Arterial Priority Option for the TRANSYT-7F Traffic-Signal-Timing Program

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The objective of this research was to modify TRANSYT-7F so that arterial priority can be increased and minor-movement performance degradation can be controlled. The product is known as TRANSYT-7F with Arterial Priority Option (APO). TRANSYT-7F "globally" minimizes overall stops and delay to all vehicles. This is satisfactory for a grid network on which good traffic performance is desired equally for every street. However, it is unsatisfactory for arterials on which progression for the through movement typically is considered much more important than minimizing stops and delay for left-turning and side-street motorists. In the United States, TRANSYT-7F is widely perceived as unsatisfactory for arterial signal timing. TRANSYT-7F with APO modifies the iterative-search process to give priority to the arterial. APO changes the optimization process, not the traffic flow model. In general, the user specifies which links are to receive priority and the degree of saturation for the minor movements (nonpriority links). The performance index (PI) equation is formulated to minimize stops and delay for only the priority links. The degree of saturation specified by the user for the minor movements is used to control the performance degradation to acceptable levels. The results of a program run may be used to make changes to the list of priority links and to the required degree of saturation of one or more nonpriority links on the basis of the engineer's judgment. APO is thus user interactive; the engineer retains control over the optimization and can tailor it to local conditions.

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TRANSYT-7F is ideally matched to the development of grid-system signal-timing plans because of the equal priority given to all motorists. For an arterial, the traffic engineer and the motorist want timing plans that give priority to the through arterial movements. They want arterial progression even if minor movements must experience more delay and stops. Because TRANSYT-7F is widely accepted and used, what has been needed is a methodology that permits the user to control the amount of priority that is allocated to the arterial. To accomplish this objective, the user of APO is permitted to specify the minor-movement degree of saturation within a range so that this value becomes the criterion on which to degrade performance. As the minor movement is degraded, the arterial will be given more priority through the increase of split times and the adjustment of offsets; thus, the arterial timing plan will provide smoother progression.

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PROCEDURE

After several false starts in the development of a procedure to accomplish arterial-priority timing, it was realized that modification of the existing TRANSYT-7F software was necessary. In this section the development of the APO is described.

The source code for the existing version of TRANSYT-7F was obtained from Gary Euler of FHWA. It was supplied on a floppy disk and occupied 230 kilobytes (K) of storage. The source code has 13 modules and must be compiled and linked using a FORTRAN 77 compiler, such as that of Microsoft (*1*). Euler also furnished a descriptive report (*2*) of the source code structure with names and meanings of variables.

For user control of procedures giving more priority to an arterial, several measures of effectiveness were considered. It was concluded that the degree of saturation was the most appropriate measure of effectiveness because it is directly related to delay. Thus, as the arterial priority is increased, the degree of saturation for the minor movement will increase because of increasing delay. As the delay increases for minor movement, vehicular stops will also increase, because TRANSYT-7F computes stops as a function of the cyclic flow profile.

TRANSYT-7F with APO changes the optimization process, not the traffic flow models. In general, the user specifies which links are to receive priority and the degree of saturation for the minor movements (nonpriority links). The performance index (PI) is formulated so that it uses only the priority links in the calculation. No longer is a global PI calculated to determine the optimum solution. For each nonpriority link, TRANSYT-7F with APO sets a ± 5 percent range for the specified degree of saturation. At each intersection, each nonpriority link is checked for degree of saturation during the iterative search process.

TABLE 1 CARD TYPE 31: PRIORITY LINK LIST CARD

Field	Column	Description	Range
1	1	"31"	Optional
2-16	10-80	Link numbers which have priority	Link numbers

When the computed value for the degree of saturation on the nonpriority link is within the range, the iterative search is stopped and begun again at the next intersection.

Three areas of the source code—user input, optimization model, and output—were changed. Modifications are described as follows.

Changes to User Input

The input format for the priority data was structured similar to TRANSYT's existing format. Two arterial priority cards were designed. Card type 31 designates which links are to be included in the priority scheme. Card type 32 indicates which links do not have priority and their associated desired degree of saturation. Both card types have a straightforward coding format. Table 1 shows the format for card type 31. Card type 32 is shown in Table 2.

Changes to Optimization Model

TRANSYT-7F with APO continues to use the iterative-search process as described in the previous section but interrupts the iterative process on each pass so that the nonpriority-link degree of saturation can be evaluated. Formulation of the PI includes only those links that the user indicated on card type 31. Therefore, the modified version does not calculate a global PI to determine the optimum solution. Instead, it calculates a PI designated only by priority links.

In summary, there are two ways to halt the modified search technique of TRANSYT-7F with APO. When the new PI is greater than the old PI, subroutine hill-climb decides that an optimum solution has been found and goes to the next intersection. This is exactly the same as in the existing version of TRANSYT-7F. With APO the non-priority-link traffic flow is degraded to be within the range of the degree of saturation as assigned by the user, the iterative-search technique is stopped, and the subroutine hill-climb goes to the next intersection.

