TRANSYT-7F or PASSER II, Which Is Better—A Comparison Through Field Studies

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Several studies have compared the arterial signal timings optimized by TRANSYT-7F and PASSER II. The comparisons, however, were based on simulated results. In this study, the TRANSYT-7F timing plans were compared with the PASSER II timing plans based on operational characteristics, field results, and simulated results. These comparisons were possible because (a) the signals on two arterials in San Francisco were optimized by TRANSYT-7F and implemented in 1987, (b) the same signals were retimed by PASSER II and implemented in 1988, and (c) before-and-after studies were conducted. From the field results, the overall effectiveness of TRANSYT-7F and PASSER II was about the same in terms of travel time and stops along the arterial (excluding cross streets). On one of the arterials, the offset pattern and operational characteristics of the TRANSYT timing were very different from those of the PASSER timing; on the other arterial, they were very similar. The TRANSYT-7F simulated travel times were reasonably close to the field travel times. However, the simulated measures of effectiveness in general were inclined in favor of the timing plans optimized by TRANSYT-7F. The field data for travel time were reliable and easy to collect. Statistically, one to five samples were required to attain a 95 percent level of confidence for the example arterials, each with 30 or more signalized intersections.

TRANSYT-7F and PASSER II are two popular programs for signal timing. TRANSYT-7F optimizes signals by minimizing vehicle delay and stops to all approaches, and PASSER II optimizes signals by maximizing the bandwidth along the arterial. Several studies have compared TRANSYT-7F, PASSER II, and other bandwidth programs. Skabardonis and May (*1*) compared the arterial signal timings optimized by TRANSYT-7F, PASSER II, and MAXBAND and found that TRANSYT-7F produced the best result in terms of a performance index (a combination of delay and stops expressed as a number). Cohen (*2*) compared the arterial signal timings optimized by TRANSYT-7F and MAXBAND and found that TRANSYT-7F produced a better result in terms of delay and stops. Liu (*3*) compared the arterial signal timings optimized by TRANSYT-7F without bandwidth constraint, TRANSYT-7F with bandwidth constraint, MAXBAND, and PASSER II. He found that TRANSYT-7F without bandwidth constraint produced the best result in terms of delay and stops.

Although these findings suggest that TRANSYT-7F produces better results, many traffic engineers prefer PASSER II. A recent survey of traffic engineers indicated that 63 percent used PASSER II and 26 percent used TRANSYT-7F to analyze coordinated signalized intersections; however, the same survey indicated that 93 percent of them obtained information about alternative traffic computer programs through literature (*4*). It appeared that the findings did not convince many traffic engineers. One reason may be that PASSER II is easier to use and provides visible and verifiable progression along the arterial. Because signal progression is readily perceived along the arterial, complaints from the public are minimized. Another reason may be that traffic engineers have reservations about findings based on simulation results. Skabardonis and May's findings were based on the TRANSYT-7F simulated results. Cohen's and Liu's findings were based on the TRANSYT-7F and NETSIM simulated results. However, simulation has its merits. Different scenarios can be easily analyzed at minimal cost. Furthermore, it is difficult to implement the signal timing plans from different models on the same arterial for the sake of comparison. However, simulation may be different from what is actually happening in the field. Comparison through field studies may provide better insight.

The signals on two arterials, Geary Boulevard and 19th Avenue, in San Francisco were optimized by TRANSYT-7F and implemented in January 1987 as part of the California Department of Transportation's Fuel Efficient Traffic Signal Management (FETSIM) program. The original offsets on both arterials were set manually with a double alternate pattern. Although the TRANSYT-7F timings resulted in annual savings of $3.5 million (based on simulation results) (*5*), about 10 complaints on 19th Avenue were received during the first 3 months after implementation.. About 10 to 15 complaints on the same arterial were received during the next 15 months. The majority of complaints were that the northbound (a.m. inbound) progression was bad. In response to the complaints, the a.m. timing on 19th Avenue and the p.m. timing on Geary Boulevard were retimed using PASSER II and implemented in June 1988. After the signals were changed to PASSER timings, one response was received during the first 3 months. The response complimented the good progression in northbound 19th Avenue and urged the same in southbound. There was no response on Geary Boulevard during the TRANSYT-7F nor the PASSER timings.

Although these user responses were not a scientific sampling, they did represent some users' perceptions. Because timings from both TRANSYT-7F and PASSER II were being implemented on the same arterials, we had the opportunity to find out whether TRANSYT-7F or PASSER II is really better. We conducted before-and-after field studies by com-

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paring the operational characteristics and the field results under both timings. Because collecting field data is usually time-consuming, the comparison described how and what data were collected, the required sample size to achieve a 95 percent level of confidence, and the statistical test to compare the data in order to get some idea of how much effort is involved. Because many findings were based on the simulated results of TRANSYT-7F, as mentioned earlier, field results were also compared to TRANSYT-7F simulated results to see if there were discrepancies.

The signal timing plans that were implemented to the arterials were developed from TRANSYT-7F, Release 4, and PASSER II-84. The model-simulated results were from TRANSYT-7F, Release 6.

STUDY ARTERIALS

The study arterials were (a) Geary Boulevard with 30 signals and (b) 19th Avenue and Park Presidio Boulevard (referred to as 19th Avenue) with 33 signals (see Figure 1). The signals are fixed-time. Geary Boulevard is a two-way street with curb parking, left-turn pockets, and three lanes per direction. There are retail stores and parking activity is heavy. 19th Avenue

