VEHICULAR TRAFFIC PROGRESSION
TIME-SPACE PLOT PROGRAM

Texas Highway Department
Division of Automation
Revised 1973

This program is a modified version of a program written by IBM. The original program made no warranty expressed or implied as to the function or performance of this program and the user of the program was expected to make final evaluation as to its usefulness in his own environment. Through use over a period of time modifications were made by the Texas Highway Department with the intent of simplifying the input requirements but retaining the program's practical usefulness.

VEHICULAR TRAFFIC PROGRESSION TIME-SPACE PLOT PROGRAM

I. Introduction

The Vehicular Traffic Progression Time-Space Plot program designs traffic signal progressions with maximum average vehicle speeds and minimum signal cycle time within given restrictions such as speed limits and required traffic volumes. A least squares fit model is used to develop a space periodicity constant from given volume and distance data. This, in turn, is used to calculate a maximum speed-minimum cycle combination for the maximum volume demand in the system. Results in terms of calculated green splits, cycle time, speeds and signal offsets are printed and the computed time-space diagrams are available as either a plot or a simulated plot printed on the remote terminal.

The results generated by this program may not necessarily represent the optimum solution for a particular artery. No differentiation is made between free-flow or forced-flow traffic conditions which may represent the actual conditions as submitted to the program. However, the user can approach the optimum solution by supplying the most accurate values for the Average Speed, the Lower and Upper Cycle Limits and the Cross Street Intervals. If the "floating" car study or other similar studies as well as traffic and pedestrian counts are used as the basis for determining the values supplied for these items, the probability of approaching an optimum solution will be increased.

II. Input Data

The data form for this program is shown in Figures 1 and 2. Figure 1 shows the front side of the form where data entry is made. Figure 2 shows the back side of the form which has notes on data entry and sample problem input.

For each problem there must be one Card Type 1 for identification, one Card Type 2 to specify the system parameters and as many Card Type 3 cards as necessary to specify the parameters for each intersection included in the evaluation. A maximum of thirty intersections may be used. The input requirements for each type of card will be given on the following pages.

Card Type 1

This card identifies the traffic signal system. All entries are left justified except the District Number which is right justified.

Columns 1-6. Name of the city.

Columns 17-32. Name of the artery.

Columns 33-48. Name of the first cross street.

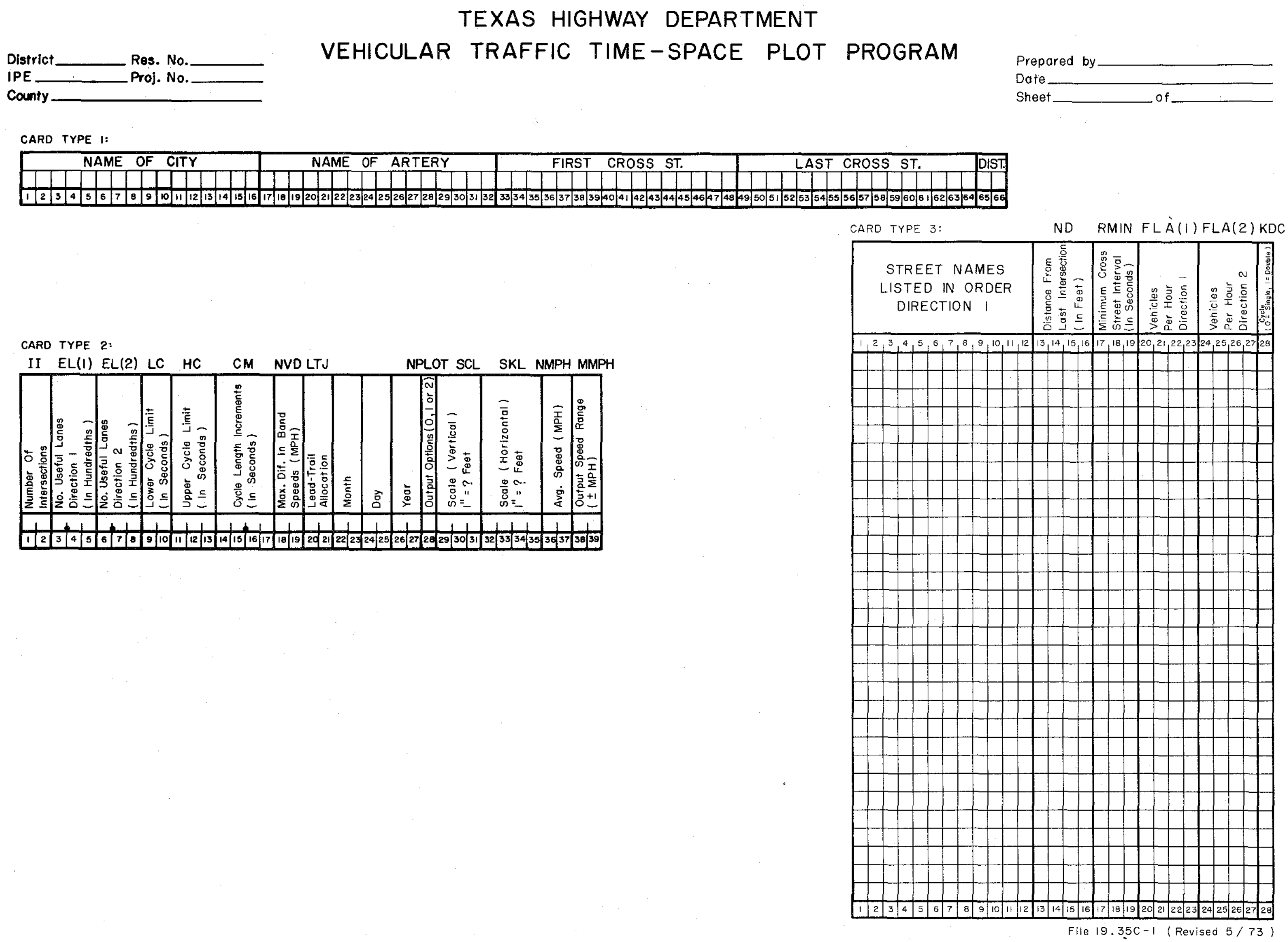
Columns 49-64. Name of the last cross street.

