THE APPLICATION OF TRANSYT-7F TO DETERMINE SUITABLE SIGNAL POLICY FOR BUS ARTERIAL ROUTES: A CASE STUDY OF R296 SECTION, CHIBA

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1. INTRODUCTION AND PROBLEM STATEMENT

In Japan, most of the roads are two-direction arterial road with narrow two lanes. The traffics have to be mixed with public transits to travel along these arterials. The public busses usually travel slowly and often stop to load/unload passengers at bus stops. Their operations interrupt the flow of other vehicles and cause to increase the delay of entire system. Moreover, the system becomes more critical when the busses stop to load/unload passengers at bus stops near to intersection approaches. The vehicles followed this bus, even though they approach those intersections during green time interval, cannot pass through the bus due to the no passing zone. Subsequently, these events increase the long queue and high delay for entire system.

2. OBJECTIVE AND SCOPE OF STUDY

The objective of this study is to propose suitable signal timing policy to increase the operation performance of typical signal control systems along the bus arterial routes. This study focuses only on the determination of appropriate signal timing policy for passive traffic control strategy, fixed-time signal setting timing plan based on history data, which can apply instantly without any requirement of supplying facilities to the fixed-time signal control systems, which are typically installed at the intersection along the arterial road in Japan.

3. CONCEPTUAL DETERMINATION OF SUITABLE TIMING POLICY

To deal with the above-mentioned problems about bus operation, the solution should focus on which signal timing policy can develop signal timing plan that provides priority to bus operation route in order to minimize stops and increase travel speed of bus. Typically, there are several well-known signal timing policies, including Minimizing Delay (Delay), Minimizing Stops (Stop), Minimizing Fuel Consumption (Fuel) and Maximizing Progression policies[1].

Key Wards: Signal Timing Policy for Bus Arterial Routes and Signal Timing Optimization Program
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These signal timing policies produce different signal timing plans. However, among the previous mentioned policies, only Maximize Progression policy is able to develop signal timing plan that favor to a specific route. Consequently, the Maximize Progression policy setting progression to bus arterial route was selected to develop the optimal signal timing plan through TRANSYT-7F[2], version 10. Due to the flexibility of the TRANSYT-7F[2], the progression policy could be implemented based on various objective functions, including PROS, DI and PROS/DI. Their definitions and objective functions are presented in Table 1.

Table 1 Objective Functions and Their Definitions

Codes	Objective Functions and Their Definitions
PROS	PROS is a representative of the opportunities for vehicles to progress through multiple signals on green or the number of successive green signals that will be encountered at the design speed with out stopping. The objective function is: $PROS_e = \dfrac{\sum_{i=1}^{A} DDF_i \sum_{k=1}^{2} WD_{ik} \sum_{j=1}^{N} \sum_{t=1}^{C} PROS_{ikjt}}{\sum_{i=1}^{A} \sum_{k=1}^{2} WD_{ik} \sum_{j=1}^{N_i} \sum_{t=1}^{C} CPROS_{ikjt}}$
Note: Since there are too many parameters to specify their meaning, the meanings of each parameter could be followed up the Manual[2]	
DI	DI is a measure of disadvantageous operation; that is, stops, delay and fuel consumption or is simply a linear combination of delay and stops, whose units differ. The objective function is: $DI = \sum_{i=1}^{n} \left\{ \left(w_{d_i} d_i + K w_{s_i} s_i \right) + U_i \left(w_{d_{i-1}} d_{i-1} + k w_{s_{i-1}} S_{i-1} \right) \right\}$
Where: w_{di}=Delay Weighting Factors on Link I, d_i=Delay on Link I, K=Stop Penalty Factor, S_i=Stops on Link i, w_{si}=Stops Weighting Factors on Link I, Ui=Binary Variable, n=Number of Link	
PROS/DI	PROS/DI is a representative of combination advantages of maximizing PROS with advantages of minimizing DI. The objective function is: $PI = \dfrac{\left(100 \bullet PROS_e\right)^{WP}}{DI}$
Where: WP is the relative weighting value of PROS to the DI.	

Source: Manual of TRANSYT-7F[2]

However, Manual of TRANSYT-7F[2], recommends that when the arterial routes are explicitly considered, PROS/DI is likely to optimize progression. In contrast, PROS-only often fails in allowance of minor movements and DI-only usually results in excessive stops and fuel consumption. Therefore, PROS/DI with relative weighting value, WP=100 (a default value) was selected as an objective function for progression optimization.

4. EVALUATION OF SELECTED POLICY

For the evaluation of selected policy, a segment of R296 with bus operation route in Chiba prefecture has been selected as a test site. The selected policy setting progression along R296 was implemented to develop the optimal coordinated time plans by TRANSYT-7F(2).