Evaluation of the degree of saturation provides the user with a great deal of flexibility and control over the signal-timing plan that is developed by TRANSYT-7F. The APO allows the user to interact with the optimization process.

Changes to Output

A summary performance table by link type was added to the existing TRANSYT-7F output tables. The user can

TABLE 2 CARD TYPE 32: NONPRIORITY-LINK DEGREE OF SATURATION

Field	Column	Description	Range
1	1	"32"	Optional
		************** Alternative 1*************	
2	5	All links not listed on card type "31" have no priority	-999
3	10	Degree of Saturation	10 to 150
		************** Alternative 2 ************	
2	5	Non-priority link	Link #
3	10	Degree of Saturation	10 to 150
4	15	Non-priority link	Link #
5	20	Degree of Saturation	10 to 150
		Alternate link numbers and degree of saturation	

apply this table in conjunction with present tables to evaluate the effects of selecting TRANSYT-7F with APO.

FINDINGS

A section of Tenth Street in Atlanta, Georgia, was selected to test TRANSYT-7F with APO. Tenth Street is an east-west arterial located just to the north of the Atlanta central business district near the Georgia Institute of Technology campus. The test section is from Fowler Street on the west to West Peachtree Street on the east. There are five signalized intersections in this 1,765-ft section of roadway.

Initial conditions for Tenth Street included the following:

- Traffic flow and network data were coded as discussed in the previous section.
- The signal phasing used was that which existed at the time the data were collected. The existing phasing for each intersection was
  - — Intersection 1: Tenth and Fowler streets—two-phase operation,
  - — Intersection 2: Tenth Street and Techwood Drive—three-phase with a leading westbound left turn,
  - — Intersection 3: Tenth Street and Techwood Drive—three-phase with a leading eastbound left turn,
  - — Intersection 4: Tenth and Spring streets—three-phase with a leading eastbound left turn,
  - — Intersection 5: Tenth and West Peachtree streets—three-phase with a leading westbound left turn.
- All clearance interval times were set to 4 sec and were fixed so that TRANSYT-7F did not vary these intervals.
- No pedestrian time was coded; the minimum time for each variable (green) interval was set at 1 sec.
- A 60-sec cycle was used for this example. Several runs of TRANSYT-7F using the cycle-selection feature of the program indicated that this cycle was appropriate.

The initial conditions for all TRANSYT-7F runs were the same.

To demonstrate user control and flexibility of TRANSYT-7F with APO, a series of computer runs to simulate traffic flow on Tenth Street was performed. For purposes of brevity and illustration, only two examples are presented.

TRANSYT-7F with APO was used to give priority to eastbound Tenth Street. The links selected for priority were 113, 213, 313, 413, and 513. From an evaluation of the output in comparison with TRANSYT-7F without APO, the following observations were made:

- The eastbound PI was reduced to 6.25 vehicle-hr/hr from the base timing plan of 16.23 vehicle-hr/hr. This presented a 61 percent reduction in PI. Eastbound delay was reduced from 7.20 to 2.66 vehicle-hr/hr, or 63 percent. Stops were reduced from 1,298.94 to 530.62 vehicles/hr, or 59 percent.
- Degree of saturation on the nonpriority links increased.
- The platoon-progression diagram (Figure 1) indicated that priority was indeed given to the eastbound arterial on Tenth Street.

To further demonstrate the flexibility and user control of TRANSYT-7F with APO, arterial priority was given to both eastbound and westbound movements concurrently. The priority links for this run were 113, 213, 313, 413, 513, 414, 214, 314, and 114. The results were as follows:

- Progression was possible in both directions (Figure 2).
- Global PI was increased to 121.17 from 91.51 for the base timing plan, an increase of 32 percent.
- Both directions of the arterial have less delay and fewer stops when compared with the base timing plan. Eastbound PI was reduced by 24 percent and westbound PI by 39 percent.
- Total delay for the eastbound arterial was reduced by 41 percent, from 7.20 to 4.25 vehicle-hr/hr. In the west-