Columns 65-66. District number.

Card Type 2

This is the system control card on which the system parameters are specified. All entries are right justified except those where there is a preprinted decimal point. Entries in these columns must conform to the decimal point.

Columns 1-2, II. The number of signalized intersections to be considered in the progression designs. Maximum number is 30. (There must be as many of Card Type 3 as specified here.)



TEXAS HIGHWAY DEPARTMENT
VEHICULAR TRAFFIC TIME-SPACE PLOT PROGRAM

District ________ Res. No. ________
IPE ________ Proj. No. ________
County ________

Prepared by ________
Date ________
Sheet ________ of ________

CARD TYPE 1:

NAME OF CITY	NAME OF ARTERY	FIRST CROSS ST.	LAST CROSS ST.	DIST.
1–16	17–32	33–48	49–64	65–66

CARD TYPE 2:

II	EL(1)	EL(2)	LC	HC	CM	NVD	LTJ				NPLOT	SCL	SKL	NMPH	MMPH
Number Of Intersections	No. Useful Lanes Direction 1 (In Hundredths)	No. Useful Lanes Direction 2 (In Hundredths)	Lower Cycle Limit (In Seconds)	Upper Cycle Limit (In Seconds)	Cycle Length Increments (In Seconds)	Max. Dif. In Band Speeds (MPH)	Lead-Trail Allocation	Month	Day	Year	Output Options (0, 1 or 2)	Scale (Vertical) 1" = ? Feet	Scale (Horizontal) 1" = ? Feet	Avg. Speed (MPH)	Output Speed Range (± MPH)
1–2	3–5	6–8	9–10	11–13	14–17	18–19	20–21	22–23	24–25	26–27	28	29–31	32–35	36–37	38–39

CARD TYPE 3:

	ND	RMIN	FLA(1)	FLA(2)	KDC
STREET NAMES LISTED IN ORDER DIRECTION 1	Distance From Last Intersection (In Feet)	Minimum Cross Street Interval (In Seconds)	Vehicles Per Hour Direction 1	Vehicles Per Hour Direction 2	Cycle (0 = Single, 1 = Double)
1–12	13–16	17–19	20–23	24–27	28

File 19.35C-1 (Revised 5 / 73)

Figure 1. Front Side of the Data Form

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VEHICULAR TRAFFIC TIME-SPACE PLOT PROGRAM
(CONTINUED)

CARD TYPE 1:

NAME OF CITY (cols. 1–16)	NAME OF ARTERY (cols. 17–32)	FIRST CROSS ST. (cols. 33–48)	LAST CROSS ST. (cols. 49–64)	DIST. (cols. 65–66)
LEAGUE CITY	US 390	WASHINGTØN ST	CØLUMBIA AVE	12

NPLOT: Time-space diagram: 0 = no diagram; 1 = printer simulated plot; 2 = digital plot.

