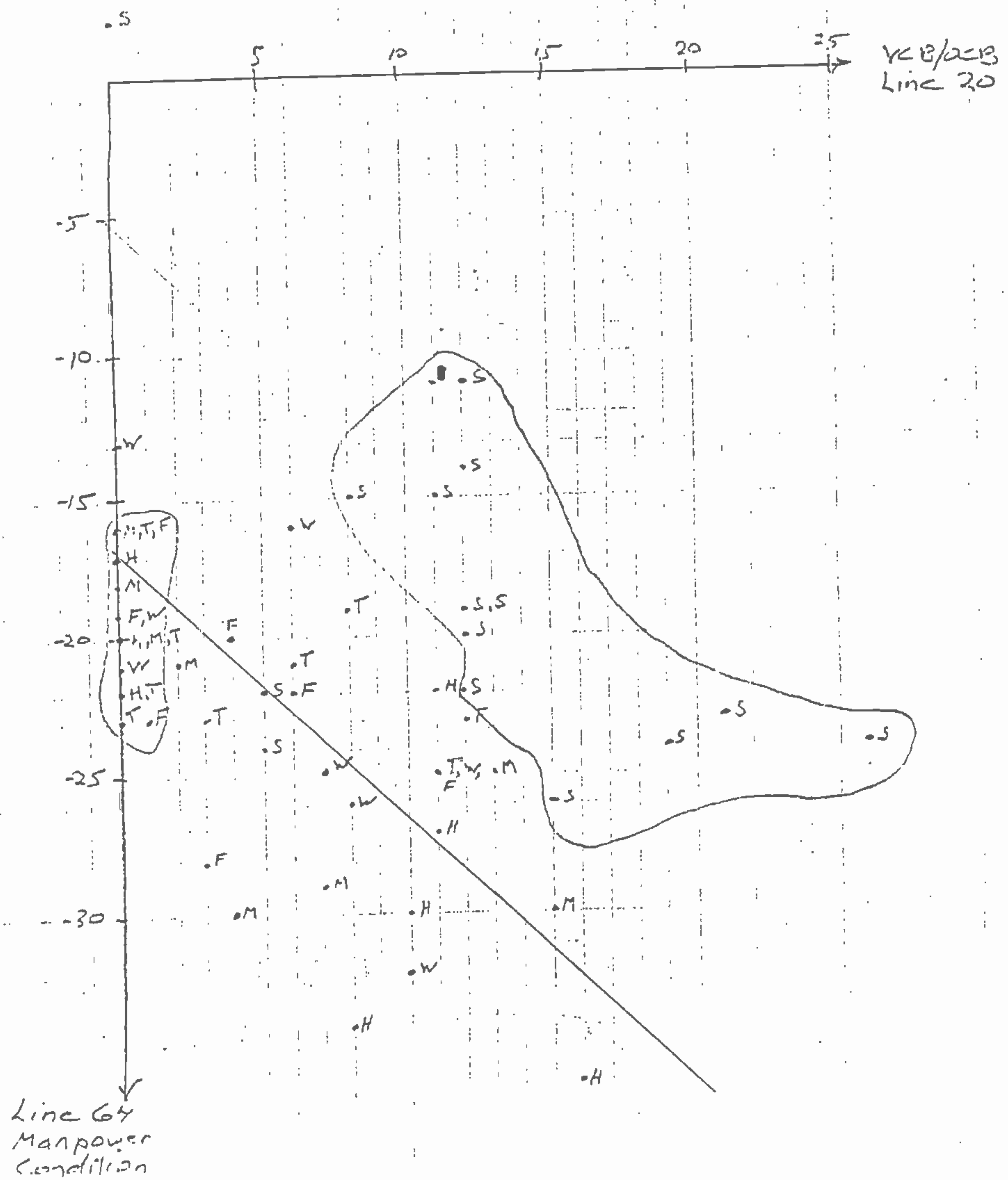
RTD

Subtask: [illegible] - X-4 Date Page of

Preparer

Subject: DIVISION

Weeks 16 to 23



Southern California Rapid Transit District, 425 South Main Street, Los Angeles, CA 90013

MKTG 9
REV 8/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

RTD

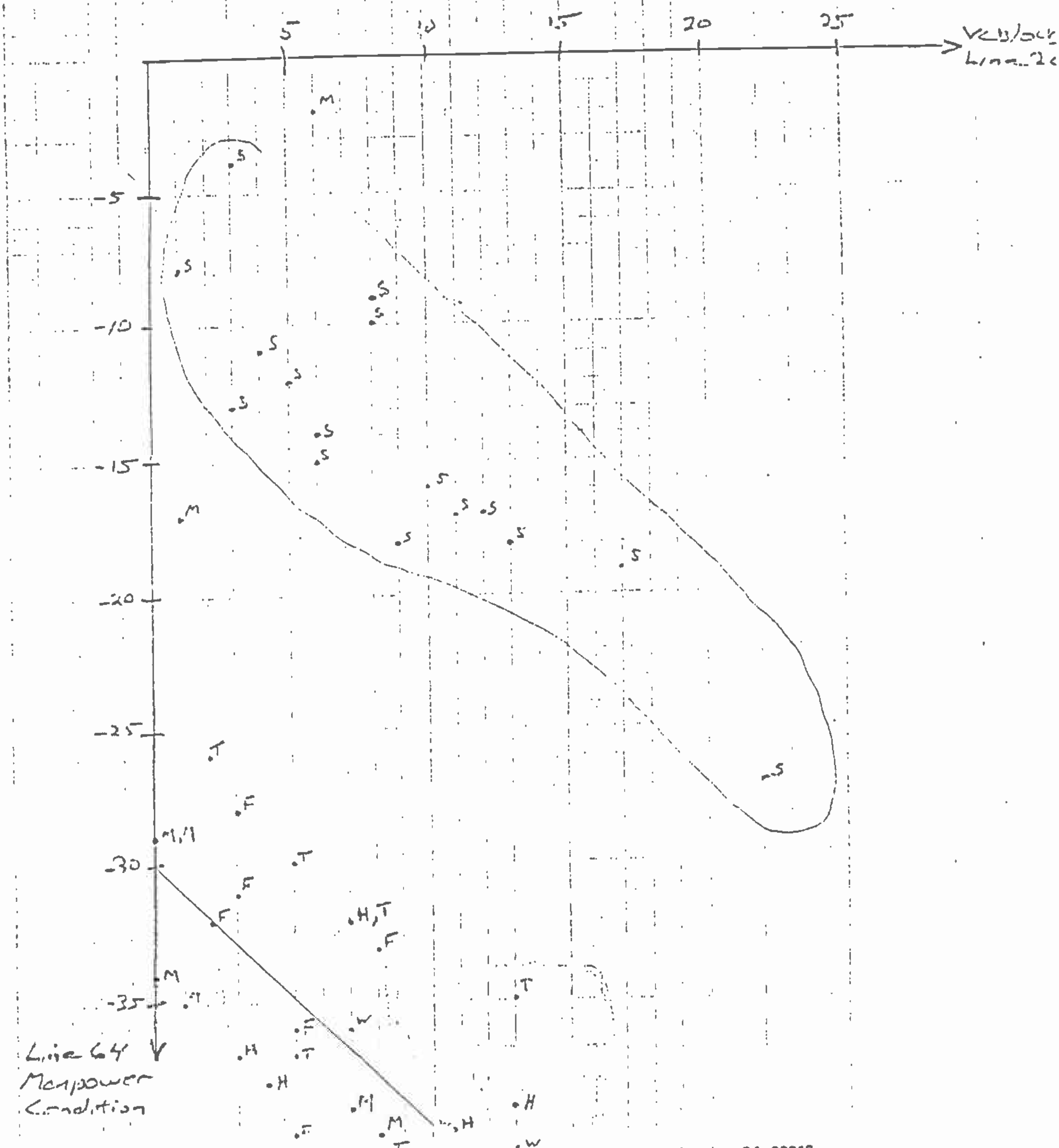
4-5

Subtask | Date | Page of

Preparer

Subject

Jan. 6 - March 1, 1986



2. Week ending July 13 through week ending August 31, 1985 weeks 16 through 23 of the 26-week study time period), and

3. Week ending January 11 through week ending March 1, 1986.

Examination of the data for the three time periods suggests the following conclusions for division 1:

- o For weekdays, a manpower shortage averaging approximately fifteen operators was absorbed without using VCB/OCBS for the two eight-week time periods in 1985. For weekdays in 1986, a manpower shortage averaging approximately thirty operators was absorbed without using VCBs/OCBs--this is double the number observed for the 1985 time periods.

- o For Saturdays and Sundays, a manpower shortage averaging approximately five operators was absorbed without using VCBs/OCBs for all the eight-week time periods. This difference for Saturdays and Sundays is probably due to the small number of trippers operated on these days, since the more efficient manning of trippers is an effective means of reducing actual operator requirements.