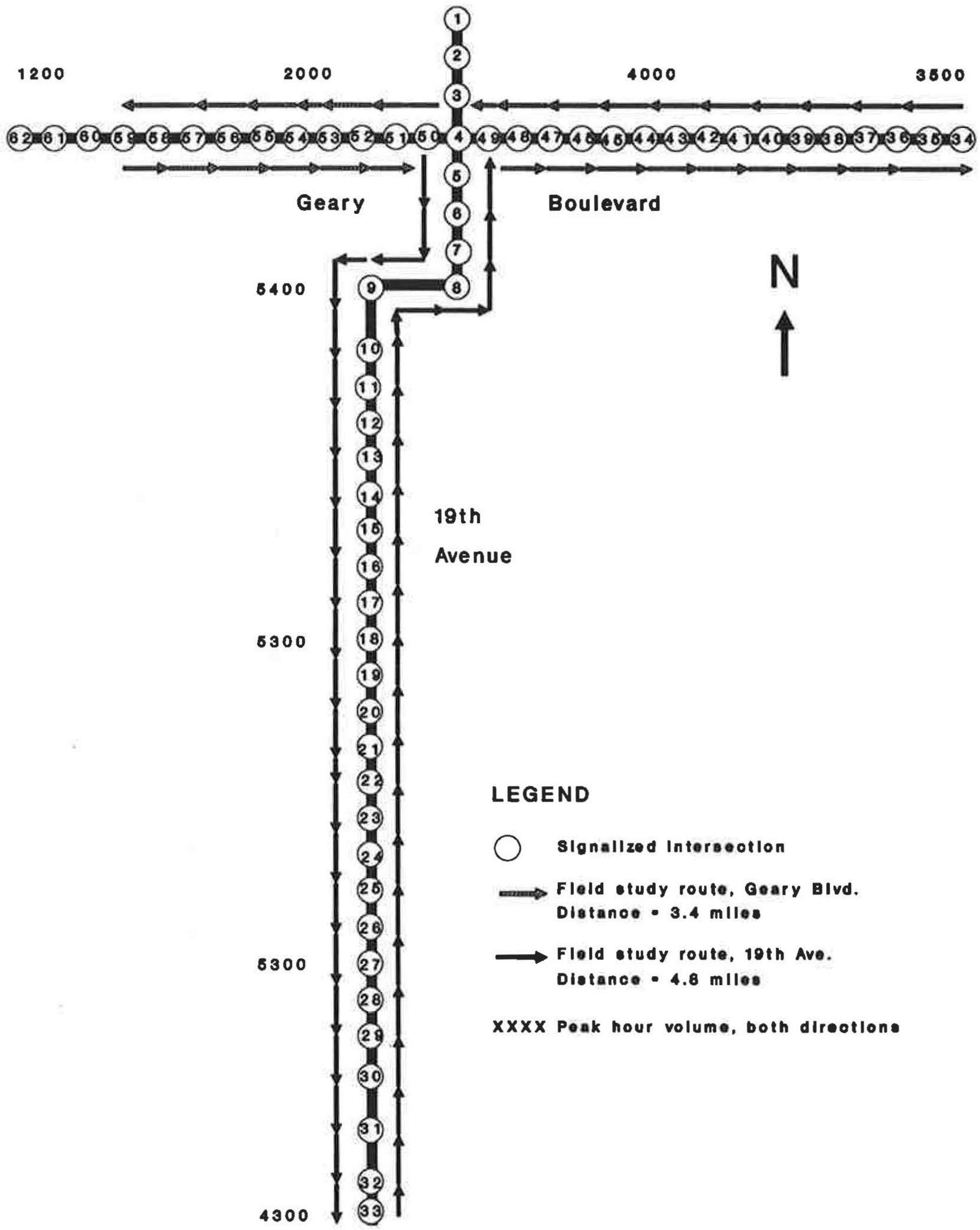


FIGURE 1 Study arterials.

is also a two-way street with three lanes per direction. Left turns are allowed in only a few intersections. Portions of the street have curb parking; however, there are no retail stores and parking activity is insignificant. Figure 1 shows the peak-hour traffic volumes.

Each arterial had three timing plans per day. We chose the p.m. timing plan on Geary Boulevard and the a.m. timing plan on 19th Avenue for comparison because they are the most critical.

TRANSYT-7F TIMINGS

In developing the timing plans, turning-movement counts were collected at each signalized intersection. We went through the processes of model calibration, cycle length selection, optimization, and fine-tuning (*5*).

During model calibration, we selected five key intersections from each arterial. For each selected intersection, we (a) recorded the major platoon arrivals and compared them with TRANSYT's flow profiles, and (b) observed the queue lengths and compared them with TRANSYT's maximum back of queues. From simulation runs, links with at least 95 percent degree of saturation were checked in the field to see if they were congested.

During cycle length selection, we made runs with cycle lengths between 65 and 95 sec. We included runs with double cycles on selected intersections. We selected 85 sec as the cycle length on both arterials based on minimum fuel consumption.

During optimization, we were concerned that the offsets on 19th Avenue were too close to a simultaneous pattern. We therefore explored the following options: (a) performing normal optimization; (b) applying delay and stop weights to links along the arterial; (c) first using PASSER II to optimize the offsets, then inputting the resulting offsets to TRANSYT-7F for optimization of both offsets and splits; and (d) modifying TRANSYT's hill-climb steps to emphasize offset optimization. The resulting offsets from these options were similar. Therefore the normal optimization option was used for both arterials.

During fine-tuning, we drove through the arterials to check any abnormal stops or delay. Several offsets and splits were modified based on field checks.

We continued to make minor adjustments until May 1988. Minor adjustments were necessary because the input coding, from which the signal timing was obtained, might not represent 100 percent of the field conditions. TRANSYT-7F was a versatile tool for fine-tuning. If the signal timing of a particular intersection is not working properly, one can (a) change the split or offset of any affected intersection, then resimulate the changed part along with the rest of the network; (b) update the input data and reoptimize the offsets and splits of the affected intersections while the rest of the network remains fixed; (c) update the input data of affected intersections and reoptimize the whole network; or (d) use any combination of these options. This flexibility allows improving localized drawbacks while preserving system-wide efficiency.

Figures 2 and 3 show the time-space diagrams for TRANSYT-7F timings. These timings were completed after the final adjustments and were the ones under which the field studies were conducted.

PASSER II TIMINGS

Although PASSER II can optimize cycles, splits, offsets, and phase sequences, we optimized only the offsets because (a) we were retiming the same signals on the same arterial; (b) the roadway widths on both arterials were wide, and the minimum green time on cross streets (for pedestrians walking across the arterial) were long enough for traffic volumes on cross streets; and (c) the signals were predominately two-phased. However, PASSER II cannot optimize offsets only. To prevent splits from varying, we coded the minimum green equal to the existing green plus yellow and all-red times for each phase. We used the total directional volume as the bandwidth split. On 19th Avenue, however, because of motorists' complaints, we used a 65 percent bandwidth split to favor the northbound traffic, even though the total flow in this direction was 52 percent.

PASSER II can optimize up to 20 intersections per run. However, the arterials used had 30 and 33 intersections. Instead of arbitrarily dividing the arterial into two runs, intersections with similar volumes were grouped into segments. Each segment was optimized with a separate directional bandwidth split. After optimization, we manually aligned the through bands from each segment so that there was a continuous through band in the major flow direction while as much smooth flow as possible was maintained in the reverse direction. The resulting timing has the following characteristics:

1. The through bands on both directions of each segment are wider than those of arterials that are not segmented. The fewer the number of intersections, the wider the through bands, because fewer intersections means less constraints for PASSER II to maximize.
2. Having wider through bands within each segment means traffic has better progression and fewer stops within the segment, and the segment boundaries become the scheduled stopping points. That is, if a vehicle can pass the boundary intersection, it will not have to stop until the next boundary intersection.

During the first 2 months after implementation, we made minor adjustments to the offsets of intersections both within the same segment and between different segments. Adjusting a few seconds of offsets, at the northbound approach to Lincoln Avenue on 19th Avenue (Intersection 11 in Figure 1), for instance, remedied the spillback. However, PASSER II was not a good tool for minor adjustments. We could not freeze the timings on certain intersections while optimizing the others (although one can freeze the phase lengths and splits by coding the minimum greens, one cannot freeze the offsets). When we reran PASSER II by changing the queue clearance time on one or two intersections to try to avoid the spillback that was observed in the field, for instance, we got different offsets on almost all intersections. Because all of the timings had been set in the field, it was impractical to change all of them to correspond to PASSER II's optimal timing. Whenever we made adjustments, we still reran PASSER II to get some ideas and made the adjustments manually.

Figures 4 and 5 show the time-space diagrams for the PASSER II timings. These timings were completed after the minor adjustments and were the ones under which the field studies were conducted.