EL: Useful lanes are lanes of moving traffic and do not include parking lanes. A lane for turning movements may be shown as an effective function of a lane for through traffic.

LC: Show desired minimum cycle length from calculations based on vehicle and pedestrian traffic volume counts.

HC: Suggest upper cycle length not be more than 10 seconds longer than the lower cycle limit.

CARD TYPE 2:

II	EL(1)	EL(2)	LC	HC	CM	NVD	LTJ				NPLOT	SCL	SKL	NMPH	MMPH
Number Of Intersections	No. Useful Lanes Direction 1 (In Hundredths)	No. Useful Lanes Direction 2 (In Hundredths)	Lower Cycle Limit (In Seconds)	Upper Cycle Limit (In Seconds)	Cycle Length Increments (In Seconds) (Note 1)	Max. Dif. In Band Speeds (MPH) (Note 2)	Lead-Trail Allocation (Note 3)	Month	Day	Year	Output Options (0, 1 or 2)	Scale (Vertical) 1" = ? Feet	Scale (Horizontal) 1" = ? Feet	Avg. Speed (MPH) (Note 4)	Output Speed Range (± MPH) (Note 5)
1–2	3–5	6–8	9–10	11–13	14–17	18–19	20–21	22–23	24–25	26–27	28	29–31	32–35	36–37	38–39
4	2.10	2.10	45	45	5.00	0	00	5	30	73	1	30	500	36	10

CARD TYPE 2 NOTES

NOTE 1 (CM):
Multiples of 5.00 seconds are suggested for fixed time signals.

NOTE 2 (NVD):
For average offset, suggest 0 MPH be used; for preferential offset, suggest 10 MPH be used.

NOTE 3 (LTJ):
Lead or Trail speeds in red (suggest 00 or 03 be used)
- 00 – Offsets computed from input are used
- 01 – Offsets will be trail justified
- 02 – Offsets will be lead justified
- 03 – Attempt is made to line up each through band with the start green

NOTE 4 (NMPH):
Average speed of platoons of vehicles traveling through the signal system. If no entry is made, the program uses 30 MPH.

NOTE 5 (MMPH):
Output is generated only for the range of speeds (columns 38 – 39) above and below the average speed (columns 36 – 37). If no entry is made, the program uses ± 10 MPH (columns 38 – 39).

CARD TYPE 3:

STREET NAMES LISTED IN ORDER DIRECTION 1	ND	RMIN	FLA(1)	FLA(2)	KDC
	Distance From Last Intersection (In Feet)	Minimum Cross Street Interval (In Seconds)	Vehicles Per Hour Direction 1	Vehicles Per Hour Direction 2	Cycle (0 = Single, 1 = Double)
1–12	13–16	17–19	20–23	24–27	28
WASHINGTØNST	0	13	275	250	0
HARRISBURGST	1905	14	275	250	0
VELASCØ BLVD	719	17	350	250	0
CØLUMBIA AVE	2647	13	250	300	0

Insert 1 only when cross street phase is to occur every other cycle.

File 19.35C-2 (Revised 5 / 73)

Figure 2. Back Side of the Data Form

Columns 3-5, EL(1). The equivalent number of useful lanes in Direction 1 (from the first to the last intersection).

Columns 6-8, EL(2). The equivalent number of useful lanes in Direction 2 (opposite direction).

Columns 9-10, LC. The lower limit of the cycle times (in seconds) to be considered in the progression designs. It is recommended that the cycle time used be obtained from calculations based on vehicle and pedestrian volume counts for specific traffic volume conditions.

Columns 11-13, HC. The upper limit of the cycle times (in seconds) to be considered in the progression designs. It is recommended that the cycle time used be no more than 10 seconds above the lower cycle limit (LC). Since the minimum cross street interval times (columns 17-19 of Card Type 3) will usually increase as the cycle length increases, the minimum cross street interval times would be irrelevant for any cycle lengths more than 10 seconds above the lower cycle limit. If a progression design of only one cycle length is desired, the same cycle length should be entered for the lower and upper cycle limits.

