Review of the Use of Part-Time Transit Operators and Methods for Assigning Part-Time Work

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ABSTRACT

The use of part-time transit operators is a subject of increasing attention as a means of controlling labor costs and improving transit productivity. Part-time operators can significantly reduce the cost of providing peak-period service because they are subject to less restrictive work rules than are their full-time counterparts: they typically receive no spread or overtime premiums, they almost always receive lower fringe benefits, and they may earn lower wages. Three of four labor contracts permit the use of part-time operators, and one of every twenty operators nationwide is a part-timer. A national perspective on the range and norms of contractual provisions affecting the use of part-time operators is offered. The methodologies used by three transit agencies to assign part-time operators on the basis of existing run cuts, in accordance with the different work rules that govern the use of part-timers at each agency, are presented. The methodologies used by two systems to incorporate part-time operators into automated run-cutting procedures are also presented.

Productivity in the transit industry has become a subject of increasing attention as capital and operating costs have risen and fare-box recovery ratios have fallen in recent years. Transportation wages and fringe benefits account for nearly half of total operating costs. Transportation salaries and wages accounted for 32 percent, and fringe benefits another 13 percent, of total 1980 transit operating expenses according to the American Public Transit Association (1). It is logical, therefore, to focus on controlling labor costs in the effort to improve transit productivity.

Operator labor costs are significantly affected by the work rule provisions that are a fundamental part of all operator-management contracts (2). These work rules were formulated in response to the peaked nature of transit demand. Approximately two-thirds of all daily transit passengers are carried during the morning and late afternoon commuter peak periods. Less than half this number of passengers is carried in the early morning, midday, and late evening periods.

The numbers of vehicles (including spares) and operators (including absence and vacation extras) are determined by peak-period passenger demand. Twice as many operators are needed in the two peak periods as in the base period. The additional operators can be provided in three ways: (a) by assigning regular operators to split runs that include both a morning and an afternoon shift and a break in between; (b) by assigning extraboard operators to short tripper assignments; or (c) by working short trippers on an overtime basis. Each approach can be costly, involving spread premiums, unproductive guarantee pay, or overtime pay.

The use of part-time operators (PTOs) can significantly reduce the cost of providing peak-period service, thereby improving labor productivity, for the following reasons:

1. PTOs are subject to less restrictive work rules than are their full-time operator (FTO) counterparts. In nearly eight of every ten transit systems, PTOs receive no guarantee pay per assignment. The median guarantee at transit systems that have one is only 2 hr per assignment, compared to a guarantee of 8 hr for FTOs.
2. PTOs typically receive no spread or overtime premiums. However, they may be subject to a maximum spread time, or effectively restricted to working only single trippers, by daily or weekly work hour limitations.
3. PTOs almost always receive lower fringe benefits than do FTOs. A transit system can save on both fixed and variable fringe benefit costs if a PTO obviates the need to hire an additional FTO.
4. PTOs earn lower wages than FTOs at two of every ten systems permitted to use PTOs.

The use of PTOs has become widespread in systems of all sizes in all regions of the nation. Three of four systems are currently permitted to use PTOs, and one of every twenty operators nationwide is a PTO.

The Urban Mass Transportation Administration (UMTA) of the U.S. Department of Transportation undertook a study in June 1984 to (a) examine the extent to which PTOs are currently used in the U.S. transit industry and (b) identify methods currently used to assign PTOs to work assignments.

The findings of that study are presented in this paper. First, a national perspective on the range and norms of contractual provisions affecting the use of PTOs is presented. Second, current methodologies used to assign PTOs work is presented. Three methods are described for assigning work on the basis of existing run cuts and two methods are presented that are used to incorporate PTOs into automated run-cutting procedures. In the third and final section the major conclusions of the study are summarized.

NATIONAL PERSPECTIVE ON THE EXTENT OF PART-TIME OPERATOR USE

An analysis of the Comparative Labor Practices Reports 3 (Number of Employees by Type) and 5 (Part-

Time Operators) compiled by the American Public Transit Association (APTA) and telephone interviews and site visits conducted as part of this study indicate that the use of PTOs is widespread, in systems of all sizes in all regions of the nation. Three of four labor contracts permit the use of PTOs, and one of every ten operators at these systems is a PTO. The typical PTO (a) is a union member, (b) is paid at or near the FTO wage scale, (c) is permitted to work a maximum of 25 to 30 hr per week, (d) receives no guarantee per assignment or premium pay, and (e) receives reduced fringe benefits compared to FTOs. PTO seniority is generally not transferable to FTO status. About half of the sample agencies require that all PTOs be laid off before any FTOs are laid off.

These findings were developed through a statistical analysis of the data assembled for 228 transit agencies in the United States. The transit systems in the sample ranged in size from agencies with fewer than 10 employees to the largest system in the country, the New York City Transit Authority, that has more than 10,000 employees. Summary numbers were computed for the major labor practices regarding PTO use. Chi-square tests were made to determine if there were differences in practices by system size or geographic region. A value of 95 percent (i.e., probability of chance = 0.05) was used as the confidence level in these tests.

System size was frequently found to be a significant variable in the chi-square tests of PTO labor practices. Labor practices in small systems (50 or fewer employees) are less restrictive regarding the use of PTOs than are those in large systems (more than 50 employees). This suggests that the labor-management climates in small and large systems may be different with respect to PTOs.