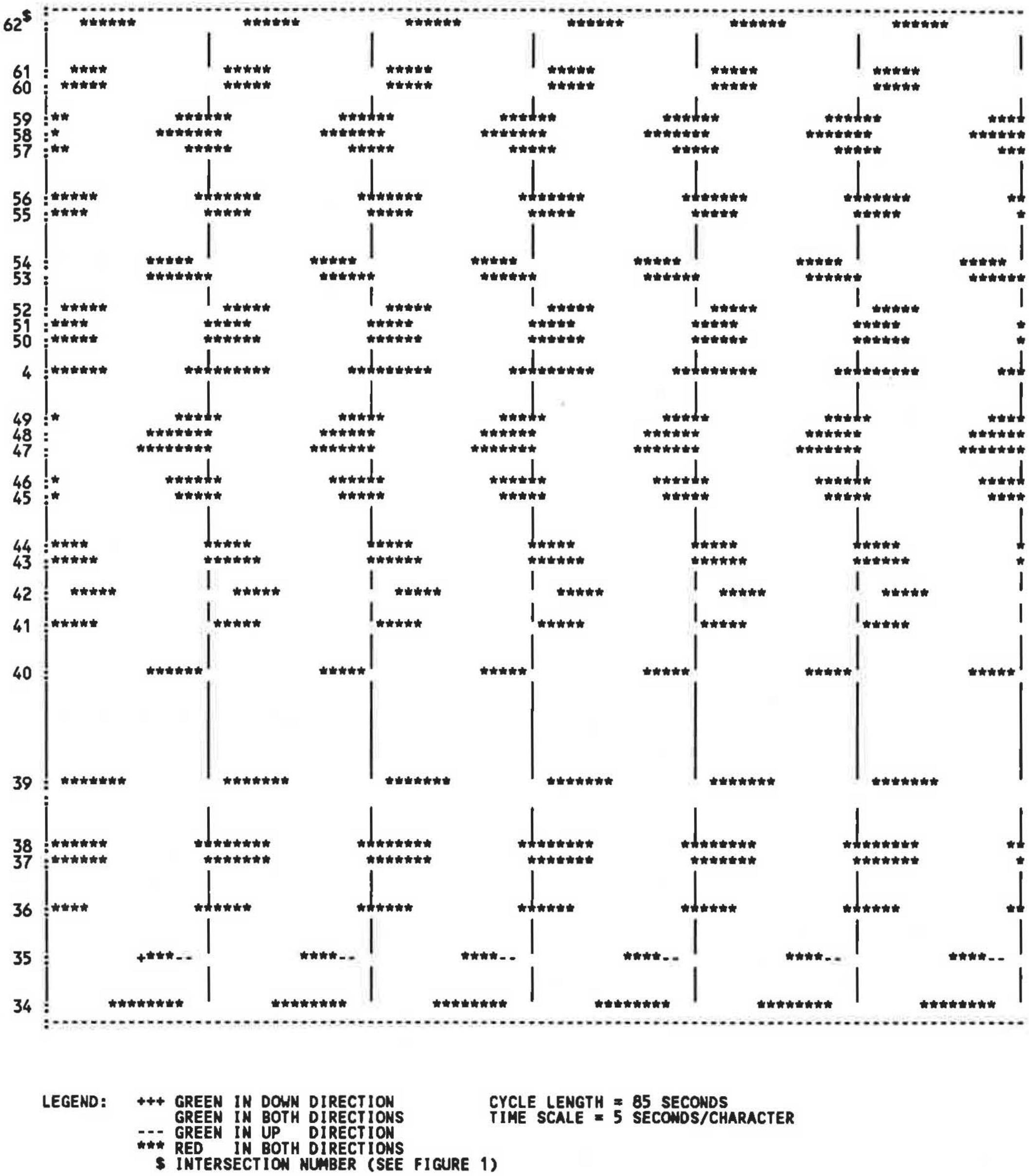


FIGURE 2 Geary Boulevard time-space diagram, from TRANSYT-7F.

FIELD STUDIES

The field studies were on four routes (Geary eastbound, Geary westbound, 19th Avenue northbound, and 19th Avenue southbound), as shown in Figure 1. Field studies under the TRANSYT timings were conducted in June 1988, and those under the PASSER timings were conducted in October 1988. Although the before and after studies were several months apart, the flow pattern would probably remain the same because (a) there were no major changes in land use along the study routes; (b) the study periods (a.m. and p.m. peak hours) were the commuting periods, and commuting traffic is usually not sensitive to monthly or seasonal changes except during major holiday periods; and (c) June and October are not major holiday periods for commuters. To minimize the variation of the before and after field data, the field studies were conducted along the same routers, during the same peak hours, and by the same driver and recorder during the TRANSYT and PASSER timings. Furthermore, we defined the data collection method precisely, especially in defining the number of stops. The number of stops was defined as follows:

- A stop occurred whenever the test vehicle was motionless for 3 sec or more. This avoided the ambiguity of minor stop-and-go situations.
- Only one stop was counted within the same phase on the same approach, even if there were two or more legitimate motionless periods. This avoided counting a stop more than once due to temporary lane obstruction, lane changing, or turning right on red by the preceding vehicles.

We wanted to collect travel time, stopped delay, and number of stops data. From previous studies on the same arterials (*5*), however, stopped delay data were not reliable because

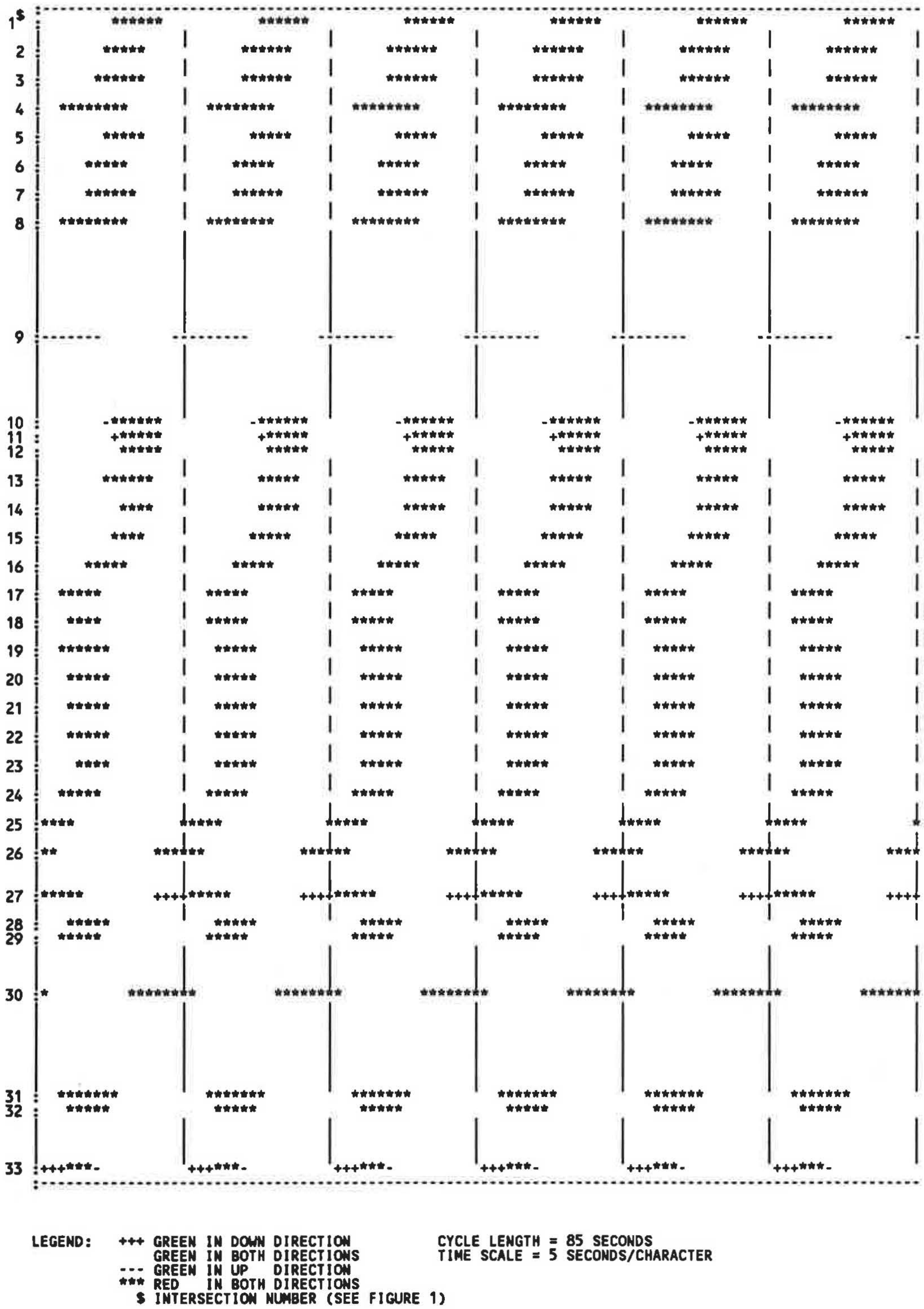


FIGURE 3 19th Avenue time-space diagram, from TRANSYT-7F.

of the ambiguities of slow-moving or stop-and-go situations. Stopped delay times varied so much that the sample size would have to be over 20 to attain a 95 percent level of confidence. We therefore ignored delay and concentrated on getting reliable travel time and stop data.