Columns 14-17, CM. The increment of change (in seconds) to be applied to the cycle lengths considered in the progression designs. A 5.00 second increment is recommended for fixed-time signal systems, but a different increment could be used for digital or analog traffic responsive signal systems.

Columns 18-19, NVD. The maximum allowed difference in band speeds (in MPH) between opposing directions. Since the free flowing speed of traffic in both directions along a street is approximately the same under most conditions, it is suggested that a 0 MPH difference be used for average offset conditions. If a "floating car" study of traffic along the street shows that the average speed of one direction is greater than that of the opposite direction, a maximum difference in speed as found from the study could be used. For preferential offsets a maximum difference in speeds of not more than 10 MPH is suggested.

Columns 20-21, LTJ. The lead-trail allocation controls the through band computations in order to lead or trail justify with the green intervals.

If LTJ = 0, offsets computed from the input are used.

= 1, offsets are trail justified.

= 2, offsets are lead justified.

= 3, an attempt is made to line up each through band with the start of the green interval of the first intersection in each direction.

It is recommended that either 0 or 3 be used.

Columns 22-27. Month, day, year.

Column 28, NPLOT. Controls the time-space diagram plot options.

If NPLOT = 0, no diagrams are generated.

= 1, printed simulations of the diagrams are generated at the District terminal.

= 2, plotted versions of the diagrams are generated for plotting at D-19.

Columns 29-31, SCL. The vertical scale (in seconds) equivalent to one inch on the diagrams. Omit if NPLOT = 0.*

Columns 32-35, SKL. The horizontal scale (in feet) equivalent to one inch on the diagrams. Omit if NPLOT = 0.*

*These scales will be adjusted to meet plot limitations, if necessary.

Columns 36-37, NMPH. The average speed (in MPH) which limits the range of speeds to be considered in progression designs. The range of speeds considered in the progression designs is 15 MPH below to 15 MPH above the average speed entered. The average speed should be based on the average speeds obtained from the "floating car" study or other similar studies of both directions of travel during peak and off-peak volume conditions. The floating car study is based on the average speed found to exist by traveling within or following platoons of cars which are traveling in both directions. This average speed is figured from five to ten trials during off-peak volume conditions and from five to ten trials during peak traffic volume conditions. The speeds obtained should be free flow speeds of platoons between stopping points such as stop signs and stops at traffic signals. Trial runs during both off-peak and peak periods should be made to determine if different average speeds occur. If they do, two time-space diagrams should be prepared.

Columns 38-39, MMPH. The range around the average speed (± MPH) used as output limits. Output will only be generated for progression designs with speeds within this range.

Card Type 3

This type of card gives the parameters for each intersection to be included in the evaluation. A maximum of thirty intersections may be used. All entries are right justified except the name of the street which is left justified.

Columns 1-12. Name of cross street.

Columns 13-16, ND. Distance (in feet) from the last intersection.

Columns 17-19, RMIN. Minimum cross street interval (in seconds) which includes the green and amber time intervals for the cross street phase; and, if there is a protected left turn phase, the time interval for the turn phase may also be included. It is suggested that two-phase operation be assumed in completing the input sheet for the first submission and that the minimum cross street interval be obtained from the calculations used in determining the lower cycle limit (LC). If protected left turn phases from the main street (onto the cross street) are needed at some intersections, a second submission can be made. The results of the first submission should make it possible to determine if the protected left turns are to be leading, lagging, or split with the left turn from one direction leading and from the opposite direction lagging. If both left turns are to be either leading or lagging, the time required for the left turn phase interval should be added to the minimum cross street interval in the second submission. If the left turn is leading in one direction and lagging in the other direction at an intersection, two-phase operation should also be assumed for that intersection in the second submission; and the leading and lagging left turns for that intersection should be plotted by hand on the diagrams produced for the second submission.

Columns 20-23, FLA(1). Vehicles per hour in Direction 1 approaching the intersection.

Columns 24-27, FLA(2). Vehicles per hour in Direction 2 approaching the intersection.

Column 28, KDC. Control for designing single or double cycle times for an intersection.

If KDC = 0, a single cycle will be designed for that intersection. (A cross street phase is to occur each cycle length at an intersection.)

= 1, a double cycle will be designed for that intersection. (A cross street phase is to occur ar every other interval at an intersection.)