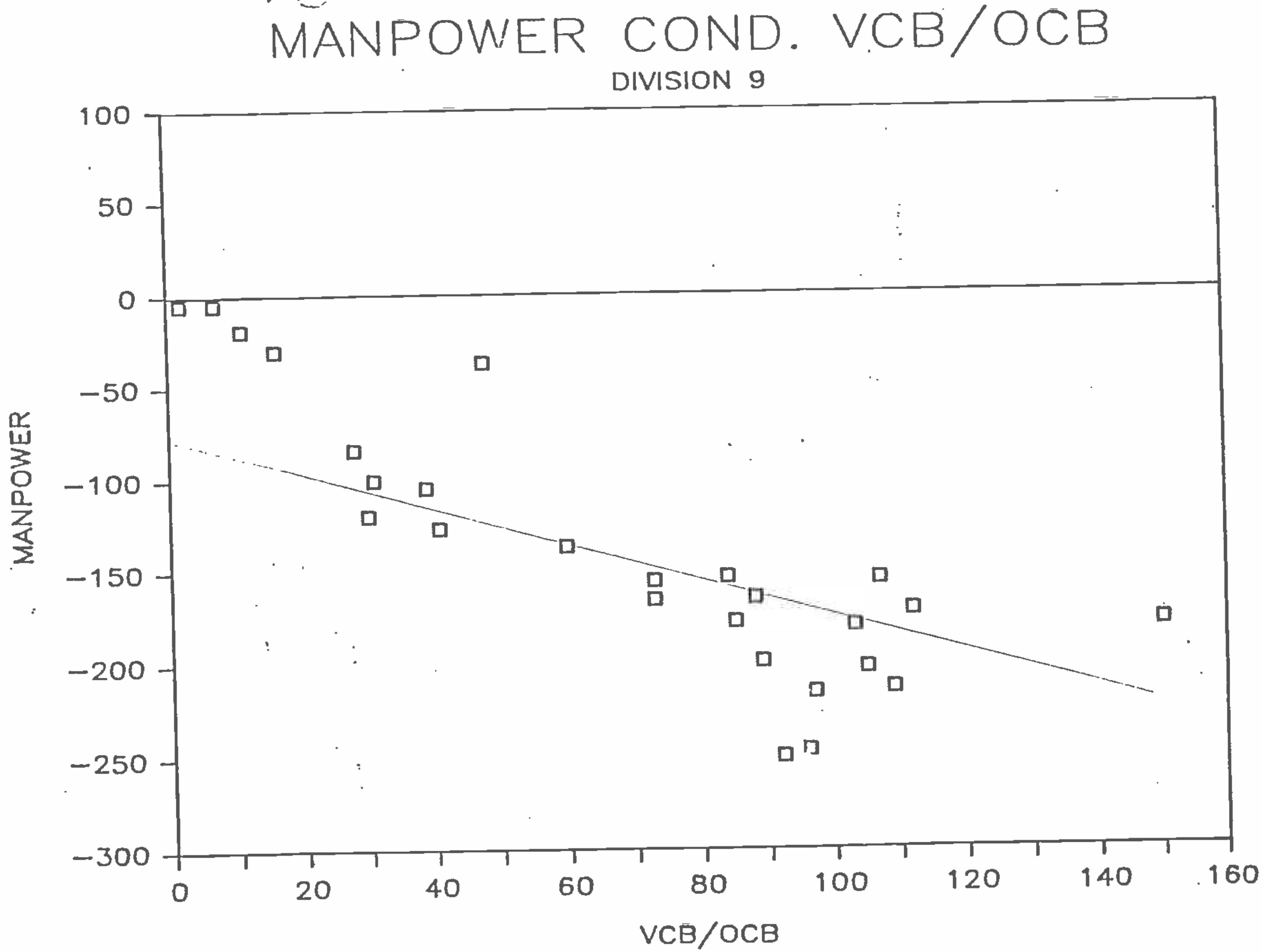
Figure 4-6 shows the weekly number of VCBs/OCBs plotted against the manpower condition for the District's division 9. An approximate best fit line with a one-to-one slope is drawn in Figure 4-6 as was also drawn through the division 1 and systemwide data. For the 26-week period, the division operated at negative manpower condition levels similar to those recorded for division 1. On the average, the division absorbed daily operator requirements totaling approximately 80 operator-days per week without using VCBs/OCBs to meet projected operator requirements. As was noted for the systemwide data, but not for division 1, there is a clustering of data points above the line at lower negative manpower condition levels, as well as some possible clustering below the line at higher negative manpower condition levels.

In Figures 4-7 through 4-9, the daily manpower condition and the number of VCBs/OCBs are plotted for the three eight-week time periods described earlier. Examination of this data for the three time periods indicates the following conclusion.

- o The data points appear to be more scattered and, except perhaps for the first time period, not as well fitted to the hypothesized one-to-one relationship between the number of VCBs/OCBs and the negative manpower condition at any levels of negative manpower condition.

- o Data points for Saturdays and Sundays lie above the one-to-one lines. On the average, manpower shortages of five or fewer operators per day were absorbed without using VCBs/OCBs for Saturdays and Sundays in each of the three time periods. For the summer, 1985 and 1986 time periods, it is noted that both the number of VCBs/OCBs and the negative manpower condition were consistently highest on Saturdays and Sundays.