To verify the reliability of the program and evaluate the selected policy, the rest of the aforementioned signal timing policies also have been implemented. This study has conducted the program reliability by following the mention of Park(3), "the reliability of an optimization strategy refers to the ability of a strategy to achieve the objective for which it was designed". The selected policy was evaluated by comparing with the other aforementioned policies. The performances of each policy were assessed through Performance Index, PI of TRANSYT-7F(2), a representative value of the performance of traffic network. After the optimal signal timing plans of each policy have been assessed, the performances of each developed signal timing plan could be compared with the performance of the existing signal timing of the selected study site.

5. RESULTS AND DISCUSSIONS

The differences of Measures of Effectiveness (average delay, total stops and fuel consumption), PROS, and PI between the exiting signal timing plan and the developed signal timing plans of each policy are presented as histograms in figure 1, 2, 3, 4 and 5, respectively.

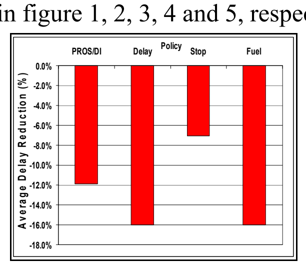

Figure 1 Average Delay Reduction

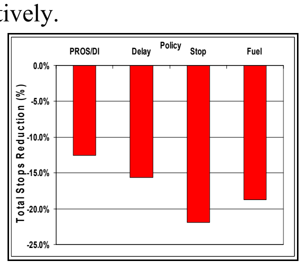

Figure 2 Total Stops Reduction

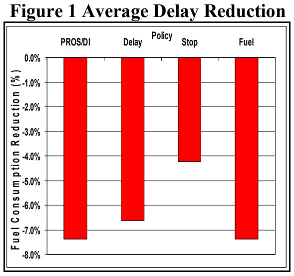

Figure 3 Fuel Consumption Reduction

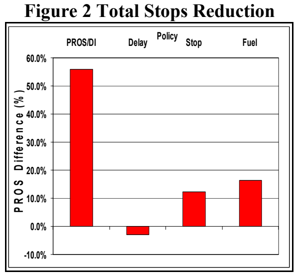

Figure 4 PROS Difference from Existing Timing Plan

According to the histograms in figure 1-4, for the minimization policies, the developed optimal timing plan of Delay Policy produced the most decreasing average delay as shown in figure 1, and also those of Stop and Fuel Policies produced the most decreasing total stops and fuel consumption, as shown in figure 2 and 3, respectively. And for maximization policy, the optimal timing plan of PROS/DI Policy produced the most increasing PROS, as shown in figure 4. With respect to achieve the specific objective of each policy, the optimal timing plan based on each policy produced the performances, accomplishing to the objective of each policy.

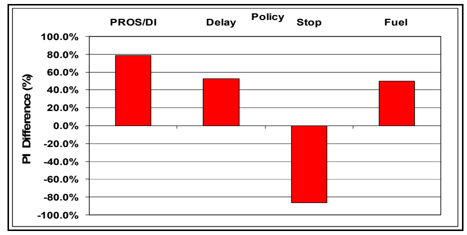

Figure 5 PI Difference from Existing Timing Plan

In figure 5, The PROS/DI Policy produced the most increasing Performance Index, PI. It is implied that the developed optimal timing plan of this policy could improve the system performance with approximately 80 percent total of increasing number of vehicles, including busses progressing through multiple intersections without stop and minimizing delay, stops and fuel consumption.

6. CONCLUSIONS AND RECOMMENDATIONS

- Implementations of each policy produced explicitly performances achieving to each objective of them. These findings reveal that this program is reliability.
- The Maximize Progression policy based on PROS/DI, setting progressing on bus operation route is recommended to implement in order to increase the performance of the typical signal control systems along the bus arterial routes.
- For application of this proposed policy to other bus arterial routes, not only the relative weighting value, WP = 100 but also other relative weighting values should be tried to implement in order to achieve the most suitable signal timing plan for each specific site.
- The further study should consider the other more advance and complicated traffic control strategies, such as signal preemption at specific intersections or system wide and real time traffic control systems in order to achieve the best system performance.

7. REFERENCES

(1). Leonard, J., D. and Rodegerdts, L., A., Comparison of Alternate Signal Timing Policies, Journal of Transportation Engineering, ASCE, p.510-520, 1998.
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(3). Park, B., et al., Evaluating the reliability of TRANSYT-7F optimization schemes, the 79th Annual Meeting Transportation Research Board (CD-ROM), Paper No. 00-1650, 2000.