III. Output

Part of the computed output and one example of the printer simulated plot and the digital plot of the output for the sample problem on the data form are shown in Figures 3, 4, 5 and 6.

Figure 3 shows the signal system identification. Each submitted signal system is assigned a number called a data set number by the program and the number of data sets processed at one time is not limited by the program. The program was written for the highest speed of traffic to consistently be in one direction (Direction 1). In order to consider the possibility that the highest speed of traffic is from the opposite direction (Direction 2), the program prints output with the highest speed first in Direction 1 (odd-numbered data sets) and the next data set will have the highest speed in Direction 2 (even-numbered data sets). Therefore, for each submitted signal system two data sets will be printed out. The data set number is printed at the top of every page of output. In Figure 3, the data set number is 2 and, therefore, this shows the output for Direction 2 of the first signal system submitted.

Besides the data set number, the identification output includes the header information given on Card Type 1, the date entered on Card Type 2, and the input for each intersection given on the remaining Card Type 3 cards. The computed green ratios for both directions is shown for each intersection. They are computed in simple proportion to given cross street intervals for a mid-range cycle time. The design range is a 30 MPH range (± 15 MPH) around the average speed which limits the progression speed range to be considered. However, only the progression speeds within the output range (± MMPH) are printed out.

DATA SET 2

DATE 5/30/73

LEAGUE CITY DISTRICT 12

TIME-SPACE DIAGRAM FOR US 390
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FROM COLUMBIA AVE TO WASHINGTON ST

INPUT DATA

AVERAGE SPEED = 36 MPH
DESIGN RANGE = 21 MPH - 51 MPH
OUTPUT RANGE = 26 MPH - 46 MPH

SIGNAL	DISTANCE	CROSS STREET INTERVAL	VOLUMES		COMPUTED GREEN RATIOS		CYCLE
COLUMBIA AVE		13.	300.	250.	0.711	0.711	0
	2647						
VELASCO BLVD		17.	250.	350.	0.622	0.622	0
	719						
HARRISBURGST		14.	250.	275.	0.689	0.689	0
	1905						
WASHINGTONST		13.	250.	275.	0.711	0.711	0

Figure 3. Signal System Identification Output

Figure 4 shows the design results. The program will attempt to design a maximum of nine solutions for each data set submitted. When a feasible solution is found that satisfies volume demands,is within allowable speed and cycle ranges, and is within the output range, the program prints out the solution number and the design results. If no solution is found in nine tries, a message is printed indicating that no solution was found. As shown in Figure 4, solution 2 was one of the solutions that met the design criteria. At the top of the design results printout page, the system control input (as entered on Card Type 2) is shown as well as the computed maximum equivalent free flow volumes and associated maximum speeds.

The design results shown include:

1. the through-band widths given in per cent of cycle time
2. the limiting intersections identified by number
3. the computed progression speeds rounded to the nearest MPH
4. the largest inputted demand volumes and their respective intersection numbers
5. the offsets in seconds given in respect to the first intersection and their per cent of cycle time
6. the green splits in seconds.

The time-space diagrams are available as either printed simulations (Figure 5) or a digital plot (Figure 6) and correspond to the solution given in the printed output. The time-space diagrams are identified by artery name, data set and solution number. The intersections are indicated by repeating red intervals. These are shown on the plots by solid horizontal lines on the plot and dashed horizontal lines on the simulated plot. On the simulated plot the cycle length is indicated by each horizontal pair of asterisks. The through-bands are drawn through the most limiting intersections. If through-bands do not exist for a solution, no diagram will be generated.

DATA SET 2 SOLUTION 2

IH	II	EL1	EL2	C	LC	HC	CM	NVD	LTJ	NPLOT	KS	MAX.VOLUME		MAX.SPEED	
1	4	2.10	2.10	45.0	45	45	5.00	0	0	1	3	422	562	51	51

RESULTS
=========

	THRU BAND PERCENT	INTERSECTIONS LEAD	INTERSECTIONS TRAIL	SUGGEST SPEED	DEMAND VOLUME	TOWARDS INTERSECTION		
DIRECTION 1	39.9	3	4	36	300.	1	FROM COLUMBIA AVE	TO WASHINGTON ST
DIRECTION 2	40.4	4	3	36	350.	2	FROM WASHINGTON ST	TO COLUMBIA AVE
TOTAL (DIR.1&2)	80.3			36	650.			