To determine the sample size, we applied the following equation (*6,7*):

$$N = (KS/E)^2 \quad (1)$$

where

N = number of samples,
K = 1.96 for a 95 percent level of confidence,
S = standard deviation, and
E = tolerable error, equals 1 min per route distance for

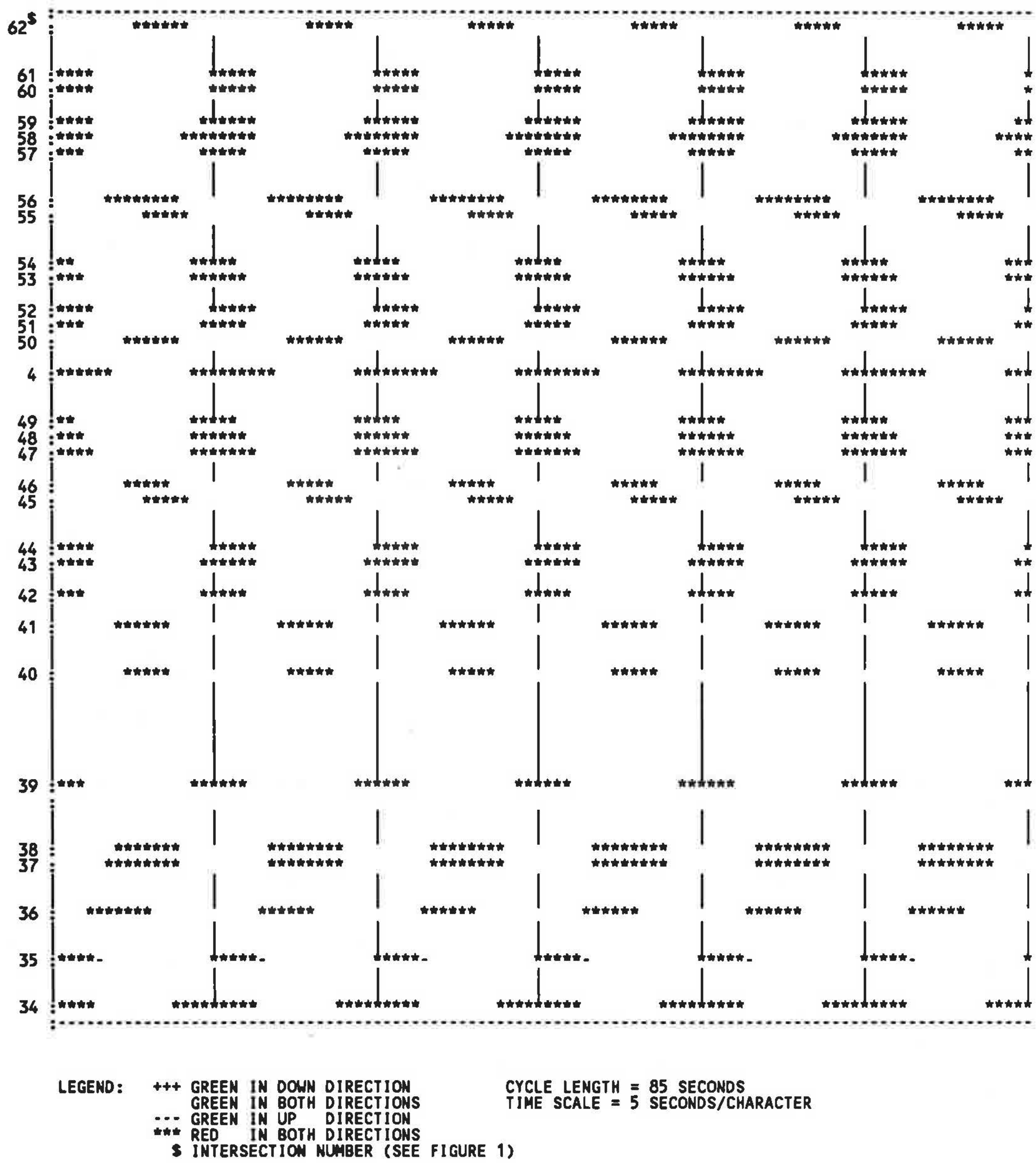


FIGURE 4 Geary Boulevard time-space diagram, from PASSER II.

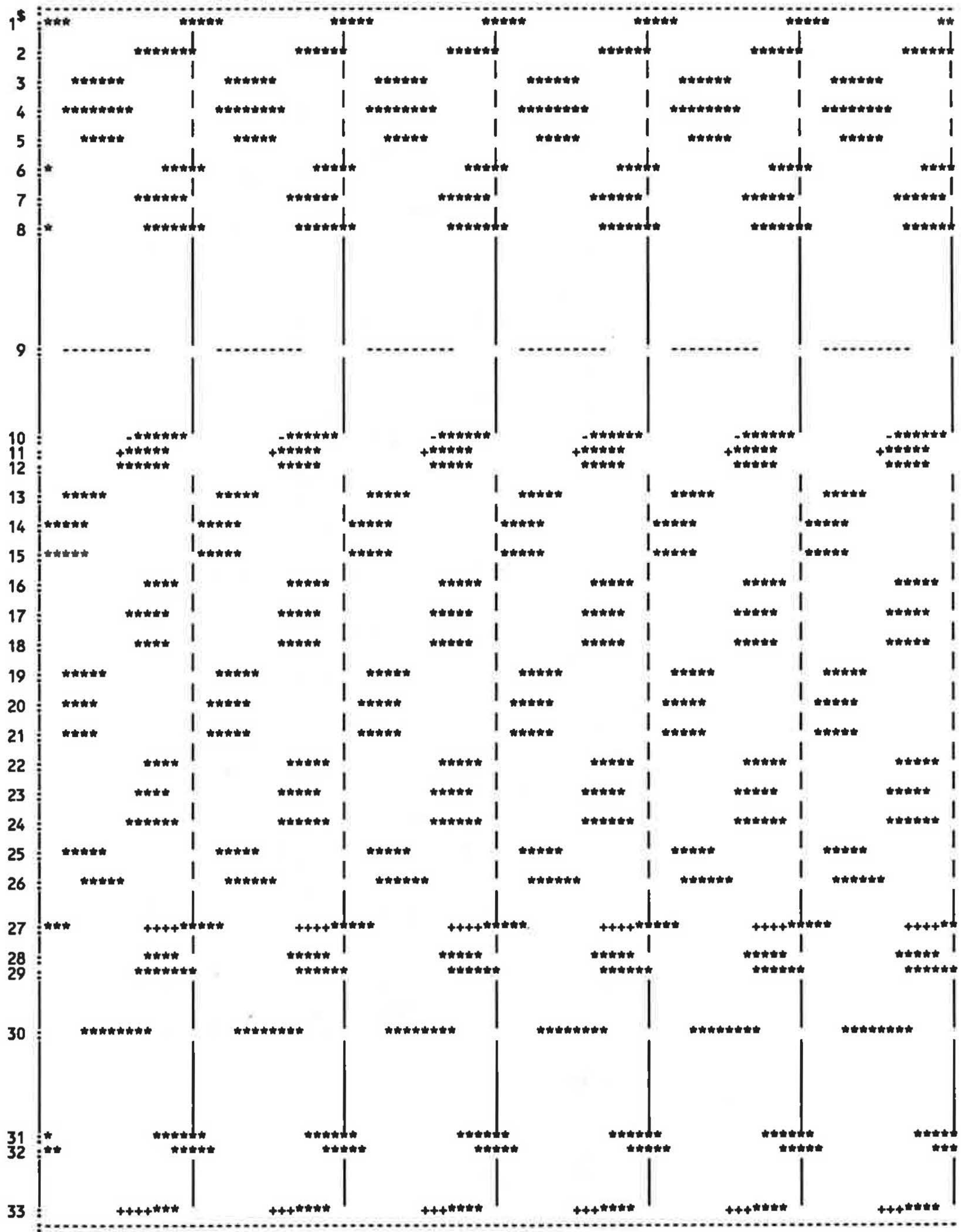
travel time and 1 stop per route distance for number of stops (route distances on Geary Boulevard and 19th Avenue were 3.4 and 4.8 mi, respectively).

