CHAPTER 5 COMPUTATIONAL EXPREIMENTS ALONG AN ARTERIAL

To further investigate the applicability of the proposed models to implement the TPS strategies along an arterial, trainings and validations of the TPS with GFLC and AGFLC along an arterial under three different coordinated signal systems are conducted in this chapter, of which Section 5.1 and 5.2 present an exemplified example and a field case, respectively.

5.1 Exemplified Example

5.1.1 Data and Parameters

(1) Traffic data

A case study on an exemplified example with two assumed consecutive intersections is conducted. The geometry configuration is shown in Figure 5-1. Assume that each intersection has two lanes in each approach with saturation flow of 1800 pcu/hr/lane. The same ten-hour five-minute flow rates tested in the previous isolated intersection are given in TPS control directions and non-TPS directions. Bus arriving pattern and average loading factors for private car and bus are also assumed to be the same as those in the isolated intersection.

The cycle length and green time of pre-timed signal at the first intersection are set as 156 and 100 seconds. The other parameters are set as follows: G_{max}= 130 seconds, G_{min}= 20 seconds, AR= 3 seconds, H=13 seconds, and L= 10 seconds. Offset for progressive coordinated signal is assumed to be 20 seconds which is equal to the traveling time between the two intersections.

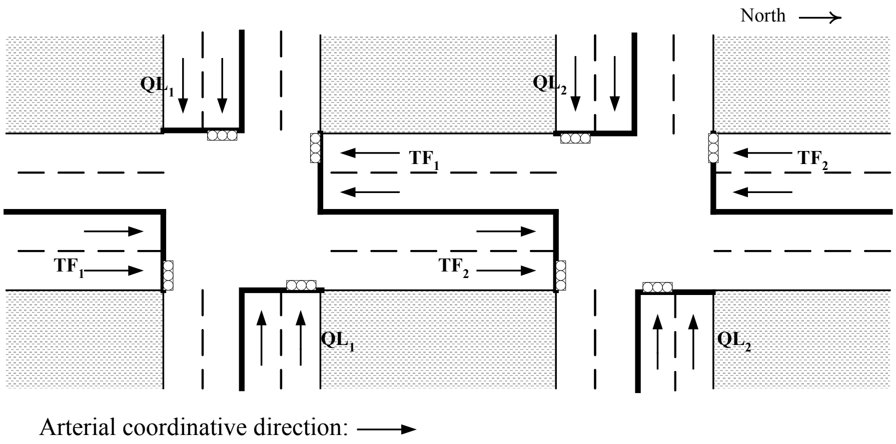


Figure 5-1 Configuration of the exemplified example at two consecutive intersections.

(2) Parameters Settings

The parameters of GA and ACO algorithms, such as population size, crossover rate, mutation rate, a, h, δ, ε, NE_t, α, β, ξ, ρ, q_0, θ_{i6}, τ^0, K, and t_{max} are set the same as those in the isolated intersection experiment. The predetermined rule table is also set the same in chapter 4.

5.1.2 Fitness Value of TPS Along an Arterial

For synchronizing the signal control of sequential intersections, three coordinated signal systems including simultaneous, alternate, and progressive systems are considered. For ease of comparison, the cycle times of these three systems are assumed to be identical and unchanged. The simultaneous system implements exactly the same signal timing plans simultaneously in sequential intersections without time lag (offset). The progressive system implements these plans with offset. The alternative system implements two timing plans with inverse green and red times. The TPS strategy is implemented to determine the timing plans at the first intersection, while the timing plan at the succeeding intersection is decided by the coordinated system. The traffic flow conditions of downstream intersection are determined by the upstream traffic flows and upstream signal control results (depicted in Figure 5-2). Due to the complication of signal synchronization and delay estimation, this study firstly validates the proposed models at two consecutive intersections, the generalization of more signalized intersections and network level is further considered in future studies.