Figure 4-6


MANPOWER COND. VCB/OCB
DIVISION 9
100
50
0
-50
-100
-150
-200
-250
-300
MANPOWER
0
20
40
60
80
100
120
140
160
VCB/OCB

MKTG 9
REV 8/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

RTD

4-7

Subtask

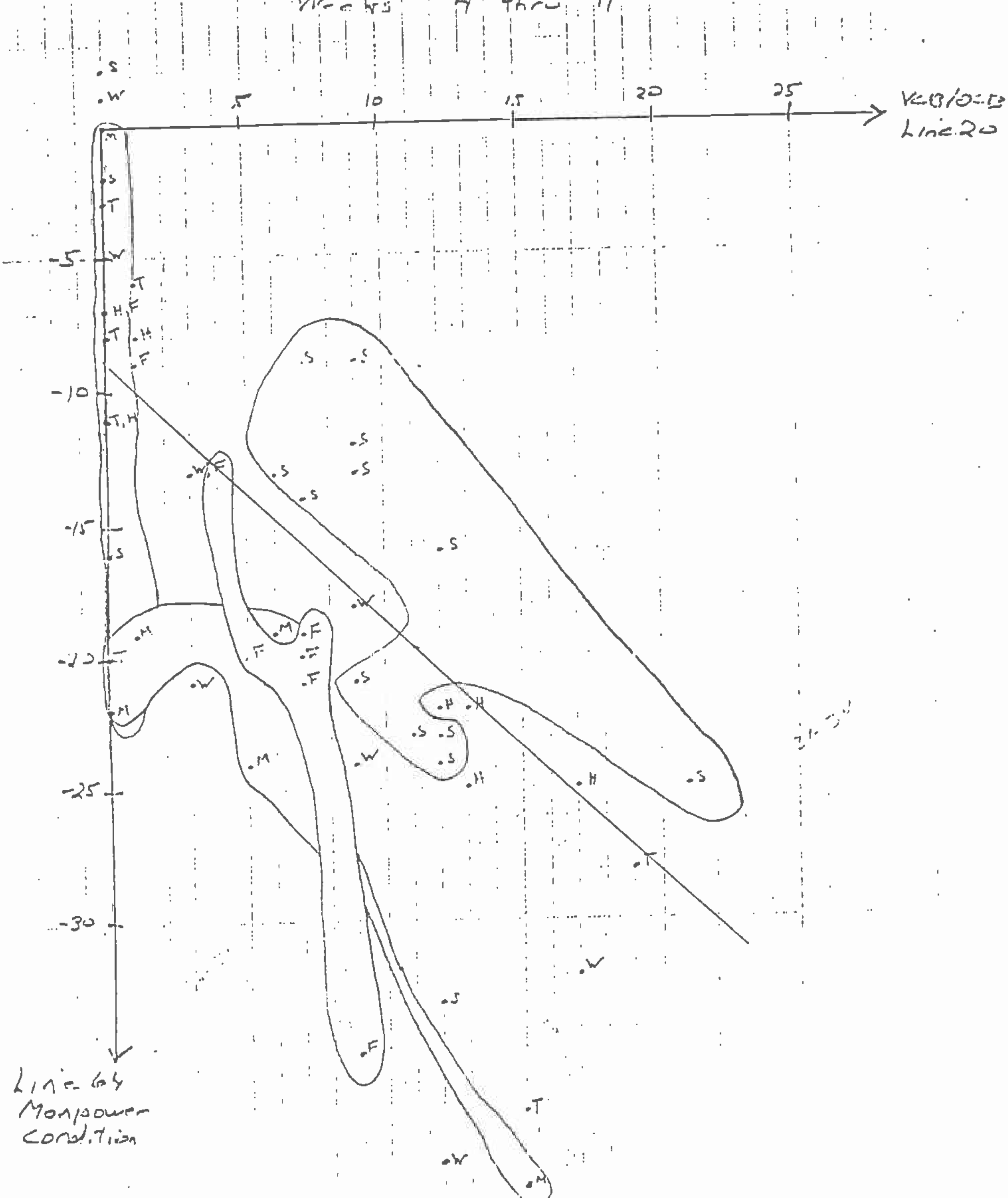
Date

Page of

Preparer

Subject Division 4

Weeks 4 thru 11



MKTG 9
REV 8/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

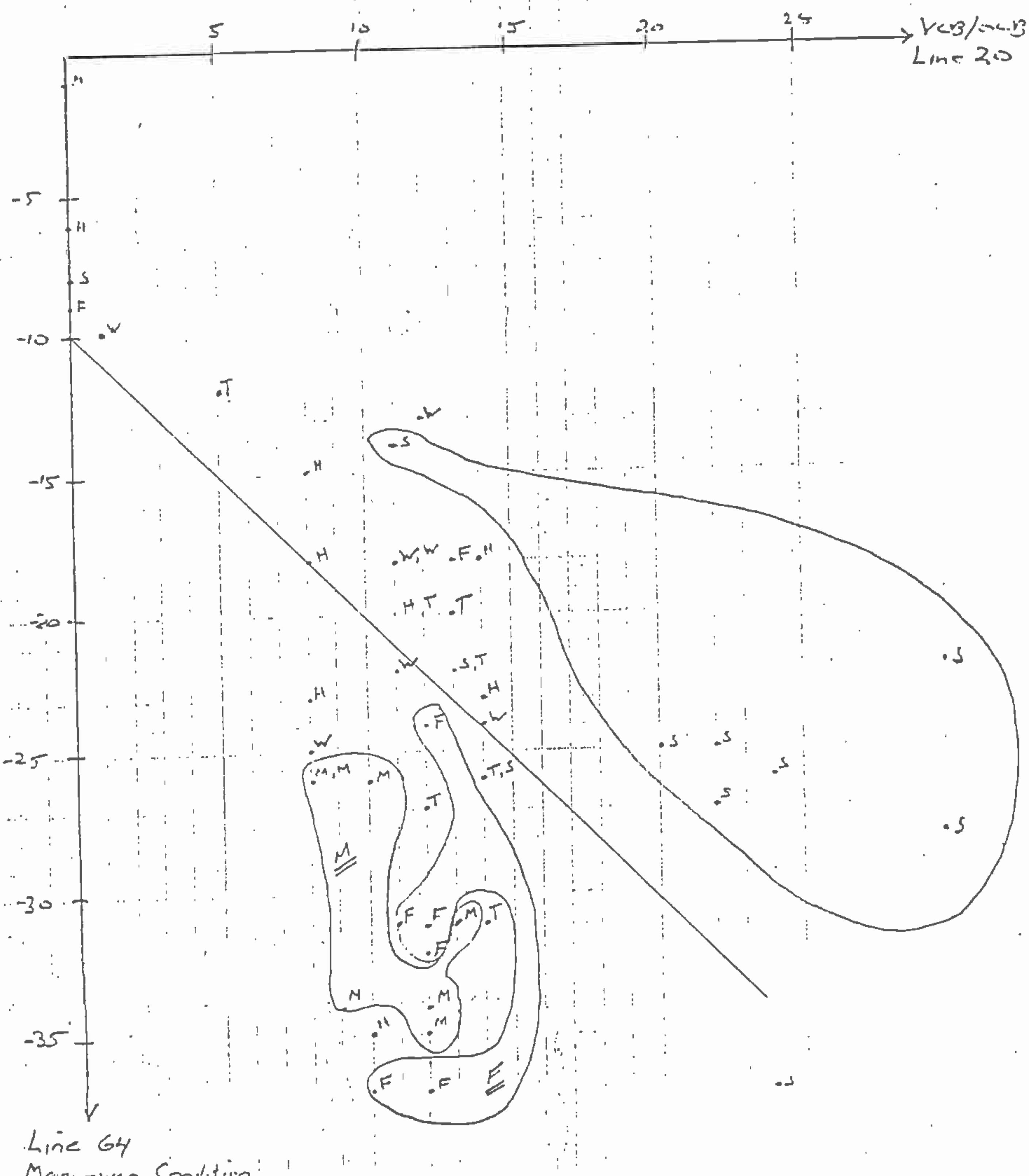
RTD

Figure 4-8

Subtask | Date | Page | of

Subject: Division 9 | Preparer

Weeks 16 thru 23



Southern California Rapid Transit District, 425 South Main Street, Los Angeles, CA 90013

MKTG 9
REV 8/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

RTD

Figure 4-9

Subtask

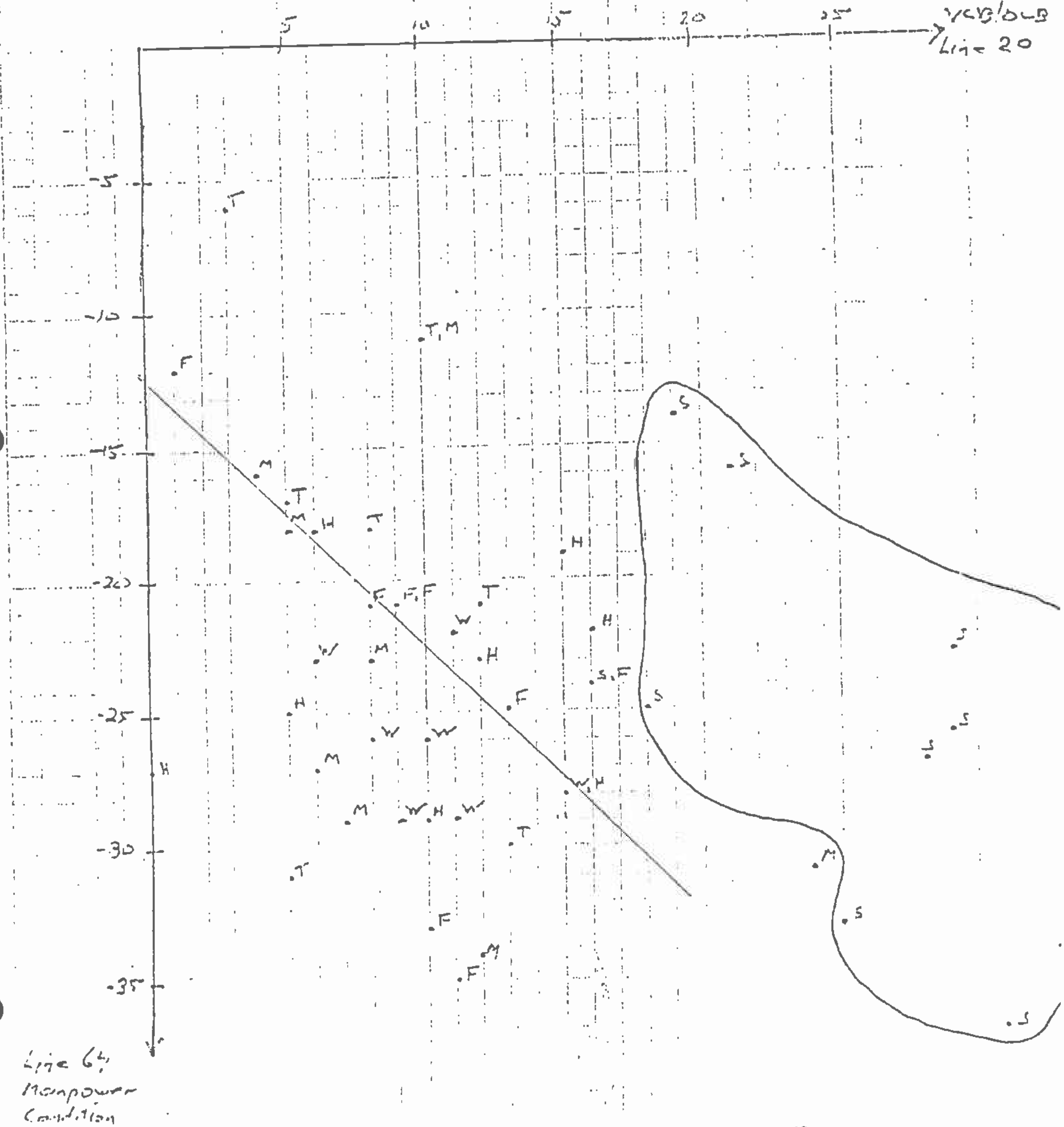
Date

Page of

Preparer

Subject

Jan. 6 – March 1, 1988



- For weekdays, a manpower shortage averaging roughly between ten and fifteen operators was absorbed without using VCBs/OCBs for each of the time periods. However, for negative manpower conditions exceeding approximately 20 to 25, it appears that the use of VCBs/OCBs was limited to a maximum of between ten and fifteen per day. This maximum number corresponds very roughly to one-half of the number of extra board operators scheduled off for each day of the week in the time periods. Whether or not explained by the distribution of extra board operator days off, the apparent limitation of VCBs/OCBs on weekdays to a maximum of between ten and fifteen operators is very noticeable in Figures 4-7 through 4-9, and also when Figures 4-3 through 4-5 are reviewed again.

The study team carried out interviews at both divisions 1 and 9 to investigate dispatching procedures under operator shortage conditions. At division 9, the markup for the following day was reviewed with the markup dispatcher. The projected manpower condition at the start of the markup was (-40). In order to operate the next day's scheduled service with this negative manpower condition level, the following steps were taken in marking up work assignments for the next day.

- One regular operator volunteering for days off work was called for work as a VCB.

- Out of nine extra board operators taking their day off, six were called for work as OCBs. Two of the remaining three operators were assigned to extra supervisory assignments and therefore not available for OCB work. The third extra board operator not called for OCB work was sick.

- Seven open a.m. biddable trippers were withheld from the markup to be assigned on the following day to regular operators who had requested the additional work. The withholding of these open biddable trippers from the markup was not in accordance with written UTU contract provisions.

- Eight open regular runs were withheld from the markup in order to be assigned on the following day to regular operators willing to work on their day off as an OCB if assigned a particular work assignment. The withholding of these runs from the mark-up, and their assignment to OCB operators based on the request of the operators was not in accordance with written UTU contract provisions.

- Manpower requirements for division 9 are based on using 23 report operators. For the day being analyzed, this was reduced to three a.m. report assignments and two p.m. report assignments. In addition, roughly ten to fifteen open biddable and non-biddable trippers starting in the p.m. were not marked up (which is permitted by UTU contract provisions). Assuming that the number of open trippers in the a.m. and p.m. were roughly balanced after the assignment of the open a.m. biddable trippers to regular operators, this means that ten to fifteen extra board operators were marked up with a.m. tripper piece of work plus a second report piece of work. These operators could then be used for open work assignments other than for the ten to fifteen open p.m. trippers. The open p.m. trippers might be worked at overtime by regular or extra board operators completing their regular work assignments or cancelled if no operators were available.

How many assignments were cancelled as result of mark-up?

At division 1, a week where negative manpower conditions ranged from -biddable trippers. By combining the open a.m. biddable trippers with thNassumed that between 26 anunderstanding of dispatching procedures under operator shortage conditions. For Monday through Friday, a total of only eighteen VCB/OCB operators were employed despite the high negative manpower condition levels. Service cancellations for the week were within the normal range experienced by the division, so that excessive cancellations did not result from the combination of high negative manpower condition levels and limited use of VCBs/OCBs. The division's management interviewed by the study team attributed the division's ability to work at these levels to the efficient handling of open tripper work. It was further explained that selected work was being withheld from the markup to be worked on overtime by regular operators. While it was not possible to review the daily markup and dispatching records for the week under examination, study team analysis and discussions with the division's management suggest that following considerations contributed to the division's effective dispatching of work assignments at the high negative manpower condition levels.

- o Open biddable trippers were not out of balance by between twelve and fourteen in the a.m. Open non-biddable trippers were out of balance by approximately fourteen in the p.m. For manpower planning purposes, it would be assumed that between 26 and 28 operators were required for these open biddable and non-biddable trippers. By combining the open a.m. biddable trippers with the open p.m. non-biddable trippers into daily work assignments, actual manpower requirements could be reduced by twelve to fourteen operators. Alternatively, by withholding any of the open a.m. biddable trippers or p.m. non-biddable trippers from the markup (permitted only for the p.m. trippers by written UTU contract provisions as already noted) and then assigning them to regular or extra board operators as additional work, actual manpower requirements could be reduced further by up to a maximum of 26-28 operators per day.

- o Division 1 manpower requirements for the week were based on 32 report assignments for each weekday, Monday through Friday. The division's management indicated that a maximum of 23 report assignments would be adequate to protect against unanticipated missouts and operator absences. By marking up only 23 report assignments, actual manpower requirements could be reduced by nine operators per day in comparison to projected requirements.