After collecting three samples, we computed the standard deviation and applied Equation 1 to estimate the sample sizes for travel time and stops for each route. We repeated the process after each additional run until the number of field samples was equal to or greater than the computed sample size for travel time. We conducted additional samples to satisfy the computed sample size for stops, if possible.

The last lines on Tables 1 and 2 show that the sample size required to attain a 95 percent level of confidence for travel time ranged from 1 to 5 and that for stops ranged from 2 to 25. Hence, travel time requires less effort. The results also show that a street with less traffic friction requires fewer samples. For example, on 19th Avenue, where there were few left turns and parking activities, the required sample size for travel time ranged from one to five and that for stops ranged from two to seven. On Geary Boulevard, where there were heavy left turns and parking activities, the required sample size for travel time ranged from 3 to 5 and that for stops ranged from 4 to 25.

COMPARISON OF TIMING PLANS AND OPERATIONAL CHARACTERISTICS

The TRANSYT and PASSER timing plans on 19th Avenue were different (see Figures 3 and 5). The offsets by TRANSYT were mostly simultaneous and those by PASSER were double and triple alternates. Through our field observation, the PASSER timing plan had the following characteristics:



LEGEND: +++ GREEN IN DOWN DIRECTION
GREEN IN BOTH DIRECTIONS
--- GREEN IN UP DIRECTION
*** RED IN BOTH DIRECTIONS
$ INTERSECTION NUMBER (SEE FIGURE 1)

CYCLE LENGTH = 85 SECONDS
TIME SCALE = 5 SECONDS/CHARACTER

FIGURE 5 19th Avenue time-space diagram, from PASSER II.

1. At the start of green, if our test vehicle was not within the through band, it would hit the red signal at the next one or two intersections (because of double or triple alternating of offsets). After that, we would join the platoon of vehicles within the through band and would go through many intersections without stopping. The platoon of vehicles within the through band became larger as more vehicles joined. The more intersections the platoon of vehicles could go through, the more vehicles would accumulate behind it. Soon the length of the moving platoon became so long that it would oversaturate the green signal. That is, vehicles at the front of the platoon would arrive at the beginning of the green signal and

TABLE 1 FIELD RESULTS UNDER TRANSYT-7F TIMING

	Geary boulevard				19th Avenue/Park Presideo Boulevard			
	Eastbound		Westbound		Northbound		Southbound	
Test Run No.	Travel Time (Min/Mi)	No. of Stops (Per Mi)	Travel Time (Min/Mi)	No. of Stops (Per Mi)	Travel Time (Min/Mi)	No. of Stops (Per Mi)	Travel Time (Min/Mi)	No. of Stops (Per Mi
1	2.89	1.46	3.94	2.92	2.84	1.67	2.59	1.46
2	3.48	2.92	3.08	2.04	2.61	1.25	2.72	1.67
3	2.88	1.17	3.45	2.33	2.77	1.67	2.55	1.46
4	2.54	0.58	3.13	1.75	2.65	1.67	2.61	1.67
5	2.97	1.17	3.39	2.04	2.69	1.67	2.48	1.25
6	2.92	1.17	3.47	2.33	2.62	1.46	2.53	1.46
7	2.90	1.46	3.48	2.33	2.85	1.67	2.65	1.46
8	3.14	2.62	3.41	2.04	2.65	1.67	2.65	1.46
9	3.19	1.46	3.07	2.04	2.57	1.67	-	-
10	-	-	3.48	2.04	2.63	1.46	-	-
Average	2.99	1.55	3.39	2.19	2.69	1.59	2.60	1.49
Req'd Runs[1]	3	25	3	4	1	2	1	2

[1]Required sample size to attain 95% confidence level, computed from equation 1.

TABLE 2 FIELD RESULTS UNDER PASSER II TIMING

	Geary boulevard				19th Avenue/Park Presideo Boulevard			
	Eastbound		Westbound		Northbound		Southbound	
Test Run No.	Travel Time (Min/Mi)	No. of Stops (Per Mi)	Travel Time (Min/Mi)	No. of Stops (Per Mi)	Travel Time (Min/Mi)	No. of Stops (Per Mi)	Travel Time (Min/Mi)	No. of Stops (Per Mi)
1	2.89	1.75	2.60	0.87	2.22	0.42	2.70	1.67
2	3.02	2.33	2.55	0.87	2.64	0.84	3.07	2.30
3	3.29	2.04	3.74	2.33	2.39	1.04	3.35	2.30
4	3.03	1.46	3.33	1.75	2.37	1.04	3.15	2.09
5	3.04	1.75	2.97	1.17	2.30	0.84	3.17	2.51
6	2.85	1.75	2.92	1.17	2.75	1.25	3.27	2.30
7	3.15	2.04	3.42	2.33	3.23*	1.88*	3.81*	2.30*
8	2.47	1.17	3.27	2.04	4.04*	1.88*	3.50*	2.51*
9	3.18	2.33	3.00	1.17	-	-	-	-
10	2.96	1.46	2.59	0.58	-	-	-	-
11	3.22	2.62	3.37	2.04	-	-	-	-
12	3.22	2.33	2.90	2.04	-	-	-	-
12	3.39	2.04	2.93	2.04	-	-	-	-
14	3.34	2.04	2.87	2.04	-	-	-	-
15	3.36	2.04	3.27	1.75	-	-	-	-
Average	3.09	1.94	3.05	1.61	2.44	0.90	3.12	2.19
Req'd Runs[1]	3	7	5	15	4	7	5	7

[1]Required sample size to attain 95% confidence level, computed from equation 1.
*During foggy weather, not included in the averages and other statistical calculations.

would go through without stopping, but vehicles at the back of the platoon would arrive at the same approach beyond the green signal and would have to stop for the red signal.

2. At the start of green, if our test vehicle was within the through band and was the leading vehicle, it could theoretically go through all of the intersections without stopping. However, in a heavy traffic situation such as 19th Avenue, we could not do so because even if we maintained a speed matching the design speed of the through band, we would join the back of another moving platoon after going through about 10 intersections. This "other" moving platoon was from the through band of the previous cycle. Once we joined the back of this other moving platoon, we would no longer be the leading vehicle and would have difficulty maintaining a constant speed (because of frictions from preceding vehicles). We would stop sooner or later because the vehicle at the front

of this other moving platoon would oversaturate the green signal, as mentioned in Point 1.

3. We encountered midblock stops or stop-and-go situations quite often, probably because of the long platoon. However, most of these stops did not fit our definition of stops and were not counted in our field data.

4. Such timing appeared to encourage motorists to travel at the design speed because they would get the best progression at this speed. However, it appeared that it would also encourage motorists to go through yellow signals, because if they could pass the yellow signal, they could remain within the through band and pass many intersections without stopping.

5. During foggy weather, the progression became very bad (see Run Numbers 7 and 8, Table 2). Motorists became cautious and drove slower than the design speed, so, a vehicle originally within the through band would be out of the through band, or "out of sync," after passing a few intersections. Once out of the through band, the vehicle would have to stop once or twice before returning to the through band.

The TRANSYT-7F timing on 19th Avenue, by comparison, did not provide a through band. Our test vehicle would stop after going through several intersections, no matter when we started during the cycle. This was probably because of the simultaneous offsets. Because each vehicle would stop after going through several intersections, the platoons were in small bundles rather than in long queues. There were fewer midblock stops and stop-and-go situations. This is probably because the platoons were in small bundles and the queues were shorter. This timing plan appeared to encourage speeding because the higher the speed, the more intersections the vehicle could go through. However, it appeared that one would not be encouraged to go through yellow signals, because passing one intersection during yellow would not necessarily have the advantage of passing the next intersection. Although we did not experience foggy weather during field studies, we expect the progression would not be as dramatically changed as that of the PASSER timing because the platoons of vehicles were in smaller bundles.