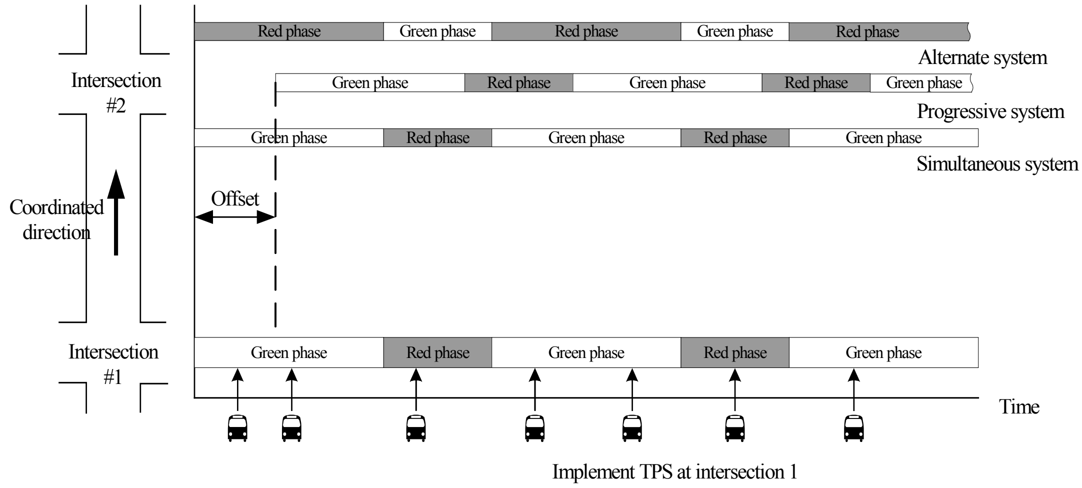


Figure 5-2 TPS along an arterial under three coordinated signal systems.

The same performance index, *TPD*, used in isolated intersection case is adopted in this chapter. So the objective function *E* is equal to *TPD* and the fitness value of GA in the arterial case can be also defined as $f=1/TPD$. The analytical approach with fluid approximation to estimate the total vehicle delay, which is the entire area between cumulative arrival and departure curves, is illustrated in Figure 5-3 for simultaneous coordinated system of two adjacent intersections.

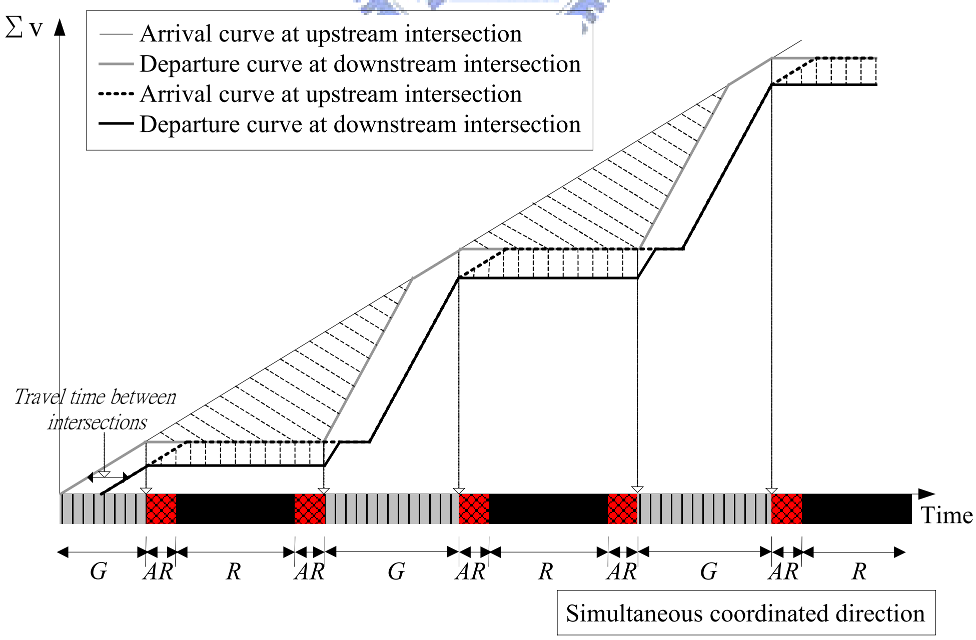


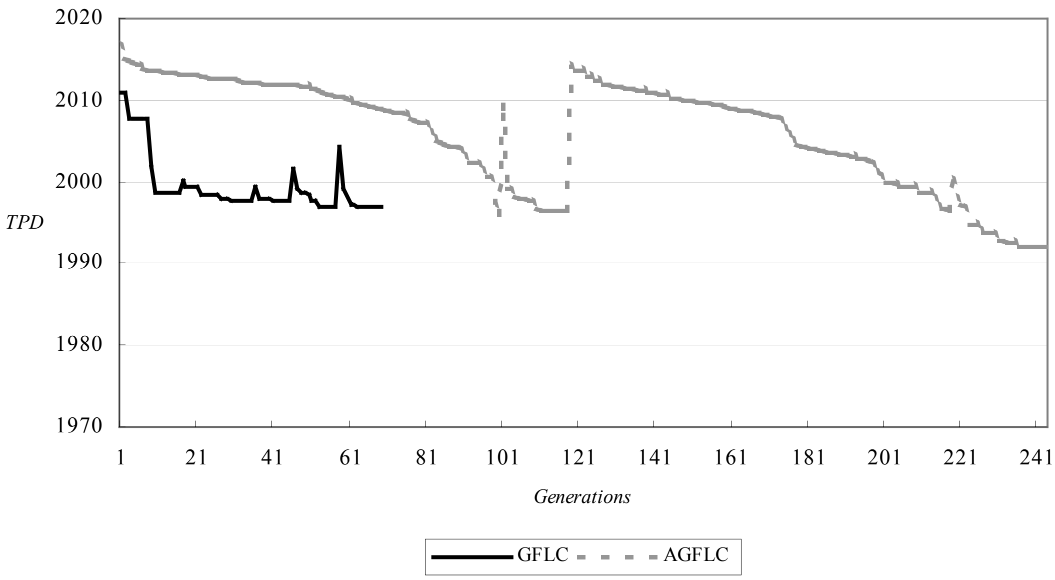
Figure 5-3 Estimation of vehicle delays at two consecutive intersections (simultaneous coordinated system).