4.2 BUS OPERATIONS WITH NEGATIVE MANPOWER CONDITION LEVELS

A three-step model to describe the methods and procedures used by District's operating divisions at negative manpower condition levels has been developed based on the study team's findings and conclusions. The three-step model is summarized in Table 4-1. It incorporates seven separate methods that dispatching personnel may utilize when the actual number of operators available falls below the projected operator requirements for the following day. Specifically, the methods included in the model are as follows:

- Using operators for VCB/OCB work on their days off;
- Reducing the number of report assignments;
- Combining open biddable and non-biddable trippers to minimize operator requirements;
- Service cancellations;
- Withholding open a.m. biddable trippers from the markup so that this work can be assigned to regular run operators;
- Withholding open regular runs from the markup so that these runs can be assigned to operators as OCB work; and
- Using operators after missing out.

Violates UTU Contract

These methods address the operator shortage condition by increasing the number of operators available, by maximizing the work for available operators, or by lowering actual operator requirements. Each of these methods is discussed in the following sections.

4.2.1 Use of VCB/OCB Operators

The District is permitted to use operators for work on their day off when additional operators are required to ensure that operating schedules are maintained. As already discussed, operators may volunteer for days off work (referred to as VCB work) or be required by the District to work on their days off (referred to as OCB work). In step I of the model, only a limited number of VCB/OCB operators should be required to maintain adequate operator staffing levels. At the smaller negative manpower condition levels characterizing step I operations, it should be possible to make up for the projected operator shortages without employing more than a few VCBs/OCBs per day. In step II of the model, the number of extra board operators are generally working at least one day off per week and regular operators requesting VCB work are being used to the maximum extent possible. As the operator shortage increases to step III conditions, the number of VCB/OCB operators will be increased until extra board operators are working on both their days off per week and regular operators are being used as much as possible for VCB/OCB work.

Steps in Operator Dispatching Under Negative Manpower Conditions

	Step I	Step II	Step III
Manpower Condition (Average division for one day)	0 to -15	-10 to -40	Over -35
Approximate Operator/ Assignment Ratio	Greater than 1.27	1.20-1.30	Less than 1.23
VCS/OCSs	May be used at times but should not exceed 100 per week systemwide.(a)	10-15 per day; up to 700-800 systemwide per week	15+ per day
Reduced Report Assignments	Some	Yes	Less than average number of missouts and unanticipated absences
Combining Biddable and Non-biddable Trippers	Yes	Yes, with regular runs where possible	Yes
Service Cancellations (lates and missed pullouts)	Less than 50 per week systemwide	Up to 100+ per week systemwide	Increasing
Withhold a.m. Trippers from Markup	Occasionally	Yes	As many as possible
Withhold regular runs from Markup	No	Occasionally	Yes, up to 5-10 per day

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

RTD

Subtask: Table 4-1
Subject:
Date:
Page 2 of 2
Preparer:

	Step I	Step II	Step III
Use Operators After Missing Out	Occasionally	Some, up to 3 per day	As many as possible
Operator sick days and missouts	No change	Probably unchanged in the short run.	Increasing; [illegible] missing out.

NOTES: (a) Data analysis suggests that vcs/ccss may be used at this step instead of using other available methods.

Southern California Rapid Transit District, 425 South Main Street, Los Angeles, CA 90013

The use of operators for VCB/OCB work may result in significant operating cost reductions for the District. Additional unscheduled overtime pay costs will be incurred from the VCB/OCB work. On the other hand, operator fringe benefit and unscheduled guarantee or report time pay costs will be reduced for the District. However, there are limits to the amount of VCB/OCB work that is possible and, if increased VCB/OCB work results in significantly higher operator sick leave and related costs, to the amount of VCB/OCB work that serves to minimize District operating costs.

The District's agreement with the UTU specifies how extra board and regular operators may be used for work on their days off. Certain provisions serve to limit the amount of VCB/OCB work that may be scheduled, and also result in most VCB/OCB work being assigned to extra board operators. When additional operators are needed, operators must be called for work in the following order:

1. Extra board operators volunteering for work on one or both of their bid days off.

2. Regular operators volunteering for work on one or both of their bid days off, subject to rest and qualifications.

3. Extra board operators <u>not</u> volunteering for days off work.

4. Regular operators <u>not</u> volunteering for days off work.

We are experiencing this now!

Since the number of regular operators volunteering for days off work is often limited and regular operators are restricted by rest and qualifications requirements for VCB/OCB work, the order of calling results in extra board operators being used for VCB/OCB work up to working both of their days off in a week. In the short run, working both days off in a week may be acceptable but this amount of VCB/OCB work could not be maintained for extended time periods. At division 9 which was experiencing large operator shortages in April, it was noted that large numbers of OCB operators were calling in sick and missing out, particularly for OCB work on Saturdays and Sundays.

The use of regular operators for VCB/OCB work is restricted by rest and qualifications requirements. When called for VCB/OCB work, extra board operators are assigned work according to their position on the extra board. Regular operators called for VCB/OCB work are assigned work according to the bottom positions on the extra board, typically meaning work assignments starting in the afternoon or later. For many regular operators, this can result in there not being enough rest time between the end of the OCB assignment and the start of the regular work assignment on the following day. Additionally, an operator working a VCB/OCB assignment must be qualified for the line or lines operated. Extra board operators must be qualified for all lines operated from a division but regular operators are only required to be qualified for their regular work assignment.

Operators can be effectively employed for VCB/OCB work under negative manpower conditions. Study team investigations are not conclusive concerning the maximum number of VCBs/OCBs that should be employed.

However, it is suggested that limiting days off work for extra board operators to one day per week may represent a significant point in the use of VCBs/OCBs at a division. Above this level, additional VCBs/OCBs may be employed but this is at least partly accomplished by withholding selected work assignments from the markup as OCB work for regular operators. In the proposed model of division operations under negative manpower conditions. the transition from step II to step III operations has been defined to be roughly at the point where days off work for extra board operators is limited to one day per week. Allowing for extra board operators not being available due to sickness and other reasons and for variations in the assignment of days off for extra board operators, it appears that this point corresponds to roughly between 700 and 900 VCBs/OCBs per week for the system.

4.2.2 Reducing Report Operator Requirements

Report assignments are scheduled daily to provide protection against operators not being available for their work assignments after the time when open assignments are recorded for the next day's markup. The number of report assignments is based on the past operating experience of each division, but based on study team investigations, appears to be set at the near worst case level for manpower planning purposes. Therefore, it is possible for a division to mark up a lower number of report assignments in anticipation that worst case conditions will not occur. In step I of the proposed model, it is assumed that report assignments may be reduced by a small number that could vary from day-to-day. When step II is reached, the number of report assignments will be reduced from the worst case to be roughly the same as the average number of operator missouts and unanticipated absences. At step III, only a few report assignments will be possible and service cancellations should be expected to increase unless the number of operator missouts and unanticipated absences is unusually low.

Report operator requirements represent a significant portion of the daily manpower requirements, and the largest portion of the daily requirements which can only be estimated from past experience or as a best guess. Manpower requirements for selected extra work assignments cannot be projected with certainty as well, but these requirements are typically small.

For weekdays in the eight-week time period from week 4 through week 11, the District's projected report operator requirements averaged approximately 290 per day. This represents approximately 9.5 percent of the total number of scheduled work assignments, including tripper combinations dispatched by the District on weekdays. When the ratio of daily report assignments to daily work assignments was calculated for each of the District's operating divisions it was ranging from a low of 0.073 to a high of 0.146. The ratio may be expressed in percentages as ranging from 7.3 percent to 14.6 percent for comparison with the systemwide average of 9.5 percent reported above. For Saturdays and Sundays, the ratios of report assignments to daily work assignments were significantly higher and varied within a wider range from division to division as summarized in the following table.

	Sunday	Monday through Friday	Saturday
Low	0.106	0.073	0.091
Median	0.178	0.097	0.168
High	0.324	0.146	0.355

Note that approximately <u>one-third</u> of the day's work assignments are being protected by report operators for the divisions having the highest ratio of report assignments for Saturdays and Sundays.

It is expected that ratio of report assignments would be higher for Saturdays and Sundays due to the reduced service levels being operated on these days. Further analysis also indicates that the District's smallest divisions (6 and 16) have ratios which are higher than the median ratios for weekdays, Saturdays, and Sundays and that the District's largest divisions (5,7, and 9) have ratios which are consistently lower than the median ratios. For the smallest and largest divisions, these results are as would be expected. Figure 4-10 shows the relationship between the ratio of daily report assignments and the number of daily work assignments being dispatched. The ratio of report assignments increases steeply as the number of daily work assignments being protected is reduced. Note that several points are plotted outside of the shaded area in Figure 4-10. The points falling below the shaded area are for divisions 12, 16, 18 (Sundays only), 6 (weekdays only), 8 (weekdays only), and 15 (weekdays only). Above the shaded area, the points correspond to divisions 1 (weekdays only), 2 (weekdays and Saturday only), 3 (Saturday only), and 15 (Saturday only). Further investigation of the possible reasons for these outlying points should be undertaken by the District in the future.

4.2.2.1 Division 1 Report Operator Requirements

The number of report assignments used for manpower planning purposes at the District's operating division 1 was analyzed for three eight-week periods (weeks 4 through 11 and weeks 16 through 23 of the 26-week study time period, and from the week ending January 11, 1986 through the week ending March 1, 1986). Over-looking small daily variations, the number of report assignments used for manpower planning were as follows.