Use of PTOs

One hundred seventy-six or 77 percent of the transit agencies in the sample are permitted to use PTOs. The ability to use PTOs is statistically related to the size (measured in terms of number of FTOs employed) of the system. As the data in Tables 1 and 2 indicate, a higher percentage of systems with fewer than 50 employees than of systems with more than 50 employees is permitted to use PTOs. This may suggest that FTOs in small transit systems feel less threatened by PTOs than do their counterparts in large systems.

A statistical relationship was also found between the ability to use PTOs and geographic location. The transit systems in the APTA reports were coded by UMTA federal region and grouped into five geographic areas (see Table 2). Between 85 and 95 percent of the transit systems in the west (i.e., midwest, southwest, and west) are permitted to use PTOs compared to 60 percent of the systems in the east (i.e., northeast and southeast). This regional relationship may reflect historic differences in the relative power of management and labor in contract negotiations.

Number of PTOs

The 176 systems permitted to use PTOs employ a total of 42,173 FTOs and 4,402 PTOs. This number of PTOs is equivalent to 10.44 percent of the number of FTOs, or 9.45 percent of the total operator work force. Therefore, nearly one of every ten operators at systems permitted to use PTOs is a PTO.

The number of PTOs that can be hired is often limited in the labor contract. Almost half of the

TABLE 1 Use of Part-Time Operators by System Size

Number of Employees	Systems in Sample		Systems Permitted PTOs		Systems Not Permitted PTOs	
	Number	Percentage	Number	Percentage of System Employee Class	Number	Percentage of Employee Class
0-25	51	22.4	47	92.2	4	7.8
26-50	42	18.4	34	81.0	8	19.0
51-100	44	19.3	30	68.2	14	31.8
101-250	37	16.2	29	78.4	8	21.6
251-500	18	7.9	12	66.7	6	33.3
501-1,000	14	6.1	10	71.4	4	28.6
More than 1,000	22	9.6	14	63.6	8	36.4
Total	228	100.0	176	77.2	52	22.8

Note: Chi-square = 12.59, degrees of freedom = 6, and probability of chance = 0.05.

TABLE 2 Use of Part-Time Operators by Geographic Location

Location	UMTA Region(s)	Systems in Sample		Systems Permitted PTOs		Systems not Permitted PTOs	
		Number	Percentage	Number	Percentage of Systems in Region	Number	Percentage of Systems in Region
Northeast	1, 2, 3	59	25.9	35	59.3	24	40.7
Southeast	4	32	14.0	19	59.4	13	40.6
Midwest	5, 7	62	27.2	53	85.5	9	14.5
Southwest	6	21	9.2	19	90.5	2	9.5
West	8, 9, 10	54	23.7	50	92.6	4	7.4
Total		228	100.0	176	77.2	52	22.8

Note: Chi-square = 28.27, degrees of freedom = 4, and probability of chance = 0.00.

contracts that permit the use of PTOs have an expressed provision that limits the number that can be employed. As the data given in Table 3 indicate, the most common limitation is to express the maximum number of PTOs as a percentage of the number of FTOs. Sixty-four systems have this provision with percentages ranging from 5 to 100 percent. In the remaining 19 contracts, an actual number is specified in 12 contracts and the maximum number is based on the number of scheduled runs, biddable runs, unsigned trippers, or peak-hour trippers in the contracts.

The size of the transit system was found to be statistically related to the type, if any, of limitation on the number of PTOs. In small systems (i.e., 50 employees or fewer) more than 86 percent of the contracts have no provision that limits the number of PTOs who can be hired (see Table 3). In contrast, 74 percent of the contracts in large systems (i.e., more than 50 employees) contain some type of limiting provision. This difference further supports the inference that FTOs in small systems feel less threatened by PTOs or have had less power in labor negotiations than FTOs in large systems, or both.

PTO Wages

PTOs are typically paid the same wage that is paid to FTOs. Nearly eight of every ten PTOs (79 percent) earn the same wages as FTOs. Six percent earn 50 to 74 percent of FTO wages and 14 percent receive between 75 and 99 percent of FTO wages. Only one system, the San Francisco Bay Area Rapid Transit District (BART), was found to pay a higher wage rate to PTOs. PTOs at BART receive 110 percent of the FTO wage rate. No statistical relationships were found between wage rates and system size.

PTO Fringe Benefits

Although their basic wages are generally the same, PTOs usually receive fewer fringe benefits than FTOs. At nearly nine of every ten transit agencies, PTOs are union members and are therefore represented by grievance and arbitration procedures. However, PTOs are often treated differently in terms of seniority and layoff procedures. Seniority as a PTO is transferable to full-time status at only about three of every ten systems (see Table 4). Almost one-half of the systems require that all PTOs be laid off before any FTOs are laid off. A system size relationship was again found in which a greater percentage of small systems tend to allow the transfer of PTO seniority and do not require PTOs to be laid off first.