SIGNAL	SELECTED OFFSETS SEC.	SELECTED OFFSETS PERCENT	GREEN SPLITS SECONDS			
COLUMBIA AVE	0.0	0.0	32	13	32	13
VELASCO BLVD	2.0	4.4	28	17	28	17
HARRISBURGST	23.0	51.2	31	14	31	14
WASHINGTONST	44.9	99.9	32	13	32	13

Figure 4. Design Results Output

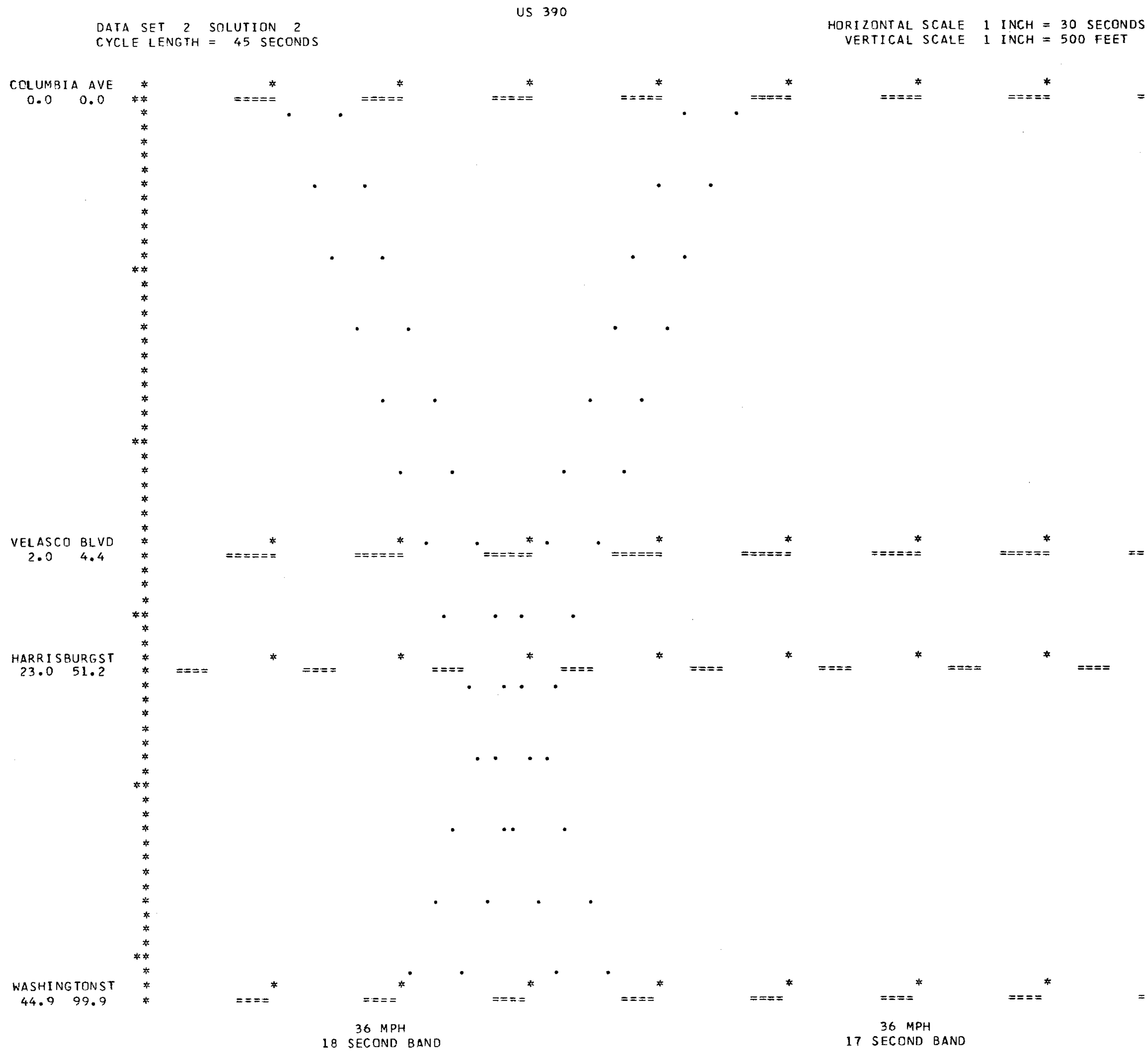

Figure 5. Printer Simulated Time-Space Diagram

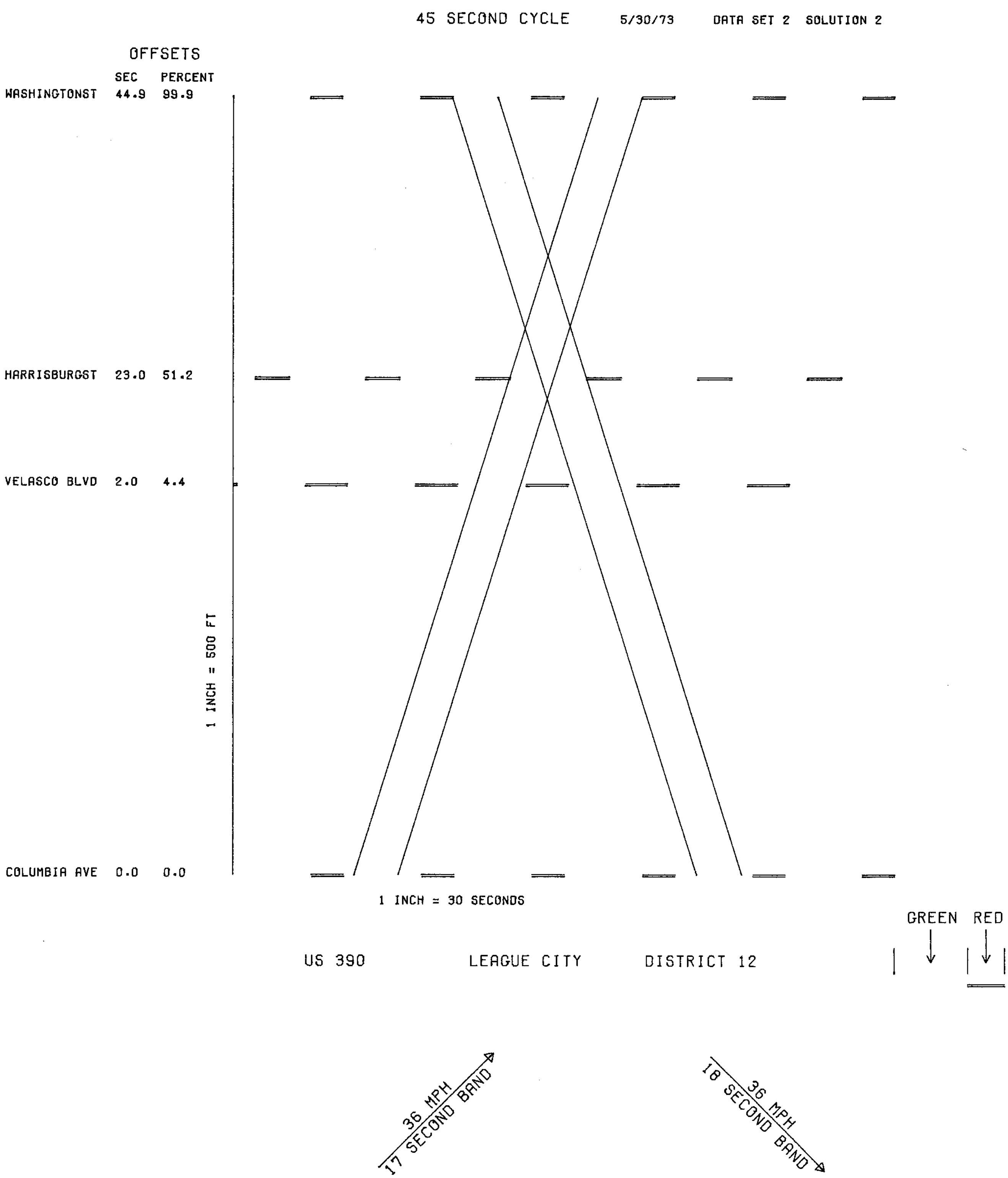

Figure 6. Digital Plot of the Time-Space Diagram

The final selection of the best progression design is left to the individual traffic engineer. The solutions generated by the program may result in a number of competing solutions which differ primarily in speed and/or cycle time values. More than one submission may also be needed using a different combination of speed and cycle ranges and cross street intervals to ultimately arrive at a best solution.