	Sunday	Monday through Friday	Saturday
Weeks 4-11	17	27	19
Weeks 16-18	18	26	18
Weeks 19-23	10	20	10
January-March, 1986	18	32	19

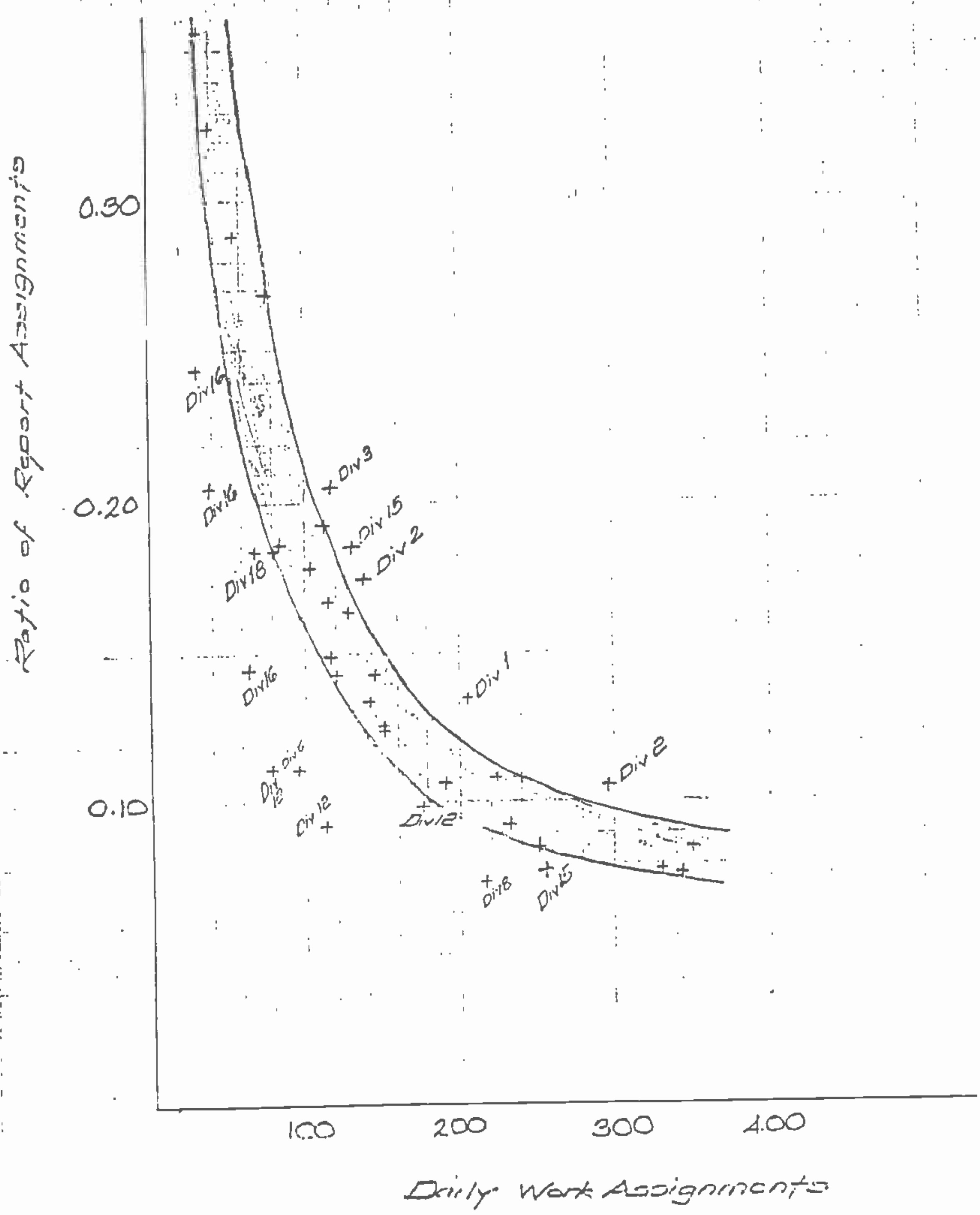
MKTG 9
REV 8/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

Working Notes

RTD

Subtask: Figure 4-10 | Date | Page | of
Subject | Preparer



Southern California Rapid Transit District, 425 South Main Street, Los Angeles, CA 90013

From this table, it is noted that the number of report assignments was significantly reduced in the summer weeks 19 through 23, but then increased again for January-March, 1986. The higher number in January-March, 1986 may be explained by increased service levels introduced following the closing of the District's division 2 in September, 1985. To eliminate differences due to service level changes, the ratio of report assignments to daily work assignments was computed for the three eight-week time periods.

	Sunday	Monday through Friday	Saturday
Weeks 4-11	0.142	0.134	0.124
Weeks 16-18	0.145	0.135	0.120
Weeks 19-23	0.081	0.104	0.067
January-March, 1986[a]	0.186	0.125	0.136

Note: [a]Computed for week ending February 1 through week ending March 1, 1986 only due to schedule changes.

In the preceding section, it was noted that the ratio of report assignments for division 1 weekdays was higher than the range plotted for all divisions. The table shows that division 1 maintained the same ratio for weeks 4-11 and weeks 16-18, and nearly the same ratio in January-March, 1986. For weeks 19-23, the ratio of report assignments was reduced to 0.104 which falls inside the shaded area in Figure 4-10. Division management indicated to the study team in April, 1986 that the division's weekday schedules could be adequately protected by approximately 23 report assignments. For approximately 257 weekday work assignments operated at division 1, this represents a ratio of 0.089 report assignments per work assignment for the weekday schedules. This ratio is approximately the same as employed for weeks 19 through 23 and, if plotted in Figure 4-10, would fall into the range observed for all divisions in this size category.

Report operator requirements should be based on operator attendance characteristics, specifically related to operator missouts and other unanticipated absences which are not known at markup time. In order to investigate the relationship between unanticipated operator absences and report operator requirements, the study team analyzed Daily Event Sheet reports for selected weeks. Table 4-2 summarizes the results of this data analysis. For the weeks analyzed, the number of report assignments used for estimating weekday manpower requirements was 32. As already noted, the division's management indicated that only 23 report assignments would adequately protect against missouts and other unanticipated absences. By comparing the number of report assignments to the data shown in Table 4-2, it may be concluded with caution that report operator requirements appears to roughly correspond with the maximum number of daily missouts and unanticipated operator absences. The data in Table 4-2 also shows that report operator requirements may vary by day of the week, Monday through Friday, as well as for Saturdays and Sundays.

4.2.2.2 Division 9 Report Operator Requirements

An analysis of the number of report assignments was conducted for the District's division 9. At this division, the number of report assignments used for estimating daily manpower requirements were as follows for the weeks analyzed by the study team.

	Sunday	Monday through Friday	Saturday
Weeks 4-11	21	26	20
Weeks 16-18	21	27	20
January-March, 1986[a]	16	23	15

Note: [a]Computed for week ending February 1 through week ending March 1, 1986 only due to schedule changes.

Service levels varied at division 9 from time period to time period, particularly with reduced service levels for the summer weeks (weeks 16 through 23). To adjust for differences due to service level changes, the ratio of report assignments to daily work assignments was calculated for each of the time periods as follow:

	Sunday	Monday through Friday	Saturday
Weeks 4-11	0.165	0.076	0.130
Weeks 16-23	0.188	0.084	0.139
January-March, 1986[a]	0.160	0.066	0.105

Note: [a]Calculated for schedules in effect from week ending February 1 through week ending March 1, 1986 only.

The results are generally consistent for the three time periods. The ratio of report assignments increases in the summer weeks since the number of report assignments was increased by one for weekdays and unchanged for Saturdays and Sundays while service levels were reduced. For January-March, 1986, the ratio of report assignments was lowered, particularly for the division's Saturday operations. In Table 4-3 the number of missouts and other unanticipated operator absences for selected weeks in the January-March, 1986 time period is summarized by day of the week. As for division 1, it may be concluded that the number of report assignments used for manpower planning purposes generally corresponds with the maximum number of missouts and unanticipated operator absences.

TABLE 4-2

UNANTICIPATED OPERATOR ABSENCES
BY DAY OF WEEK FOR OPERATING DIVISION 1

	Average	Low	High
Sunday	13	5	18
Monday	13	10	18
Tuesday	13	6	19
Wednesday	10	4	16
Thursday	10	5	16
Friday	9	5	13
Saturday	15	9	19

TABLE 4-3

UNANTICIPATED OPERATOR RESOURCES
BY DAY OF WEEK FOR OPERATING DIVISION 9

	Average	Low	High
Sunday	17	10	25
Monday	18	11	22
Tuesday	14	10	22
Wednesday	15	8	20
Thursday	12	9	15
Friday	16	13	20
Saturday	13	9	16

4.2.3 Combining Biddable and Non-Biddable Trippers

The methodology for estimating operator requirements for trippers is based on two important assumptions concerning the operation of trippers at the District. First, it is assumed that open biddable and non-biddable trippers are not paired to create work assignments for extra board operators. When estimating daily operator requirements, the highest of the a.m. or p.m. number of open non-biddable trippers is used for determining operator requirements. Where there is a surplus of open p.m. non-biddable trippers and also of open a.m. biddable trippers, it is assumed that the surplus number of open trippers will be worked as tripper/report or report/tripper assignments. The following example illustrates the effect of this assumption.

	a.m.	p.m.
Non-biddable trippers	40	45
Part-time assigned	31	22
Open biddable trippers	14	1
Extra service	4	2
Extra board balance	27	26

For this example, operator requirements would be estimated as (45-22) plus (14+4) equals 41 operators. From the above calculations of extra board balance, the open biddable and non-biddable trippers plus extra service could be operated with only 27 operators.

Second, it is assumed that open biddable and non-biddable trippers will be worked as part of tripper/reports or paired tripper combinations rather than marked up or assigned with regular run assignments. While the latter approach is often taken when there is a manpower shortage condition, operator requirements are based on the assumption that additional manpower is necessary for operating all open biddable and non-biddable trippers.

Depending on the number and other characteristics of open biddable and non-biddable trippers at a division, actual manpower requirements can be significantly reduced by combining open trippers more efficiently than is assumed for estimating the next day's operator requirements. In step I of the proposed model summarized in Table 4-1, the pairing of open biddable trippers with open non-biddable trippers as illustrated in the example may be done to reduce actual operator requirements. As operator shortages in the ranges hypothesized for steps II and III are encountered, the pairing of open biddable and non-biddable trippers with regular runs will be used to reduce actual operator requirements.

The District is able to assign part-time operators to one piece trippers where work hours are between 2.5 and five hours. To generate maximum cost savings with the allowable level of part-time operators, the District analyzes non-biddable tripper combinations to generate a rank ordered list of tripper combinations for part-time operators. The pay hours of each tripper combination is compared based on its being worked by a full-time operator with guarantee and spread premium pay provisions and being worked by part-time operators. The prioritized listing is provided to assist the Transportation Department in determining which non-biddable trippers are assigned for part-time operators.