Most transit systems do not grant sick leave, holiday, vacation, health and welfare insurance, or retirement benefits to PTOs. One-fourth of all sys-

TABLE 3 Contract Limitations on Number of Part-Time Operators

			System Size			
			50 Employees or Fewer		More than 50 Employees	
	Systems Permitting PTOs					
Limiting Provision	Number	Percentage	Number	Percentage of Systems with 50 or Fewer Employees	Number	Percentage of Systems with More than 50 Employees
Percentage of FTOs	62	36.0	8	10.4	54	56.8
Other basis[a]	19	11.0	3	3.9	25	16.8
No provision	91	52.9	66	85.7	16	26.3
Total	172[b]	100.0	77	100.0	95	100.0

Note: Chi-square $\neq 60.27$, degrees of freedom = 2, and probability of chance = 0.00.

[a] Includes the specification of an actual number and percentages based on number of scheduled runs, biddable runs, unsigned trippers, or peak-hour trippers.

[b] Four additional systems employ only PTOs and were not included in this analysis.

TABLE 4 Seniority and Layoff Procedures

			System Size			
	Systems Permitted PTOs		50 Employees or Fewer		More than 50 Employees	
	Number	Percentage	Number	Percentage	Number	Percentage
Seniority[a]						
PTO seniority transferable to full-time status						
Yes	45	28.8	33	51.6	12	13.0
No	111	71.2	31	48.4	80	87.0
Total	156	100.0	64	100.0	92	100.0
Layoff Procedures[b]						
PTOs laid off first?						
Yes	75	48.1	18	28.1	57	62.0
No	81	51.9	46	71.9	35	38.0
Total	156	100.0	64	100.0	92	100.0

[a] Chi-square (corrected) = 25.43, degree of freedom = 1, and probability of chance = 0.00.

[b] Chi-square (corrected) = 15.97, degree of freedom = 1, and probability of chance = 0.00.

tems give PTOs full or reduced sick leave (see Table 5). About one-third of the systems give PTOs full or reduced holiday, vacation, and retirement benefits. Four of every ten PTOs receive full or reduced health and welfare insurance benefits. With the exception of retirement benefits there is a statistical relationship between system size and the granting of these benefits. Roughly one-half of the small systems grant full or reduced benefits whereas only about one-third of the large systems provide them.

PTO Work Rules

The use of PTOs can significantly reduce the cost of providing peak-period service because they are subject to less restrictive work rules than are their FTO counterparts. At nearly eight of every ten transit systems, PTOs receive no guarantee per assignment. Another 16 percent receive guarantees of 2 hr or less. No statistical pattern was found in work rule guarantees, either by system size or geographic location.

PTOs also do not receive spread premiums. Only one system, the Central Contra Costa Transit Authority in California, that pays spread premiums was identified.

Spread premiums are probably not an issue in most systems because of the maximum work hour limitations that are contained in many contracts. As the data in Table 6 indicate, more than three-fourths of the systems have work hour limitations with a median

TABLE 5 Fringe Benefits

	Systems Permitted PTOs		50 Employees or Fewer		More than 50 Employees	
	Number	Percentage	Number	Percentage	Number	Percentage
Sick Leave[a]						
No	117	74.5	44	68.8	73	78.5
Reduced	20	12.7	8	12.5	12	12.9
Full	20	12.7	12	18.8	8	8.6
Total	157	100.0	64	100.0	93	100.0
Holidays[a]						
No	104	66.2	35	54.7	69	74.2
Reduced	26	16.6	11	17.2	15	16.1
Full	27	17.2	18	28.1	9	9.7
Total	157	100.0	64	100.0	93	100.0
Vacation[b]						
No	97	61.8	31	48.4	66	71.0
Reduced	33	21.0	14	21.9	19	20.4
Full	27	17.2	19	29.7	8	8.6
Total	157	100.0	64	100.0	93	100.0
Retirement[c]						
No	105	66.9	38	59.4	67	72.0
Reduced	13	8.3	3	4.7	10	10.8
Full	39	24.8	23	35.9	16	17.2
Total	157	100.0	64	100.0	93	100.0
Health and Welfare Insurance[d]						
No	93	59.6	30	46.9	63	68.5
Reduced	33	21.2	12	18.8	21	22.8
Yes	30	19.2	22	34.4	8	8.7
Total	156	100.0	64	100.0	92	100.0

[a]Chi-square = 1.12, degrees of freedom = 2, and probability of chance = 0.57.
[b]Chi-square = 12.95, degrees of freedom = 2, and probability of chance = 0.00.
[c]Chi-square = 7.4, degrees of freedom = 2, and probability of chance = 0.02.
[d]Chi-square = 7.4, degrees of freedom = 2, and probability of chance = 0.00.

TABLE 6 Maximum Work Hour Provisions

			System Size			
	Systems Permitting PTOs		50 or Fewer Employees		More than 50 Employees	
Maximum Work Hours per Week	Number	Percentage	Number	Percentage	Number	Percentage
Less than 20	3	2.2	1	1.9	2	2.4
20-24	25	18.2	10	18.5	15	18.1
25-29	27	19.7	2	3.7	25	30.1
30-39	37	27.0	11	20.4	26	31.3
40-42	13	9.5	11	20.4	2	2.4
No maximum	32	23.4	19	35.2	13	15.7
Total	137	100.0	54	100.0	83	100.0

Note: Chi-square = 29.54, degrees of freedom = 5, and probability of chance = 0.00.

value of 25 hr. There is a statistical pattern by system size: a higher percentage of small systems than of large systems has either no or extremely large maximum work hour limits. Again this small-large system pattern suggests better acceptance of PTOs by small systems than by large systems.