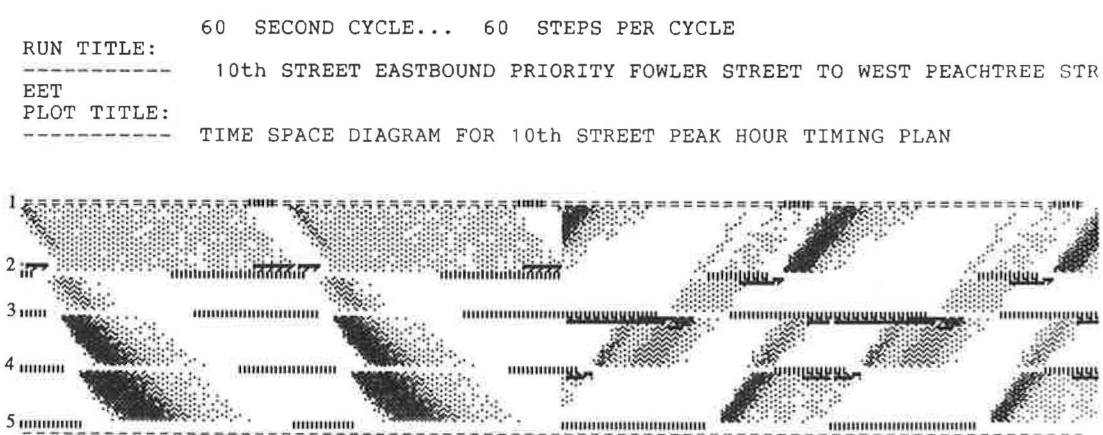

FIGURE 1 Platoon progression diagram: eastbound priority. 1 = Fowler Street, 2 = Techwood Drive, 3 = Williams Street, 4 = Spring Street, 5 = West Peachtree Street.

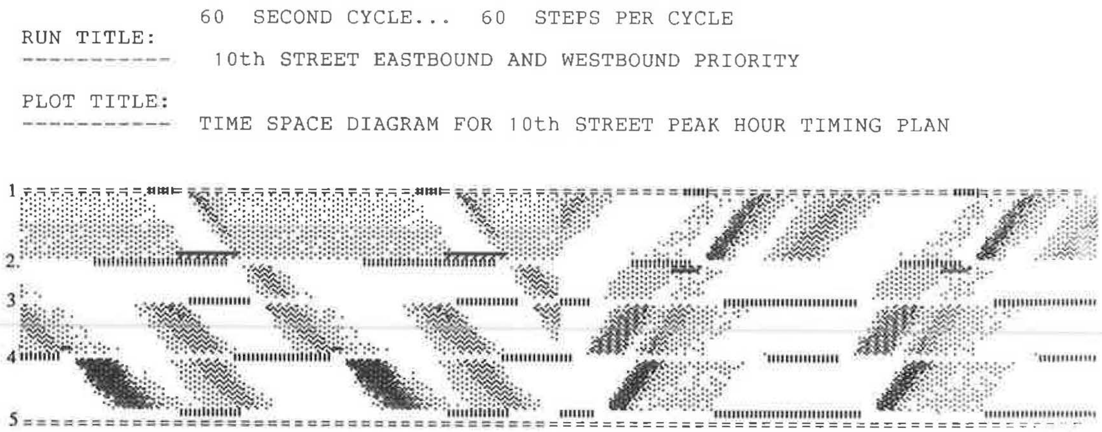

FIGURE 2 Platoon progression diagram: eastbound and westbound priority. (Streets are identified in Figure 1.)

bound direction, total delay was reduced from 4.93 to 2.93 vehicle-hr/hr, or 41 percent.

- Eastbound stops decreased from 1,298.94 to 1,161.84 vehicles/hr, or 11 percent. In the westbound direction, stops were reduced from 931.82 to 579.36 vehicles/hr, a reduction of 38 percent.
- Minor movements have more delay and stops when compared with the same movements in the base timing plan. The total global PI for the northbound and southbound links is 80.74, or 67 percent of the global PI.

CONCLUSIONS

The objective of this research was to modify TRANSYT-7F so that arterial priority can be increased and minor-movement performance degradation can be controlled. TRANSYT-7F with APO accomplishes this objective, as has been demonstrated here for Tenth Street in Atlanta.

This research led to the following conclusions:

1. User selection of APO gives a reduction of delay and stops for the arterial links and a smoother overall arterial progression.
2. Minor-movement performance degradation is controlled by the user specification of degree of saturation for the nonpriority links.
3. On examining the results of an iteration, the user may apply judgment to make changes to the list of priority links and to the required degree of saturation of one or more nonpriority links. APO is thus user interactive; the engineer retains control over the optimization and can tailor it to local conditions.
4. A particularly desirable feature of TRANSYT-7F with APO is the continued use of delay and stops in the PI formulation to find optimum signal-timing plans.

From this research, it is concluded that the concept of specifying the degree of saturation on the nonpriority links proved to be successful in controlling arterial priority. APO allows the optimization process to be user interactive and flexible. The user has firm control over the relative priority given to the various movements in an arterial system.

REFERENCES

1. *Microsoft FORTRAN 86, Version 3.2.* Microsoft Corporation, Bellevue, Wash., 1986.
2. *Traffic Network Study Tool—Version 7, Federal: TRANSYT-7F (Release 4) Software Summary.* FHWA, U.S. Department of Transportation, 1984.

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