Based on the cost analysis, part-time operators are assigned to a balanced (or nearly so) number of a.m. and p.m. trippers at each operating division. Consider the following example for a District operating division.

	a.m.	p.m.
Non-biddable trippers	46	55
Part-time assigned	28	28
Open biddable trippers	2	1
Extra service	5	5
Extra board balance	25	33

From this example, note that part-time tripper assignments have been exactly balanced, but that the extra board is not balanced between a.m. and p.m. peak periods. This means that eight full-time operators will work p.m. trippers only resulting in guarantee time being paid for the remainder of the working day for each of these operators. If the number of non-biddable and open biddable trippers were evenly balanced, all full-time operators would be assigned a tripper combination and the assignment of work for part-time operators would not be balanced between the a.m. and p.m. An alternative approach for this example operating division would be as follows.

	a.m.	p.m.
Non-biddable trippers	46	55
Part-time assigned	24	32
Open biddable trippers	2	1
Extra service	5	5
Extra board balance	29	29

Using this approach, four fewer operators are required. Furthermore, the number of pay hours will be significantly lower. In the Phase II final report, it was estimated that actual operator requirements might be reduced by approximately 46 operators (based on October, 1984 operations data) by improving the utilization of part-time operators in this manner.

Also related to the assignment of non-biddable trippers to part-time operators, it is speculated that actual operator requirements might be reduced by making the part-time assignments so that the remaining open non-biddable trippers were of the optimal size and balance between a.m. and p.m. for combining with regular runs. Under severe operator shortage conditions, actual operator requirements may be minimized if it is assumed that all open biddable trippers will be combined with regular runs and that a small surplus of short p.m. non-biddable trippers can also be combined in this manner. In this case, it may be better not to implement part-time assignments so that a.m. and p.m. extra board work is balanced. Consider the example presented above resulting in an unbalanced extra board (25 in the a.m., 33 in the p.m.). If it is assumed that the eight surplus p.m. non-biddable trippers could be withheld from the markup for assignment to regular or extra board operators after completing their days work assignment, actual operator requirements are reduced to 25 from the 29 required for the balanced extra board.

4.2.4 Service Cancellations

The District's operating divisions will cancel service only when all means of operating the service have been exhausted. Based on the study team discussions with division managers, service cancellations are made first for the following types of service where possible:

- Additional service operated under pink letters;
- Service on heavily serviced lines;
- Trippers rather than regular runs;
- Short trippers rather than long trippers; and
- Service operated in the p.m.

Also where possible, contracted service and last trip bus runs will not be cancelled. If it were necessary to cancel one percent of the scheduled work assignments on an average weekday, this would represent an operator shortage of approximately thirty operators systemwide which could not be filled by the various means described in this chapter.

4.2.5 Withholding Open Biddable and Non-Biddable Trippers from Markup

The UTU agreement allows for open trippers signing on after 12:00 noon to be withheld from the markup. When not marked up, the trippers are left open to work by available report operators or by regular or extra board operators after completing their daily work assignments for the following day. When assigned to a regular or extra board operator after completing his or her daily work assignment, the combined day's work must not exceed 11 hours, 40 minutes of work time or ten hours of driving time. It is unlikely that minor variations of either restriction would be easily identified since the operator is volunteering for the additional work and the dispatcher making the assignment needs to fill the open piece of work.

Violates UTU Contract

Written provisions of the UTU agreement do not permit open biddable and non-biddable trippers starting in the a.m. to be withheld from the markup. For high negative manpower condition levels and perhaps from time-to-time at modest negative manpower condition levels, open biddable trippers signing on in the a.m. may be withheld from the markup for assignment on the following day to a regular operator as additional work. Since many regular operators do not work biddable trippers in addition to their regular work runs, selling open trippers in this manner can be an effective approach to lowering the next day's need for VCB/OCB operators. Biddable trippers cannot be bid by an operator for selected days only, but must be worked by the operator on all days that the biddable trippers are scheduled and that the operator works. Operators desiring to work a biddable tripper for selected days only or on an infrequent basis can be employed to fill open biddable trippers. As described above for open p.m. trippers, there should be no violation of the maximum work time or driving time restrictions.

4.2.6 <u>Withholding Regular Runs from Markup</u>

Under severe operator shortage conditions and possibly from time-to-time when only modest negative manpower conditions exist, open regular runs may be withheld from the markup for assignment on the following day to a regular operator as OCB work. Operators may be willing to work on their days off as an OCB if assigned a particular work assignment. In some instances, rest time requirements or operator qualifications may limit the work which can be assigned to an operator as an OCB. By withholding selected work assignments for these operators, daily manpower requirements can be reduced. This approach to assigning OCB work is not in accordance with written provisions of the UTU agreement but is done with the UTU's concurrence.

4.2.7 <u>Using Operators After Missing Out</u>

Operators missing out may be used for work with eight hours pay time guaranteed within a spread of eleven hours. From time-to-time, operators may be used after missing out if there is available work to be filled for the day. Discussions with division management personnel by the study team indicated that operators missing out were often unwilling to work after missing out or would do so only if the missout were not recorded. For eight weeks in January-March, 1986, approximately twenty percent of the operators missing out at both divisions 1 and 9 were subsequently used for assignments after missing out. On the average, this was one operator per day with selected days being as high as three to four operators used after missing out. During this time period, the divisions were working with negative manpower conditions averaging towards the higher end of the step II range.

4.3 ESTIMATING OPERATOR REQUIREMENTS AT A DIVISION

4.3.1 <u>Estimating Assignments</u>

There are two categories of assignments at an operating division -- biddable work and nonbiddable work. Biddable work consists of assignments that are bid on by drivers in each shakeup and form regular assignments for those drivers. Nonbiddable work consists of those assignments that, under current union and District rules are not placed on the bid list at a shakeup and are reserved for assignment to the extraboard. In turn, drivers can bid for regular assignments (by seniority) or can bid to be on the extraboard. Therefore, each division consists of a group of drivers with regular work assignments that do not change from day-to-day, except for weekend work; and a group of drivers assigned to the extraboard who undertake whatever driving is required from the extraboard. As discussed in the following paragraphs, the amount of work on the extraboard varies from day-to-day for a number of reasons.

Operations at a division consist of several different types of work:

- o Regular runs (biddable)
- o Short a.m. trippers (biddable)
- o Long a.m. trippers (nonbiddable)
- o Short p.m. trippers (biddable)

- Long p.m. trippers (nonbiddable)
- Extra work (unscheduled -- nonbiddable)

Under the current union contract, regular runs and short trippers can be combined to form regular assignments that can be bid for by operators at each system shakeup. In addition, operators can bid to be on the extraboard. An attempt is made in scheduling to produce sufficient short trippers to match a substantial proportion of the regular runs, and an attempt is also made to balance open biddable and nonbiddable a.m. trippers and open biddable and nonbiddable p.m. trippers. Open biddable trippers are those short a.m. and p.m. trippers that could not be assigned with a regular run to form a biddable assignment.

4.3.2 Estimating Operator Requirements

To begin to estimate the operator requirements, it is also necessary to understand the meaning of the number that is reported for regular runs in the weekly division reports. On weekdays, the number represents the 5-day equivalent of the number of regular runs for seven days. For example, if a division shows 212 regular runs on a weekday, this number was determined by summing the number of regular runs over a seven-day week, and dividing the result by 5. The difference between the weekday and each of Saturday and Sunday regular runs shows the true difference in regular runs between these days, but the numbers reported for Saturday and Sunday are otherwise meaningless. To see how these values are arrived at, suppose that a division has 160 actual regular runs on a weekday, 150 on Saturday, and 110 on a Sunday. The total runs for a seven-day week are 1060. Dividing this by 5 yields 212, which would be shown as the weekday regular runs. The Saturday runs would then be shown as 202, and the Sunday runs as 162. The reason for using these values for regular runs is that the weekday value represents the appropriate value for determining operator needs at a division, when these are determined from an operator/assignment ratio. Thus, applying an operator/assignment ratio of 1.30 to the 212 regular runs would produce an estimate of 276 operators needed. With each operator working 5 days, this would produce an estimate of 1,380 operator days for the 1,060 total regular runs. Given extraboard requirements, vacations, and unscheduled absences, this is a reasonable number, consistent with an operator/assignment ratio of 1.30.

For example, in the fourth week of the study period, division 1 had 212 regular assignments reported on each weekday, which converts to an actual number of regular runs of 158. The division also had, in that week, an average of 6.6 open biddable a.m. trippers and 2.2 open biddable p.m. trippers each day of the week, an average of 0 pieces of extra work in the morning and 1.6 in the evening, and an average of 36 a.m. and 44 p.m. nonbiddable trippers. The division also had 308 full-time and 42 part-time operators in that week. The part-time operators were split to 25 for a.m. trippers and 17 for p.m. trippers. With this split of part-time operators, there remain 11 a.m. open nonbiddable trippers and 27 p.m. open nonbiddable trippers. Adding these to the remaining open work (open biddable trippers and extra work), there is an average of 17.6 pieces of open a.m. work and 30.8 p.m. pieces of work. Rounding each of these numbers up indicates that there are 18 pieces of a.m. work and 31 pieces of p.m. work on the extraboard during this week.

If there were no absences, the number of operators could be calculated quite simply from these numbers, together with the appropriate numbers for Saturday and Sunday. Assuming all part-time operators show up each day, then the figures of 158 regular assignments, and 18 a.m. and 31 p.m. pieces of extraboard work define the weekday situation. This would indicate that 158 full-time operators would be required to operate the weekday runs, and there would be a need for 31 extraboard operators, 13 of whom would have only a p.m. tripper to operate.

There is also a need to provide operators for Saturdays and Sundays. Consulting the same week, there are 5 fewer regular runs on Saturday than on a weekday, and 39 fewer on Sunday, giving values of 153 and 119 regular runs respectively. Part-time operators were not used on weekends at this time, and the extraboard assignments total 8 a.m. and 5 p.m. on Saturday, and 11 a.m. and 12 p.m. on Sunday. Using the highest of the a.m. and p.m. values on each day, there would be a need for 8 extraboard operators on Saturday and 12 on Sunday, and these would generate a total of 1,237 operator-day requirements for the week. Given that each operator works a five-day week, this would require 248 full-time operators to be assigned to the division for that week. Of these, 35 would be assigned to the extraboard, with 4 having a day off each weekday. The remaining 213 would be assigned to regular runs with an average of 55 having a day off on each weekday, 60 on Saturday, and 94 on Sunday.

A smaller extraboard may be appropriate, using VCBs/OCBs to complete the balance of assignments that exceed the staffing of the extraboard. Depending on the specific schedule of the extraboard work, an optimal allocation of the extraboard between assigned operators and VCBs/OCBs could be made. This would be based on the actual costs determined from pairing the morning and evening trippers, and considering guarantee times, spreads, and rates to be paid.