METHODS OF ASSIGNING PTOs WORK

The purpose of the second part of the UMTA study was to identify methods currently used to assign PTOs work. Two types of methodologies were identified: (a) methodologies used to assign PTOs work on the basis of existing run cuts and (b) methodologies used to incorporate PTOs into automated run-cutting procedures. The five methodologies that were found in the study are discussed in the next sections.

Methods of Assigning PTOs on the Basis of Existing Run Cuts

Methodologies for assigning PTOs on the basis of existing run cuts were identified at three systems. These systems are the Washington Metropolitan Area Transit Authority (WMATA), the Southern California Rapid Transit District (SCRTD), and the Alameda-Contra Costa Transit District (AC Transit). These agencies have more part-time eligible pieces of work than they have PTOs to fill them. The question they face is: "What pieces of work should be assigned to PTOs in order to maximize cost savings?"

Work rules governing the use of PTOs influenced the development of the assignment procedure at each agency. As the data in Table 7 indicate, the definitions and values of work rules vary considerably among the three agencies. For example, there are three variations of work hour limitations of which WMATA must follow one (weekly maximum), AC Transit two (daily maximum and weekly maximum), and SCRTD all three (daily minimum, daily maximum, and weekly maximum). Because each of these rules must be considered, the PTO assignment procedures at AC Transit, SCRTD, and WMATA are different.

TABLE 7 Summary of PTO Work Rules at AC Transit, SCRTD, WMATA

Work Rule Limits	AC Transit	SCRTD	WMATA
Percentage of FTOs			
Division	15	10	None
Systemwide	10	None	10
Work hours			
Daily minimum	None	2.5	None
Daily maximum	5	5	None
Weekly maximum	25	25	30
Type of work piece permitted			
Weekday trippers	Yes	Yes	Yes
Split runs	Yes	No	Yes

Washington Metropolitan Area Transit Authority

WMATA uses a three-step approach to assigning work to PTOs. First, a.m. and p.m. trippers are rank-ordered on the basis of descending pay time. Second, the number of FTOs and PTOs working trippers off of the extraboard is determined for each division by WMATA's Schedules Section. Finally, the tripper pairs with the highest pay times are assigned to FTOs by WMATA's Operations Department; the remaining pairs are assigned to PTOs.

Full-time extraboard operators, regular FTOs, and PTOs work trippers at WMATA. The number of regular FTOs working trippers is calculated at each division as the difference between the number of a.m. and p.m. trippers at that division. For example, 29 regular FTOs worked trippers at WMATA's Four Mile Run Division that had 112 a.m. trippers and 83 p.m. trippers for the schedule effective January 24, 1983. Approximately 70 percent of the remaining trippers are assigned to PTOs; 30 percent are assigned to full-time extraboard operators (i.e., FTOs). This 70/30 split was calculated to comply with the contract provision that limits the maximum number of PTOs to 10 percent of the number of FTOs, systemwide.

FTOs and PTOs are assigned to a.m. and p.m. paired trippers (or "married" trippers) on the basis of the criterion of combined pay time. The objective of WMATA's Schedules Section is to minimize make-up time (or the difference between the 8-hr guarantee and combined pay time) paid to FTOs. Morning and p.m. trippers are each rank-ordered by descending pay time. The highest paid a.m. tripper is then "married" to the highest paid p.m. tripper, the second highest paid a.m. tripper is married to the second highest p.m. tripper, and so forth.

Figure 1 shows how the a.m. and p.m. trippers were paired at WMATA's Four Mile Run Division for the schedule effective January 24, 1983. Each a.m. and p.m. tripper is ranked by number by descending pay time. The combined pay time is shown in column 6, and difference between the 8-hr guarantee and combined pay time (i.e., make-up time) is shown in column 7.

In the case of the Four Mile Run Division, this yielded 83 married trippers effective January 24, 1983. The 20 married pairs with the greatest combined pay times (and, hence, lowest combined make-up times) were assigned to FTOs. The combined make-up time for the top 20 married trippers is then determined in order to establish a daily make-up time budget for each division. In this case, the Four Mile Run Division had a budget of 23 hr 20 min of daily make-up time effective January 24, 1983. Part-time paid hours are equal to 334 hr 16 min or 5 hr 18 min per day per PTO, on average. The overtime penalty, calculated at one-half times the number of hours worked by regular FTOs assigned single-piece trippers, also appears at the top of this sheet and is equal to 34 hr 37 min.

Southern California Rapid Transit District

SCRTD uses a two-step procedure to assign work to PTOs. First, part-time eligible pieces of work are identified at each division on the basis of the constraints of the labor agreement and other practical considerations specified by SCRTD's Transportation Department. Second, these pieces of work are rank-ordered and the highest ranked pieces are assigned to PTOs; the remaining work is assigned to FTOs. PTOs are restricted to working only single-piece, weekday tripper assignments at SCRTD.