TRANSYT-7F, Release 6, has a link-to-link flow weighting feature (*8*, p. 4-52) which can be used to encourage progression along the arterial. Although this feature was not available during the 1987 project, we subsequently applied it to the 19th Avenue data set to see how the offsets would have been different. We used link-to-link weights along 19th Avenue for (a) both directions and (b) northbound only. Figures 6 and 7 show the time-space diagrams, which were similar to the one in Figure 3. Hence, even if we had applied this new feature to our TRANSYT-7F timings in 1987, the resulting progressions would have been similar. The phenomena described above would still have been true.

The TRANSYT and PASSER offset patterns on Geary Boulevard were about the same. Their operational characteristics were also similar.

COMPARISON OF FIELD RESULTS

To compare whether the changes were statistically significant, we computed the t-statistic as follows (*9*, p. 294; *10*):

$$T_{(\alpha/2, Nt+Np-2)} = \frac{X_t - X_p}{\sqrt{\left[\frac{S_t^2(N_t - 1) + S_p^2(N_p - 1)}{N_t + N_p - 2}\right]\left(\frac{1}{N_t} + \frac{1}{N_p}\right)}} \quad (2)$$

where

T = computed t-statistic, with $(1 - \alpha)$ percent level of confidence and $(N_t + N_p - 2)$ degrees of freedom;
α = 0.05;
X = mean value;
S_t = standard deviation, TRANSYT timings;
S_p = standard deviation, PASSER timings;
N_t = number of samples, TRANSYT timings; and
N_p = number of samples, PASSER timings.

If the absolute value of the computed t-statistic is less than the corresponding critical value of the t-distribution, the change is not significant.

Equation 2 assumes that the data are normally distributed and that the variance of the data from TRANSYT timing is equal to the variance of the data from PASSER timing. To test whether the data are normally distributed, we applied the Kolmogorov-Smirnov test, as follows (*9*, p. 533):

$$D = \max|F_i - S_i| \quad (3)$$

where

D = Kolmogorov-Smirnov test statistic,
F_i = cumulative frequency of the ith category from normal distribution, and
S_i = cumulative frequency of the ith category from field data.

The Kolmogorov-Smirnov test (at a 95 percent level of confidence) indicated that each of the 16 data sets listed in Tables 1 and 2 can be regarded as normally distributed.

To ensure that the variance of the data from TRANSYT timing is equal to the variance of the data from PASSER timing, we collected the data along the same routes, during the same peak hours, and by the same driver and recorder during the TRANSYT and PASSER timings, respectively. Furthermore, the denominator of Equation 2 is from the weighted average of the sample variances of the TRANSYT and PASSER timings, respectively. It is the best estimate of the population variance, which also ensures the equal variance assumption (*9*, p. 293).

Table 3 summarizes the comparison. On Geary Boulevard, there was improvement in westbound (p.m. outbound). The PASSER timing reduced travel time and stops by 10 percent and 26 percent, respectively, along the arterial when compared to the TRANSYT timing. In eastbound, however, it increased travel time and stops by 3 percent and 25 percent, respectively. The changes in westbound were significant at a 95 percent level of confidence, but those in eastbound were not.

On 19th Avenue, there was improvement in northbound (a.m. inbound). The PASSER timing reduced travel time and stops by 9 percent and 43 percent, respectively. In southbound, however, it increased travel time and stops 20 percent

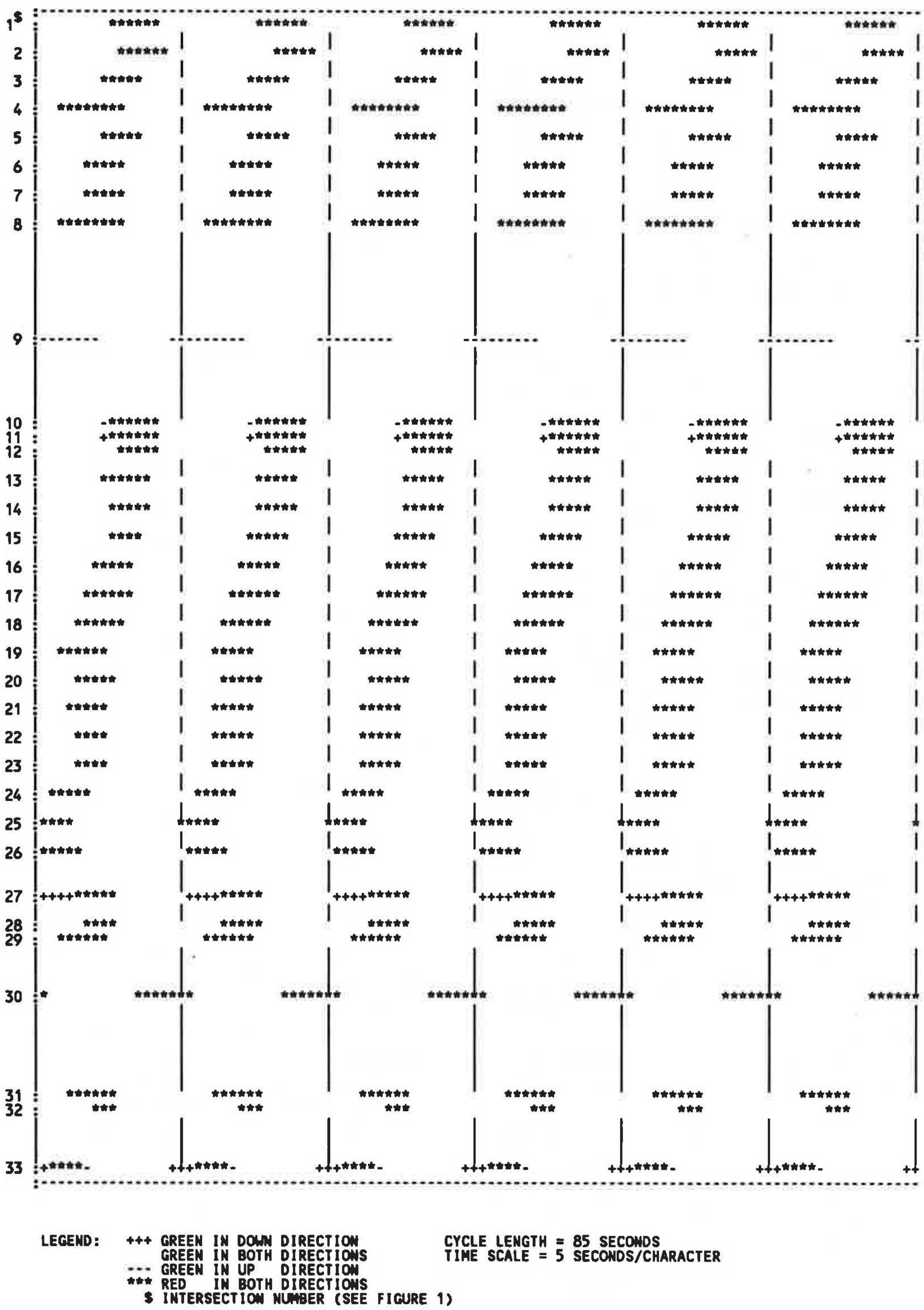


FIGURE 6 19th Avenue time-space diagram, from TRANSYT-7F link-to-link weight in both directions.

and 47 percent, respectively. All of these changes were significant at 95 percent level of confidence.