There will be a scheduled absence for vacations for each operator. Assuming that operators are required to spread their vacations uniformly throughout the year, and given the Division 1 average of 0.332 days per operator per week, the average number of days worked by an operator per week should be set at 4.668 instead of 5. Operators will also take unscheduled absences for sick leave, requests off, missouts, and other absences. The relationships developed in chapters 2 and 3 could be used to provide average estimates of the numbers of days off for unscheduled absence, and a range can also be set on these estimates, using the regression standard errors. The three relationships of interest here are those for missouts, sick days off, and requests off. For Division 1, no relationship was found for missouts, so the systemwide equation may be substituted for a Division 1 relationship. In addition, the equations of interest contain the independent variables of vacations days off per operator, operator/assignment ratio, and VCBs/OCBs. The vacation days off average for Division 1 of 0.332 per operator can be used. The operator/assignment ratio determined from vacation days and regular days off, after adding in the part-time operators and assignments, is 1.08, and this can be used initially, with a subsequent re-estimation to determine the impact of the allowances for unscheduled absence. Because a cost analysis has not been undertaken, VCBs/OCBs can be estimated from the equation for Division 1 that estimated VCBs/OCBs as a function of vacation days off. Using these, the relationships are:

VCBs/OCBs = 1.05*Vacation Days Off - 0.148 (s.e. = 0.103)

Lagged Missouts = -0.133*Operator/Assignment + 0.226 (s.e. = 0.0054)

Sick Days = 0.314*VCBs/OCBs + 0.389 (s.e. = 0.0667)

Requests Off = - 0.320*Vacation Days Off + 0.231 (s.e. = 0.0379)

Applying these equations, the estimates are as follows:

VCBs/OCBs per Assignment = 0.201

Missouts per Operator = 0.082

Sick Days per Operator = 0.452

Requests Off per Operator = 0.125

TOTAL UNSCHEDULED ABSENCE = 0.659

Total unscheduled absences per operator per week are therefore 0.659 and the 95 percent confidence bounds on this estimate are +0.151. In total, this procedure suggests that each operator will work five days per week, less vacations, and less unscheduled absences, or 4.009 days per week in Division 1 (= 5 - 0.332 - 0.659). To estimate the operator requirements allowing for scheduled and unscheduled absences, the 1237 assignments should be divided by 4.009, which yields an operator requirement of 309 operators.

Without counting absences, it was previously estimated that the requirement would be for 213 operators with regular assignments and 35 extraboard operators. The estimation of absence does not change the number of operators with regular assignments, because all of the vacation and unscheduled absence needs to be covered on the extraboard. Therefore, this estimate of the total operator requirements indicates 213 operators with regular assignments, 96 extraboard operators, and 42 part-time operators working the nonbiddable trippers. Applying the confidence range to the unscheduled absence would indicate that the extraboard requirement should lie between 84 and 108.

First, returning to the missouts that are estimated from the operator/assignment ratio, if all absence were covered from the extraboard, a re-estimate would produce a decrease in the missouts to 0.058, reducing total absence to 0.635 and an average estimate of 94 extraboard operators. This change is much smaller than the confidence range on the estimate and can be ignored safely. Second, the equation for the VCBs/OCBs suggests that, under current practice, the VCBs/OCBs should be set at 43 per week. Assuming that this is the average number of VCBs/OCBs and that the variance in the estimate is accounted for by the VCBs/OCBs, the actual extraboard required for Division 1 in this week would be about 84, and the VCBs/OCBs would range between 0 and 23. Adding in the part-time operators and the biddable and nonbiddable tripper assignments as normally calculated, the total number of assignments operated by the division in the fourth week of the study period is 264.2, and the total number of fte operators would be 318. This produces an operator/assignment ratio of 1.20. The actual number of operators on payroll that week was 308 full-time and 42 part-time, for a total of 329 fte operators, generating an actual operator/assignment ratio of 1.245. No VCBs/OCBs were called, which tends to confirm that the division was probably overstaffed in that week.

In this analysis, the only additional computation required is the extraboard requirements generated by absences of part-time operators. For part-time operators, the only categories of absence are sickness and missouts. On average, these absence categories would add about 5 nonbiddable trippers to the extraboard on each day, with 3 in the a.m. and 2 in the p.m. Because the p.m. trippers are the maximum on weekdays, this would add about 2 more operators to the total for the extraboard. Assuming that these were split equally between VCBs/OCBs and extraboard drivers, the picture would change very slightly to 85 extraboard operators, and a total staffing of 319 fte operators, and an operator/assignment ratio of 1.21. All other absence categories (military leave, suspensions, other positions, and instruction) total around .05 per operator per day, with a variation that is unlikely to be explained easily by a relationship to measures such as operator/assignment ratios and vacation days. Applying this simply as a constant adjustment, the average days worked by an operator per week should be adjusted to 3.959, which would add a further 3 extraboard operators per day. Therefore, total staffing should be 322 fte operators and the operator/assignment ratio should be 1.22.

This same analysis could be applied to each week of operation of Division 1 and could also be applied to other divisions. To apply it to Division 1, it is necessary to know the actual numbers of regular assignments for each week, the number of biddable and nonbiddable trippers, and to make an assumption about the use of part-time operators. The actual number of vacation days off scheduled for the week is also needed, or the average for the period can be used. To apply the methodology to other divisions requires the same input information and also separate equations for each division that relate the unscheduled absence categories to each of the independent variables.

Before leaving this example, it is appropriate to note the insensitivity of the operator/assignment ratio, caused by the definition of assignments. Suppose, for example, that the part-time operators were split equally between the a.m. and p.m. periods. In that case, there would be 21 nonbiddable trippers assigned from each of the a.m. and p.m. There would now be 15 and 23 open nonbiddable trippers in the a.m. and p.m., respectively. With no change in the other open work and extra work, there would be 24 and 25 pieces of open work in the a.m. and p.m., respectively, and the number of weekly assignments would decrease from 1237 to 1207. As currently operated, the total daily assignments used in computing the operator/assignment ratio would not change, so the operator/assignment ratio itself would not change. However, the above computations would indicate that the number of operators required should decrease by 8, reducing the extraboard from 89 to 81. The operator/assignment ratio that should be applied to the Division would now be 1.19. This comes about with no change in the assignments and no change in the use of VCBs/OCBs. It should also be noted that the definition of assignments is dependent on the number of biddable trippers that can be added to regular runs to form regular assignments, and the balance that is achieved between a.m. and p.m. open biddable trippers.

Equations were also estimated for late and cancelled pullouts, and for report hours. For Division 1, late and cancelled pullouts are estimated only from vacation days off, which has been assumed not to vary and is unaffected by the allocation of operators. Estimating the report hours from the VCBs/OCBs, however, indicates that the allocation of operators developed in this exercise for Division 1 would generate about 410 report hours for the week. This is significantly lower than the number of report hours recorded at Division 1 in the weeks when the assignments were at the level used in this example. During that period, report hours averaged over 550 per week.

4.3.3 Conclusions

The following conclusions and recommendations can be made:

1. The operator/assignment ratio is not necessarily an effective measure of productivity that should be applied as a goal for a division to achieve.

2. The number of operators required to operate a division can be determined from the run cuts, and from information on vacation days off at a division and the use and number of part-time operators.

3. An optimal policy on the use of VCBs/OCBs can be determined from an analysis of the costs of VCBs/OCBs and extraboard operators. The determination of the optimal use of VCBs/OCBs can then be used to modify the estimate of the extraboard staffing determined in 2, above.

4. It is recommended that further analysis be undertaken to determine the optimal use of VCBs/OCBs versus staffing the extraboard with full-time operators, based on the relative costs and the variability in the extraboard requirements.

5. It is recommended that new data be collected for each division in the District that are carefully controlled for accuracy. These data should be used to develop improved relationships for unscheduled overtime and unscheduled absence with respect to such measures as vacation days off, number of regular runs, and number of extraboard assignments. These relationships should replace the current ones that use VCBs/OCBs and the operator/assignment ratio.

6. It is recommended that the methodology developed here be applied to operations at each Division of the District to estimate the number of operators required for each new service profile, using

a microcomputer model to calculate the requirements for operators and that such calculations be undertaken each time there is to be a shake-up, or between-shake-up service change. This will provide the operator planning capability for periods of up to six months that was identified as being needed in Phase II of this study.

5. CONCLUSIONS

5.1 INTRODUCTION

The conclusions are presented in two parts. First, conclusions are summarized from the analyses reported in each of chapters 2, 3, and 4, with the emphasis on conclusions from chapters 2 and 3 that relate to a comparison of systemwide results to individual divisions. Second, conclusions and recommendations of a broader nature are presented, derived from a consideration of the entire analysis reported in this Phase, together with the work conducted in Phases I and II of this project.

5.2 DETAILED CONCLUSIONS

5.2.1 Systemwide Data Analysis

During the six-month period selected for analysis in Phase III of the study, the systemwide operator/assignment ratio ranged from a low of 1.24 to a high of 1.32. For nearly all of the 26 weeks, the operator/assignment ratio was below 1.30 and, for 18 of the 26 weeks, the ratio was below 1.27. In response to this range of operator availability, the variables of interest to the study were observed to vary as follows:

- o VCBs/OCBs -- 339 to 886
- o shineouts -- 7 to 34
- o missed/late pullouts -- 210 to 307
- o shine hours -- 5,039 to 7,255
- o unscheduled overtime hours -- 3,813 to 7,800

In general, it may be concluded that each of these variables responded to changes in the operator/assignment ratio in the expected manner. VCBs/OCBs generally decreased as the operator/assignment ratio increased; shineouts and report hours increasing as the operator/assignment ratio increases; missed and late pullouts decreasing as the operator/assignment ratio increases; and unscheduled overtime hours increasing as the operator/assignment ratio increases. Statistical models describing the response of the variables to changes in the operator/assignment ratio were successfully developed with reasonable levels of confidence being achieved, as described below.

5.2.1.1 Absenteeism

For the study period, operator absenteeism rates did not change significantly as the operator-to -assignment ratio decreased. There is no evidence based on data for the 26 weeks examined in this study that operator absenteeism does increase in the hypothesized manner.