Only certain trippers within a division are eligible to be worked by PTOs at SCRTD. They must, by contract, (a) be nonbiddable by regular FTOs, (b) have at least 2.5 hr of work, and (c) have no more than 5 hr of work. Biddable trippers are defined by the Schedules Department as short peak-period pieces of work that are worked at overtime by regular FTOs before or after their regular runs. They are generally less than 2.5 hr work time and are less costly to work at overtime than by extraboard FTOs. Unlike WMATA, SCRTD does not define the number of biddable trippers as the difference between the number of

Regular FTO Overtime Penalty

Effective: January 24, 1983
8 Hrs. Reg. MEN GUAR. 23:20
69:13 @ 1 1/2 = 34:37 O/T PENALTY
PART TIME PAY HOURS 334:16

DIVISION: Four Mile

Tripper Number	112 A.M. Pay	Tripper Number	83 P.M. Pay	Combined Pay Time	8 Hours Guaranteed
1004	3:27	2043	3:51	7:18	0:42
1000	3:26	2013	3:50	7:16	0:44
1019	3:25	2004	3:49	7:14	0:46
1003	3:24	2031	3:48	7:12	0:48
1009	3:22	2003	3:45	7:07	0:53
1055	3:19	2021	3:44	7:03	0:57
1020	3:16	2002	3:40	6:56	1:04
1025	3:15	2007	3:39	6:54	1:06
1011	3:13	2007	3:36	6:49	1:11
1002	3:12	2006	3:35	6:47	1:13
1006	3:09	2008	3:35	6:44	1:16
1032	3:08	2023	3:33	6:41	1:19
1042	3:08	2011	3:32	6:40	1:20
1061	3:08	2025	3:32	6:40	1:20
1023	3:05	2042	3:32	6:37	1:23
1050	3:05	2012	3:29	6:34	1:26
1005	3:04	2018	3:29	6:33	1:27
1014	3:04	2051	3:29	6:33	1:27
1041	3:04	2017	3:28	6:32	1:28
1031	3:03	2005	3:27	6:30	1:70
1109	2:00	2048	3:27	5:27	23:20
1103	2:00	2038	3:26	5:26	
1093	2:00	2041	3:23	5:23	
1048	2:00	2050	3:23	5:23	
1101	2:10	2054	3:23	5:33	
1090	2:11	2030	3:22	5:33	
1089	2:11	2057	3:21	5:32	
1104	2:11	2028	3:16	5:27	
1108	2:12	2014	3:15	5:27	
1094	2:14	2016	3:15	5:29	
1099	2:16	2035	3:12	5:28	
1091	2:16	2009	3:12	5:28	
1062	2:17	2015	3:11	5:28	
1037	2:17	2024	3:11	5:28	
1078	2:17	2026	3:11	5:28	
1086	2:18	2019	3:09	5:27	
1084	2:20	2000	3:08	5:28	
1092	2:21	2060	3:08	5:29	
1087	2:23	2044	3:07	5:30	
1105	2:23	2027	3:06	5:29	
1070	2:24	2047	3:06	5:30	
1033	2:24	2066	3:01	5:25	
1021	2:24	2049	3:00	5:24	
1106	2:24	2020	2:59	5:23	
1054	3:02	2037	2:57	5:59	
1053	3:01	2063	2:57	5:58	
1028	2:59	2029	2:56	5:55	
1060	2:58	2061	2:55	5:53	
1024	2:57	2039	2:53	5:50	
1012	2:56	2033	2:51	5:47	
1045	2:56	2034	2:51	5:47	
1071	2.56	2082	2:51	5:47	
1013	2:54	2043	2:49	5:43	
1018	2:54	2059	2:49	5:43	
1027	2:54	2022	2:48	5:42	

Full-Time Extraboard

Part-Time Operators

Make-up Time Budget

FIGURE 1 Facsimile of rank order of a.m. and p.m. trippers at WMATA's Four Mile Run Division.

a.m. and p.m. trippers. Therefore, after the biddable trippers have been assigned to regular FTOs, the numbers of a.m. and p.m. trippers may not be equal at the division. As a result, not all full-time extraboard operators are assigned an a.m./p.m. tripper pair. Some full-time extraboard operators must work an a.m. or p.m. tripper and stand extra during the remainder of the day.

SCRTD's prioritization algorithm consists of three procedural steps. First, a.m. and p.m. trippers are separated and listed by ascending sign-on and sign-off times, respectively. For example, as shown in Figure 2, Iteration 1, the a.m. tripper signing on at 4:32 a.m. is listed first and followed in order by those trippers signing on at 5:00, 5:09, 5:12, and 5:15 a.m., respectively. Thus, runs representing the most spread cost (i.e., the earliest pull-outs) are placed at the top of the list. These runs are best worked by PTOs because PTOs receive no spread premiums.

In the second step, the time savings that would result from exchanging the positions of run N with run N+1, N+2, and all subsequent runs are considered. This is done by computing the time savings of operating run N with an FTO and run N+1 with a PTO. The increase in FTO spread time is calculated at