From the above results, it appeared that the PASSER timings improved one direction but worsened the other. To get an overall picture, we weighted the changes by traffic volumes, as shown in Table 4. The PASSER timings increased the weighted travel time by 0.7 percent and the weighted number of stops by 2.6 percent. The TRANSYT-7F timings appeared to be slightly better; however, if we exclude the data on eastbound Geary Boulevard (because both the travel time and stops were not statistically significant), the PASSER timings would increase the weighted travel time by 0.2 percent

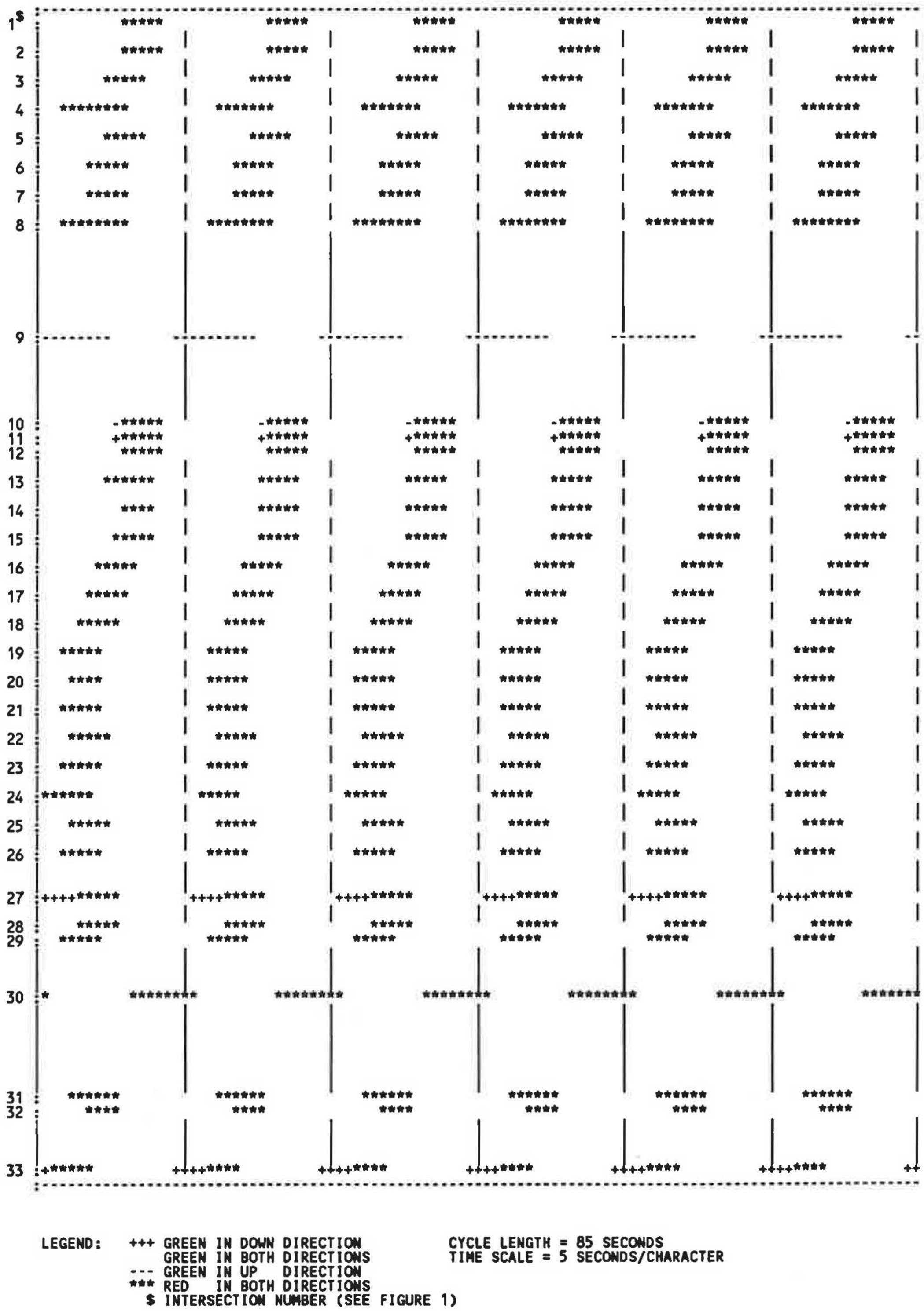


FIGURE 7 19th Avenue time-space diagram, from TRANSYT-7F link-to-link weight in northbound only.

and would reduce the number of stops by 9 percent. Therefore, we conclude that the effectiveness of the TRANSYT and PASSER timings was about the same.

In Table 3, the comparison of stops in eastbound Geary Boulevard was interesting. Although there was a 25 percent change in the number of stops, it was not significant at a 95 percent level of confidence (i.e., the result was due to chance). This happened even though we had defined stop precisely (see "Field Studies"), we had collected 9 to 15 samples (see Tables 1 and 2), and the magnitude of change was 25 percent. Also, as Tables 1 and 2 show, it may require 25 samples to attain a 95 percent level of confidence. Hence, collecting stops

TABLE 3 COMPARISON OF FIELD RESULTS

	Geary Boulevard		19th Avenue	
	Eastbound	Westbound	Northbound	Southbound
TRANSYT Timing				
Travel Time (Min/Mi)				
Mean, Xt	2.99	3.39	2.69	2.60
Standard Deviation, St	0.261	0.258	0.098	0.077
Number of Stops (Per Mi)				
Mean, Xt	1.55	2.18	1.59	1.49
Standard Deviation, St	0.743	0.315	0.146	0.134
PASSER Timing				
Travel Time (MIN/Mi)				
Mean, Xp	3.09	3.05	2.44	3.12
Standard Deviation, Sp	0.242	0.343	0.206	0.226
Number of Stops (Per Mi)				
Mean, Xp	1.94	1.61	0.90	2.19
Standard Deviation, Sp	0.392	0.582	0.285	0.288
Comparison of Travel Time				
Difference, Xt-Xp	-0.10	0.34	0.25	-0.52
% Change, 100(Xt-Xp)/Xt	-3%	10%	9%	-20%
t-Statistics[1]	-0.99	2.69	3.22	-6.14
Significant at 95% Confidence Level?	No	Yes	Yes	Yes
Comparison of Number of Stops				
Difference, Xt-Xp	-0.39	0.57	0.68	-0.70
% Change, 100(Xt-Xp)/Xt	-25%	26%	43%	-47%
t-Statistics[1]	-1.67	2.84	6.39	-6.15
Significant at 95% Confidence Level?	No	Yes	Yes	Yes

[1] Computed from equation 2.

TABLE 4 FIELD RESULTS WEIGHTED BY TRAFFIC VOLUME

	(1) Total Flow (Veh/Hr)	(2) Travel Time (Min/Mi)	(3) No. of Stops (No/Mi)	(1)x(2)	(1)x(3)
Under TRANSYT Timing					
Geary Blvd., E.B.	33255	2.99*	1.55*	99432	51545
Geary Blvd., W.B.	47755	3.39	2.19	161889	104583
19th Ave., N.B.	76806	2.69	1.59	206608	122122
19th Ave., S.B.	70606	2.60	1.49	183576	105203
	Weighted Total, All Routes:			651505	383453
	Weighted Total, Geary E.B. Excluded:			552073	331908
Under PASSER Timing					
Geary Blvd., E.B.	33255	3.09*	1.94*	102758	92645
Geary Blvd., W.B.	47755	3.05	1.61	145653	76886
19th Ave., N.B.	76806	2.44	0.90	187407	69125
19th Ave., S.B.	70606	3.12	2.19	220290	154627
	Weighted Total, All Routes:			656108	393283
	Weighted Total, Geary E.B. Excluded:			553350	300638

Change in Weighted Travel Time = (651505-656108)/651505 = -0.7%
Change in Weighted No. of Stops = (383453-393283)/383453 = -2.6%

Change in Weighted Travel Time, Geary E.B. Excluded = (552073-53350)/552073 = -0.2%
Change in Weighted No. of Stops, Geary E.B. Excluded = (331908-300638)/331908 = 9%

*Not significant at 95% level of confidence.

data may require great effort. On the other hand, travel time required five samples or less to attain a 95 percent level of confidence (see Tables 1, 2, and 3). Travel time data are also easy to obtain. Only a stopwatch is needed to record the starting and ending times. Because it is reliable and easy to obtain, one should use travel time data whenever possible.