5.2.1.2 VCBs/OCBs

For the 26-week study time period, the number of VCBs/OCBs per week ranged from 339 to 886. In this range, stable bus operations can be maintained as confirmed by the District's actual operating experience for the 26-week time period. It is believed that exceeding 700-900 VCBs/OCBs per week for extended time periods (exceeding 2-3 weeks in length) may result in reduced service reliability and instability.

For example, the study team visited the District's operating division 9 in April 1986. At this time, the division was operating under severe operator shortage conditions at operator/assignment ratios lower than 1.20. Extraboard operators were being required to work as many days as possible. Under these conditions, service cancellations were unavoidable at times. Perhaps the most convincing indicator of the conditions and of its increasing likelihood of deterioration was found in the high number of OCB operators missing out and calling in sick.

5.2.1.3 Union Contract Revision

Under the current operator's union contract, OCB work must be assigned to extraboard operators for both of their days off per week before it can be assigned to regular operators. At a systemwide level of 700-900 VCBs/OCBs, it appears that most extraboard operators would be working one and occasionally both off days per week. Data analysis for selected weeks suggests that the use of extraboard operators for days off work is limited to roughly one day per week where possible. If more OCB work is required, division dispatchers must use extraboard operators for their second day off or employ techniques not permitted by the written union contract in order to use regular operators for additional work. Requiring extraboard operators to work on their second day off may lead to decreased service reliability and increased instability in the availability of operators.

It is suggested that the District consider revising its contract with the operator's union to permit regular operators to be used for additional work when necessary. In making this suggestion, it is recognized that the District may be placed in the position of asking the union for a change when, in fact, the change is being applied in practice under operator shortage conditions.

5.2.1.4 Statistical Relationships

It has been demonstrated clearly that there is strong statistical evidence to suggest a relationship between various measures of unscheduled overtime and measures of scheduled absence (vacation days) and the manpower condition (operator/assignment ratio); and between measures of unscheduled absence and the same measures of scheduled absence and manpower condition. The evidence from the trend plots and the statistical and regression analysis show the following general conclusions for systemwide data:

1. The use of VCBs/OCBs can be predicted from the Operator/Assignment Ratio;

2. Missed and Cancelled Pullouts can be predicted from the Operator/Assignment Ratio;

3. Report Hours can be predicted from Vacation Days Off and the Operator/Assignment Ratio together;

4. Missouts can be predicted from the Operator/Assignment Ratio, but

follow from changes in the ratio by a lag of about two weeks;

5. Sick Days Off can be predicted from the Vacation Days Off, with a small additional explanation from the Operator/Assignment Ratio;

6. Requests Off can be predicted from the Vacation Days Off;

7. Other Positions cannot be predicted reliably from any of the variables of manpower condition and scheduled absence;

8. There is no evidence that unscheduled absences rise significantly following a decrease in the Operator/Assignment Ratio, or drop significantly following an increase in the Operator/Assignment Ratio.

Overall, these conclusions lead to a further conclusion that there is no evidence to support, on a systemwide basis, the supposition that a reduction in the Operator/Assignment Ratio by an amount of about 2 to 3 percent results in an increase in unscheduled absence.

5.2.2 Comparison of Systemwide and Divisional Analyses

It is useful, first, to review the differences and similarities between the two divisions (1 and 9) and the system as a whole. A summary of some relevant statistics is provided in Table 5-1. These data indicate that Division 1 is operating on a fairly tight manpower situation, with the operator/assignment ratio averaging below the systemwide figure; while Division 9 appears to have surplus manpower with an operator/assignment ratio averaging near 1.30. Both divisions show higher than average absences for vacation and sick days. Division 1 shows about double the rate of shineouts for the system, and Division 9 shows about half of the system average. Division 1 is near to the system average in regular runs, full-time operators, and part-time operators; and Division 1 is lower than the system average for open biddable trippers and extra work. The peak-to-base ratio at Division 1 is slightly higher than the average, and there are almost double the number of open biddable trippers.

Division 9 has about 50 percent more regular runs, full-time operators, and part-time operators than the system average; and Division 9 has double the open biddable trippers, open nonbiddable trippers, and extra work than the system average. The peak-to-base ratio at Division 9 is also substantially higher than the system average, and is nearly 2, indicating a large volume of tripper activity at this division.

In comparing the results of the analysis between the systemwide data and the two divisions, a number of conclusions can be drawn.

1. Division 9, with a significantly higher operator/assignment ratio than the systemwide average, shows some degree of similarity in the relationships of unscheduled overtime and unscheduled absence to the systemwide average data.

2. Division 1, with a significantly lower operator/assignment ratio than the entire District, shows marked differences in

relationships both from Division 9 and from the systemwide data.

3. At the Division level, it does not appear to be possible to predict either shineouts per assignment or missouts per operator, although missouts were found to be predictable at a system level.

It is concluded that the operator/assignment ratio should vary by operating division. Phase II of the study made the same conclusion based on differences in the average number of days absent for the District's operating divisions. In this phase of the study, analysis results indicate that unscheduled absence measures respond in significantly different ways to manpower conditions in an operating division, but no specific recommendations can be made with respect to underlying relationships or methods of control. It was also determined that report operator requirements vary significantly from division to division. Specifically, report operator requirements, expressed as the fraction or percentage of report operators to number of daily work assignments, decrease as the number of daily work assignments increase. Assuming that report operator requirements are being correctly determined, the differences in report operator requirements mean that varying operator/assignment ratios should be employed.

The study identified seven methods that District dispatchers may employ under operator shortage conditions to ensure that all services are operated. Specifically, the methods available are as follows :

- Using operators for VCB/OCB work on their days off;
- Reducing the number of report assignments;
- Combining open biddable and nonbiddable trippers to minimize operator requirements;
- Service cancellations;
- Withholding open a.m. biddable trippers from the markup so that this work can be assigned to regular run operators;
- Withholding open regular runs from the markup so that these runs can be assigned to operators as CCB work; and
- Using operators after missing out.

TABLE 5-1

COMPARISON OF SOME RELEVANT STATISTICS FOR DIVISIONS 1 AND 9 AND THE SYSTEM

STATISTIC	DIVISION 1	DIVISION 9	SYSTEMWIDE	DIVISION AVERAGE
Operator/Assignment Ratio	1.264	1.297	1.271	1.271
Vacation Days/Operator	0.332	0.317	0.253	0.253
Sick Days /Operator	0.452	0.487	0.419	0.419
Shineouts/Assignment	0.009	0.002	0.005	0.005
Regular Runs per day	214.5	295.0	2808.3	200.6
Open Biddable Trippers	6.[illegible]	7.70	47.2	3.37
Open Nonbiddable Trippers	88.8	227.5	1728	123.4
Full-Time Operators	309.8	472.5	4198.2	299.9
Part-Time Operators	47.4	75.3	594.1	42.4
Extra Work	1.74	5.51	34.2	2.44
Peak-to-Base Ratio	1.689	1.912	1.667	1.667

These methods address the operator shortage condition by increasing the number of operators available, by maximizing the work for available operators, or by lowering actual operator requirements.

Depending on the characteristics of the service operated at a division and other factors, dispatchers may elect to employ the available methods in different ways and at different times. Study results are not conclusive concerning the factors involved in determining what methods are used, but it may be concluded with certainty that differences in applying the available methods from division to division may make statistical comparisons between operating divisions difficult or impossible. In other words, statistical models developed using systemwide data or data for one operating division may not be applicable for describing the operation of another operating division under varying manpower conditions levels.

5.2.3 Optimal Determination of the Manpower Supply for a Division

It is apparent from the analyses and the results of the field visits to two Divisions that the operator/assignment ratio is not a good measure to use for setting optimal manpower levels either systemwide or within a division. Division 1 illustrates this quite clearly. Based on the operator/assignment ratio calculated for Division 1, this division should be experiencing a manpower shortage throughout the analysis period. In turn, this should generate strong relationships between the operator/assignment ratio and each of the measures of unscheduled overtime. However, the statistical and trend-plot analyses demonstrated clearly that the unscheduled overtime measures were dependent primarily on vacation days off -- a result that would be consistent with an oversupply of operators rather than an undersupply. The explanation for this unexpected result lies at least in part in the type of service profile in Division 1. In this division, the peak-to-base ratio is about average, the amount of extra work is well below the system average, as is the average number of open nonbiddable trippers. This indicates that the extraboard at Division 1 will likely be smaller than at most other divisions, and certainly much smaller than Division 9, where the extra work and open nonbiddable trippers are more than double the system average, and the peak-to-base ratio is substantially higher.

In Division 1, then, it seems likely that the operator/assignment ratio could be set much lower, because there is a small extraboard. The number of extraboard operators is apparently sufficient not only to cover the extraboard work that arises from trippers and extra work, but also some of the extraboard work that arises from unscheduled absence. Thus, there is less need for the dispatcher to call VCBs and OCBs, unless the number of regular operators on vacation is high, so that both the extraboard is increased and the number of available extraboard drivers is reduced.

As shown by the analysis in Section 4.3, the following conclusions and recommendations can be made on the determination of operator requirements and the use of the operator/assignment ratio:

1. The operator/assignment ratio is not necessarily an effective measure of productivity that should be applied as a goal for a division to achieve.

2. The number of operators required to operate a division can be determined from the run cuts, and from information on vacation days off at a division and the use and number of part-time operators.

3. An optimal policy on the use of VCBs/OCBs can be determined from an analysis of the costs of VCBs/OCBs and extraboard operators. The determination of the optimal use of VCBs/OCBs can then be used to modify the estimate of the extraboard staffing determined in 2, above.

4. It is recommended that further analysis be undertaken to determine the optimal use of VCBs/OCBs versus staffing the extraboard with full-time operators, based on the relative costs and the variability in the extraboard requirements.

5. It is recommended that new data be collected for each division in the District that are carefully controlled for accuracy. These data should be used to develop improved relationships for unscheduled overtime and unscheduled absence with respect to such measures as vacation days off, number of regular runs, and number of extraboard assignments. These relationships should replace the current ones that use VCBs/OCBs and the operator/assignment ratio.

6. It is recommended that the methodology developed here be applied to operations at each Division of the District to estimate the number of operators required for each new service profile, using a microcomputer model to calculate the requirements for operators and that such calculations be undertaken each time there is to be a shake-up, or between-shake-up service change. This will provide the operator planning capability for periods of up to six months that was identified as being needed in Phase II of this study.