Effective:
8 Hrs. Reg. MEN GUAR.
@ 1 1/2 = O/T PENALTY
PART TIME PAY HOURS

DIVISION: Four Mile

Tripper Number	112 A.M Pay		Tripper Number	83 P.M. Pay	Combined Pay Time	8 Hours Guaranteed
1035	2:53		2069	2:44	5:37	
1039	2:53		2064	2:44	5:37	
1040	2:53		2056	2:43	5:36	
1080	2:53		2052	2:43	5:36	
1001	2:52		2053	2:43	5:35	
1015	2:52		2058	2:42	5:34	
1079	2:52		2040	2:41	5:33	
1077	2:52		2046	2:40	5:32	
1008	2:51		2036	2:38	5:29	
1049	2:51		2055	2:36	5:27	
1017	2:50	Part-Time	2070	2:36	5:26	
1026	2:50	Operators	2082	2:35	5:25	
1043	2:50		2078	2:31	5:27	
1044	2:50		2065	2:24	5:14	
1068	2:50		2067	2:17	5:07	
1016	2:48		2080	2:11	4:59	
1030	2:48		2075	2:01	4:49	
1073	2:48		2081	2:00	4:48	
1067	2:47		2062	2:00	4:48	
1010	2:46		2068		4:46	
1052	2:45		2091		4:45	
1057	2:43		2072		4:43	
1007	2:42		2073		4:42	
1065	2:42		2074		4:42	
1034	2:40		2076		4:40	
1051	2:39		2077		4:39	
1095	2:38		2079		4:39	
1082	2:37		20		334:16	
1096	2:37		20			
1047	2:36		20			
1097	2:36		20			
1085	2:35		20			
1038	2:34		20			
1059	2:34	Regular	20			
1036	2:33	Full-Time	20			
1066	2:33		20			
1076	2:33	Operators	20			
1069	2:32	Working	20			
1102	2:32		20			
1107	2:32	Overtime	20			
1022	2:31		20			
1058	2:31		20			
1063	2:30		20			
1083	2:30		20			
1081	2:29		20			
1075	2:28		20			
1064	2:28		20			
1029	2:27		20			
1046	2:26		20			
1088	2:26		20			
1056	2:25		20			
1072	2:25		20			
1074	2:25		20			
1100	2:25		20			
1110	2:25		20			
1111	2:00					

PTO Pay Hours

69:13 Full-Time Regular FTO Work Hours

FIGURE 1 continued.

time and one-half the difference in sign-on time for a.m. trippers or sign-off time for p.m. trippers. Next, the decrease in work time paid to PTOs is calculated at straight time because PTOs are paid for only the hours they work, without overtime or spread premiums.

The increase in FTO spread is then added to the decrease in PTO work time. If the sum is negative, the decrease in PTO work time is greater than the increase in FTO spread time, and run N+1 is less costly worked by a PTO than by an FTO. In this case the positions of run N and run N+1 should be exchanged. If the sum is positive, the increase in FTO spread time more than offsets any PTO work time savings and the positions should not be exchanged.

All sums are positive relative to the 4:32 a.m.

Rank	Sign-On Time	FTO Spread Premium Difference	Sign-Off Time	Work Time	PTO Work Time Difference	Sum of Differences
Iteration 1: Examine Exchanging 4:32 a.m. Run						
1	4:32 a.m.		8:04 a.m.	3:32		
	5:00	+42	8:43	3:43	+11	+53
	5:09	+55½	8:31	3:22	-10	+45½
	5:12	+60	8:23	3:11	-21	+39
	5:15	+64½	8:36	3:21	-11	+53½
Iteration 2: Examine Exchanging 5:00 a.m. Run						
1	4:32 a.m.		8:04 a.m.	3:32		
2	5:12	18	8:23	3:11	32	14
	5:09	+13½	8:31	3:22	-21	-7½
	5:00		8:43	3:43		
	5:15	+22½	8:36	3:21	-22	+½
Iteration 3: Examine Exchanging 5:09 a.m. Run						
1	4:32 a.m.		8:04 a.m.	3:32		
2	5:12		8:23	3:11		
3	5:09		8:31	3:22	+21	+7½
	5:00	-13½	8:43	3:43		
	5:15	+9	8:36	3:21	-1	+8
Iteration 4: Examine Exchanging 5:00 a.m. Run						
1	4:32 a.m.		8:04 a.m.	3:32		
2	5:12		8:23	3:11		
3	5:09		8:31	3:22		
4	5:00		8:43	3:43		
	5:15	+22½	8:36	3:21	-22	+½
Iteration 5: Final Rankings						
1	4:32 a.m.		8:04 a.m.	3:32		
2	5:12		8:23	3:11		
3	5:09		8:31	3:22		
4	5:00		8:43	3:43		
5	5:15		8:36	3:21		

FIGURE 2 Example of SCRTD's part-time operator assignment algorithm.

run in Figure 2, Iteration 1, and no changes are made. The 4:32 a.m. run is therefore ranked first among the five a.m. trippers.

In Iteration 2, the 5:00 a.m. run is compared to the 5:09, 5:12, and 5:15 a.m. runs, respectively. The 5:09 and 5:12 a.m. runs have negative sums of 7.5 and 14 min, respectively. The 5:12 a.m. run is ranked second because it has the most negative sum. That is, the 5:12 a.m. run has the highest net decrease in PTO work time compared to the 5:00 a.m. run.

These computations are repeated in Iterations 3 through 5. The 5:09 a.m. run is ranked third in Iteration 3; the 5:00 a.m. run is ranked fourth in Iteration 4. The final rankings are shown in Iteration 5. It can be observed that the same ranking would be obtained by listing the runs in ascending order of the sum of differences computed in Iteration 1.

The rank-ordered list of a.m. and p.m. trippers constitutes a priority-ordered list of PTO assignments for each of SCRTD's 13 divisions. These lists are forwarded to the Transportation Department for use on a routine daily basis in assigning work to PTOs and FTOs.