COMPARISON OF MODEL-SIMULATED AND FIELD RESULTS

Table 5 shows the TRANSYT-7F simulated results under the TRANSYT and PASSER timings. The values were for links along the arterial (excluding cross streets) and were stratified to correspond to the test routes. The results show that the simulated travel time (total time), delays, stops, fuel consumption, and performance index under the TRANSYT timings were 4 to 52 percent better than those under the PASSER timings in all cases. The TRANSYT timings appeared to be better; however, the field results showed that the PASSER timings were better in some cases.

One reason for the disparity may be our choice of platoon dispersion factor (PDF) during simulation (we used PDF = 0.35 in Table 5). PDF affects the predicted flow rates from the upstream stop line to the downstream stop line and hence affects the simulated measures of effectiveness (MOEs). The TRANSYT-7F manual suggests 0.25, 0.35 and 0.5 for low-, moderate-, and heavy-friction roadway characteristics (*8*, p. 4-32). We applied all of these PDFs to simulate travel times. Table 6 (first three rows) shows the results. It shows that no matter which PDFs were used, the simulated travel times under the TRANSYT timings were 3 percent to 9 percent better than those under the PASSER timings. However, the travel times from field data (Table 6, fourth row) showed differently. It shows that the travel times on westbound Geary Boulevard and northbound 19th Avenue under the TRANSYT timings were 10 percent and 9 percent, respectively, worse than those under the PASSER timings. Hence the TRANSYT-7F simulation results were inclined in favor of the timing plans optimized by TRANSYT-7F.

Comparison of the magnitudes of the simulated and field travel times, in Table 6 (fifth row), shows that the differences ranged from 3 to 12 percent, which were reasonably close.

CONCLUSIONS

When timing arterial signals, TRANSYT-7F is expected to be better if the whole system, including cross streets, is considered; PASSER II is expected to be better if only the arterial street is considered. Field results, however, indicated that the effectiveness of TRANSYT-7F and PASSER II was about the same in terms of travel time and stops along the arterial (excluding cross streets). The offset patterns and operational characteristics of the TRANSYT timing might be different than those of the PASSER timing, as shown in 19th Avenue. On the other hand, they might be similar, as shown in Geary Boulevard. Travel time field data were reliable and easy to collect. Statistically, one to five samples were required to attain a 95 percent level of confidence for our example arterials, each with 30 or more signalized intersections. The TRANSYT-7F simulated travel times were reasonably close to the field travel times in terms of magnitude. On the other hand, the simulated travel times were inclined in favor of the timing plans optimized by TRANSYT-7F. Hence, when we make comparisons in relative terms, care must be exercised to avoid drawing the wrong conclusion. When making comparisons, travel time field data should be included whenever possible because they are reliable and easy to obtain. Though TRANSYT-7F may require more work to obtain an optimal timing plan, it is easier to use for fine-tuning or for later modification of any signals. Though PASSER II may be easier

TABLE 5 TRANSYT-7F SIMULATED RESULTS[1]

	Geary Boulevard						19th Avenue					
	Eastbound			Westbound			Northbound			Southbound		
	(1) TRANSYT Timing	(2) PASSER Timing	(1-2)/1 Percent Change	(3) TRANSYT Timing	(4) PASSER Timing	(3-4)/3 Percent Change	(5) TRANSYT Timing	(6) PASSER Timing	(5-6)/5 Percent Change	(7) TRANSYT Timing	(8) PASSER Timing	(7-8)/7 Percent Change
Total Time (Veh-Hr/Hr)	233	243	-4%	318	336	-6%	536	564	-5%	499	549	-10%
Total Delay (Veh-Hr/Hr)	75	85	-13%	98	116	-16%	178	206	-16%	167	218	-31%
Average Delay (Sec/Veh)	8.1	9.2	-14%	7.4	8.8	-19%	8.3	9.7	-17%	8.5	11.1	-31%
Uniform Stops (%)	36	48	-33%	31	42	-35%	31	47	-52%	31	46	-48%
Fuel Consumption (Gal/Hr)	307	332	-8%	403	446	-11%	797	914	-15%	734	854	-16%
Performance Index	117	143	-22%	140	184	-31%	315	433	-37%	290	410	-41%

[1]From TRANSYT-7F, Release 6's Route Summary Report, with arterial links (excluding cross street links) corresponding to the field study routes.

TABLE 6 TRAVEL TIMES FROM TRANSYT-7F SIMULATION AND FROM FIELD DATA

	Geary Boulevard						19th Avenue					
	Eastbound			Westbound			Northbound			Southbound		
	(1) TRANSYT Timing	(2) PASSER Timing	(1-2)/1 Percent Change	(3) TRANSYT Timing	(4) PASSER Timing	(3-4)/3 Percent Change	(5) TRANSYT Timing	(6) PASSER Timing	(5-6)/5 Percent Change	(7) TRANSYT Timing	(8) PASSER Timing	(7-8)/7 Percent Change
From Simulation (Min/Mi)[1]												
With PDF[2]= 25	3.10	3.22	-4%	3.05	3.23	-5%	2.50	2.61	-4%	2.53	2.76	-9%
With PDF = 35	3.12	3.23	-4%	3.09	3.24	-5%	2.53	2.63	-4%	2.56	2.79	-9%
With PDF = 50	3.15	3.23	-3%	3.14	3.26	-4%	2.57	2.67	-4%	2.60	2.84	-9%
From Field Data (Min/Mi)	2.99	3.09	-3%	3.39	3.05	10%	2.69	2.44	9%	2.60	3.12	-20%
Maximum Difference Between Simulation and Field Data[3]	-5%	-5%	NA	10%	-7%	NA	7%	-9%	NA	3%	12%	NA

[1]From TRANSYT-7F, Release 6's Route Summary Report, with Total Flow divided by Flow and the units converted to minutes per mile. The values were for through links on the arterial that correspond to the field study routes.

[2]PDF = Platoon dispersion factor.

[3]100[(Travel time from field data)-(highest or lowest travel time from simulation)]/(Travel time from field data)

NA = Does not apply.

to use for obtaining an optimal timing plan, it is difficult to use for fine-tuning or modifying selected intersections while trying to maintain an optimal setting with the rest of the system.

SUGGESTIONS FOR FURTHER RESEARCH AND DEVELOPMENT

1. These findings represent only two timing plans on two arterials. More studies are needed before we can generalize the results.

2. TRANSYT-7F assumes uniform arrival for each of the first approach entering a network. When timing an arterial, cross-street approaches are usually coded as the first approaches entering the network, hence the arrival patterns on cross streets are uniform. Although TRANSYT considers flows from cross streets, the flows may not be realistic. Future development should consider the ability of specifying arrival patterns.

3. When we try to get a different offset pattern from TRANSYT-7F optimization by applying weights to delay and stops, using link-to-link flow weighting feature, or inputting the PASSER II offsets, the result remains about the same. More research on the hill-climb process may produce a relationship to get different offset patterns.

4. In using PASSER II, one cannot freeze the offsets of certain intersections while optimizing the others. In practice, there is usually a need to change the offsets on certain intersections. When this happens, one would like to reoptimize only the affected intersections rather than the whole system. Future development should consider this possibility.

5. The green band from the PASSER II timing should enable a vehicle to travel without stopping throughout the system, if the vehicle is able to maintain a speed matching the design speed. However, this may not be possible because the vehicle may join the back of another moving platoon or queue. This moving platoon is from the previous cycle. Although PASSER II considers queue clearance time, it does not address the catching up of the moving platoon from the previous cycle. Research should be conducted to include this phenomenon into the optimization process.

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