Alameda-Contra Costa Transit District

AC Transit uses a less formalized procedure for assigning operators to part-time eligible pieces of work than does SCRTD or WMATA. Under AC Transit's labor agreement, PTOs (a) are guaranteed 2 hr per day but can work no more than 5 hr per day or 25 hr per week, (b) can work only on weekdays, (c) cannot exceed 10 percent of FTOs systemwide or 15 percent at any division, and (d) must originate and terminate their assignments at a division (i.e., no on-street relief).

AC Transit's Schedules Department selects PTO assignments from among all eligible pieces of work at each division on the basis of a number of criteria derived from the labor agreement work rule provisions and other considerations. These criteria include:

1. PTOs should generally work close to the 5-hr daily limitation;
2. PTOs should generally be assigned to early pull-outs and late pull-ins to reduce spread premiums paid to full-time extraboard operators;
3. PTOs should generally work split runs instead of straight runs;
4. If PTOs work a split run, they should work the same line in the a.m. and p.m. because PTOs break in on only one line;
5. FTOs (i.e., "expensive" labor) should be assigned to contract service operated for BART and others by AC Transit;
6. FTOs must work runs that are relieved on the street, according to the labor contract; and
7. Individual PTO preferences regarding work times, work hours, and days off may also be taken into account.

The Schedule Department's suggestions are forwarded to the Operations Department, which may take these suggestions or assign PTOs to alternate runs.

Comparison of Methodologies

A comprehensive evaluation would include testing the methodologies on a common set of PTO assignment problems. Properly constructed, this testing would provide useful information on the sensitivity and accuracy of the procedures. Unfortunately, this type of testing was not included in the UMTA study. Therefore, the comparison of methodologies in the study was limited to an evaluation of the variables that are included in each procedure.

A comprehensive procedure for assigning PTOs to runs selected from existing schedules should consider PTO pay hours, FTO make-up time, FTO spread premiums and overtime, and PTO and FTO fringe benefits. As the data in Table 8 indicate, the procedures used by WMATA, SCRTD, and AC Transit consider some but not all of these variables. Each agency considers PTO pay hours; WMATA considers FTO make-up time; and both SCRTD and AC Transit consider FTO spread premiums in assigning PTOs to existing runs. None of these agencies includes FTO extraboard overtime or FTO or PTO fringe benefits in driver assignment decisions.

TABLE 8 Comparison of PTO Assignment Procedures

	Property		
	WMATA	SCRTD	AC Transit
Type of procedure			
Automated		X	
Manual	X		X
Variables considered			
PTO pay-hours	Yes	Yes	Yes
FTO make-up hours	Yes	No	No
FTO spread premiums	No	Yes	Yes
FTO overtime	No	No	No
PTO fringe benefits	No	No	No
FTO fringe benefits	No	No	No

The importance of considering full-time extraboard operator spread premiums depends on a system's spread rule provisions and service profile. Spread premiums are most onerous at systems with relatively short maximum spread times and spread penalty thresholds, relatively sharp peaks and relatively long a.m. and p.m. peak periods. Spread premiums were shown to be significant at SCRTD, but they may or may not be as important at WMATA or AC Transit. The consideration of both spread and overtime premiums is especially important at systems such as AC Transit that pay both overtime and spread penalties when applicable.

Fringe benefits are an important factor in determining which trippers to assign to regular FTOs, extraboard FTOs, and PTOs. Systems with relatively high fringe benefits may find it less costly to assign more trippers to regular FTOs on an overtime basis in order to avoid the fixed fringe benefit costs that would be incurred by hiring additional extraboard operators. A significant operator cost savings may be attributable to the lower fringe benefits received by PTOs.

Methods of Incorporating PTOs in Automated Run-Cutting Procedures

Two automated procedures were identified that consider PTOs when run cuts are made. The first procedure uses a version of RUCUS and is used by the San Francisco Municipal Railway (Muni). The second procedure is part of a computerized scheduling package called RAMCUTTER. Both Muni and AC Transit are currently experimenting with this procedure.

San Francisco Municipal Railway

Muni uses Version 5.01 of the RUCUS run-cutting package, developed by Kenneth Roberts & Associates, to schedule both PTOs and FTOs. PTOs at Muni are permitted to work "short runs" and a PTO extraboard, up to 5 hr a day, 25 hr a week. PTOs are guaranteed 3.5 hr per assignment.

The RUCUS methodology uses a seven-step procedure. In the first step, long blocks are cut into straight runs. All runs beginning before 5:50 a.m. and ending after 6:00 p.m. are made into straight runs. The minimum and maximum platform times are specified as 7 hr 14 min and 8 hr 50 min, respectively. The maximum spread time is specified as 10 hr 59 min. (The spread premium threshold is 10 hr.) These parameters are established in an iterative fashion, through repeated attempts to improve the results of previous runs by adjusting each parameter. The straight runs are then "frozen" and are not modified in subsequent steps.

In the second step, the work remaining after the straight runs are cut is divided into two nearly equal pieces with a target platform time of 4 hr. The minimum and maximum platform times are specified as 30 min and 5 hr 45 min for any piece of a two-piece run.

Next, two-piece PTO runs are cut with relatively long spread and swing times. The minimum and maximum spreads for PTO runs are specified as 10 hr 15 min and 11 hr 59 min, respectively. As a matter of policy, 11 hr 59 min is used as the maximum spread for PTO runs; 11 hr 59 min is the maximum spread for FTO runs established by Muni's labor agreement. Swing times for PTO runs are specified as 6 hr to 9 hr 30 min. The minimum and maximum platform times for PTO two-piece runs are specified as 3 hr 20 min and 4 hr 39 min, respectively, in accordance with the 3.5 hr guarantee and 5 hr work per day limitation stipulated for PTOs in Muni's labor agreement. The PTO two-piece runs are then "frozen" and are not modified in subsequent steps.

FTO two-piece runs are cut from all remaining work in the next two steps. In both steps the maximum spread time and the average platform time are specified as 11 hr 59 min and 8 hr 30 min, respectively. FTO swing time is limited to no more than 3 hr in the fourth step.

The work remaining is then cut in the fifth step into two-piece runs with a maximum swing of 4 hr. All other parameters are held constant.

An attempt is made to reduce costs in the sixth step by switching pieces between two two-piece runs output from the fourth and fifth steps. Any one-piece trippers remaining are manually worked into the cut.

AC Transit

Muni and AC Transit are currently experimenting with an automated run-cutting procedure that takes into direct account wages, fixed and variable overhead, and work rules governing the use of both PTOs and FTOs when searching for a least-cost run cut for a given service schedule. This package, called the RAMCUTTER, was developed by Research Applications for Management (RAM), Inc.

The RAMCUTTER minimizes total annualized cost incurred for schedule work time, fixed and variable overhead, and other allowances for both FTOs and PTOs, subject to a series of constraints imposed by

the labor agreement and the schedule department. AC Transit uses a total of 270 input parameters that specify minimum and maximum constraints, various thresholds, penalties and bonuses, output formats, and so forth. Thirty-four of these variables affect the use of PTOs. These parameters include such "hard" constraints as maximum percentage of PTOs, hourly pay rate, and maximum pay time. The "soft" rules include penalties for runs starting before a specified time, runs ending after a specified time, pieces of work below a specified threshold size, runs with platform times less than a specified time, and so forth. The schedules department can also penalize (or reward) part-time work in general, thereby reducing or increasing the number of part-time runs cut by the RAMCUTTER. Annual fixed overhead costs for each PTO and FTO, and variable overhead expressed as a percentage of PTO and FTO pay times, are also direct inputs to the RAMCUTTER.

There are a large number of potential solutions for assigning PTOs and FTOs to a given service schedule. It is not practical to test each of these alternatives to identify the least-cost solution, even with modern electronic computers. A greater number of alternatives can be tested by the RAMCUTTER as schedulers allocate more and more computer time to the problem.

AC Transit's schedulers operate the RAMCUTTER in an iterative fashion. A few minutes of computer time are allocated to produce an initial run cut. Additional runs are then produced using the same amount of computer time by tightening or loosening certain constraints or rules in order to achieve implementable run cuts that are acceptable to the schedules department and others. When the input parameter values have been established, the schedulers can allocate a greater amount of computer time to achieve a more nearly optimal solution.

Comparison of Methodologies

The RAMCUTTER and RUCUS Version 5.01 are both automated procedures that consider both PTOs and FTOs when cutting runs for a given service schedule. Both consider differences in PTO and FTO work rules. The RAMCUTTER also considers PTO and FTO fixed and variable overhead costs, which RUCUS does not. In addition, the RAMCUTTER incorporates a greater number of constraints regarding start and end times, road reliefs, platform ties, and so forth, which help to generate acceptable, implementable run cuts. A comparison of the RAMCUTTER and RUCUS Version 5.01 by the creator of the RAMCUTTER at Tri-Met in Portland, Oregon, indicated that the procedures result in solutions of approximately equal cost.

CONCLUSIONS

The major conclusions of this study regarding the methods for determining the use of part-time operators are as follows:

The use of PTOs is widely regarded as a means of reducing the cost of providing peak-period transit service, thereby improving transit productivity, because

- PTOs are governed by less restrictive work rules than are their FTO counterparts,
- PTOs typically receive no spread or overtime premiums,
- PTOs almost always receive lower fringe benefits than do FTOs, and
- PTOs sometimes earn lower wages than do FTOs.

The use of PTOs is widespread in transit systems of all sizes in all regions of the nation. Three-fourths of all U.S. transit systems are permitted to use PTOs; one of every ten operators in these systems is a PTO.

A higher percentage of small systems (50 employees or fewer) are permitted to use PTOs than large systems (more than 50 employees). Labor contracts of small systems also tend to be less restrictive in the permitted use of PTOs.

A variety of procedures is being used to assign PTOs to pieces of work selected from existing run cuts. These procedures consider PTO pay hours, FTO make-up hours, and FTO spread premiums or FTO overtime, or both, in deciding which pieces to assign to FTOs and which to assign to PTOs. No procedure was identified that considered all of these variables or PTO or FTO fringe benefits.

RUCUS Version 5.01 and the RAMCUTTER are promising computerized procedures that incorporate PTOs directly into the run-cutting process. RUCUS is presently used at San Francisco Muni, and the RAMCUTTER is in the testing stages at both Muni and AC Transit.

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