To simplify the analysis, this study neglects the turning traffic and assumes the arrival traffic patterns at downstream intersections to be the same as the departure traffic patterns at the upstream intersection after a horizontal shift without phenomena of platoon diffusion or shock wave. Then the *TPD* is acquired by multiplying the preset loading factors.

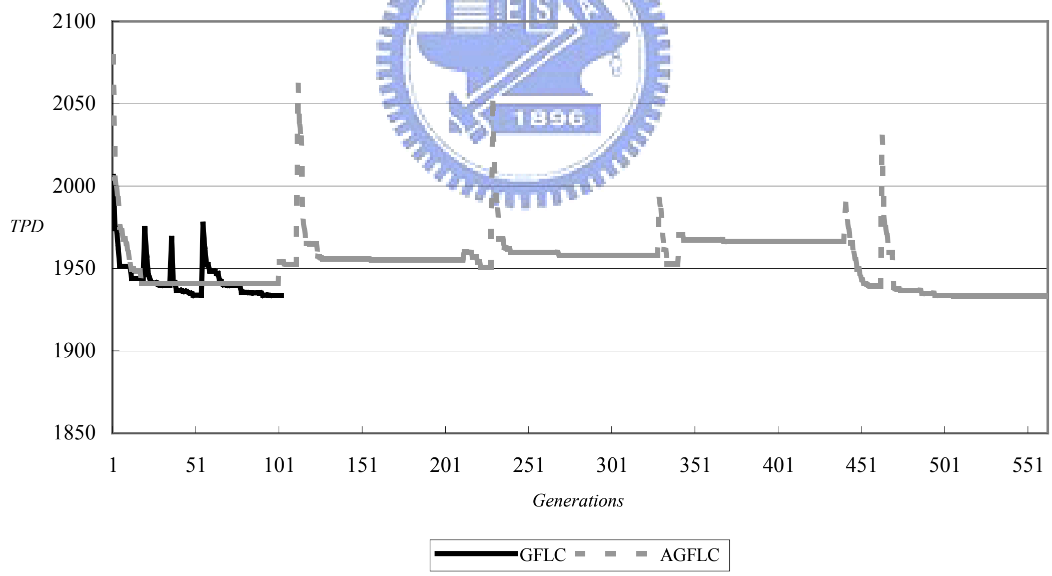
5.1.3 Learning Results

The GFLC and AGFLC conditional TPS are implemented under three coordinated signal systems (simultaneous, progressive, and alternate) and two TPS strategies (green extension and red truncation). Thus, 6 sets of GFLC and 6 sets of AGFLC are required for optimization. Taking progressive coordinated system for instance, the learning processes of green extension and red truncation are depicted in Figure 5-4. In green extension, the GFLC and AGFLC converge after 3 and 2 iterative evolutions, respectively but the GFLC only has 69 generations progressed while the AGFLC has 243 ant iterations and genetic generations. The value of *TPD* decreases from 2010.8 to 1996.9 person-hours by GFLC and from 2016.7 to 1992.1 by AGFLC. In red truncation, the GFLC converges after 2 iterative evolutions with 102 generations progressed where the value of *TPD* decreases from 2005.9 to 1933.6 person-hours. The AGFLC converges after 5 iterative evolutions with a total of 562 ant iterations and genetic generations where the value of *TPD* decreases from 2078.7 to 1993.4 person-hours. Both the processes in green extension and red truncation indicate that the AGFLC is more effective but less efficient than the GFLC. Moreover, the evolving processes also indicate that the converging variation of *TPD* in the learning processes is larger in the red truncation than in the green extension strategy.

The selected fuzzy rules and tuned membership functions for the GFLC and AGFLC are presented in Figures 5-5, 5-6 and 5-7. When implementing green extension strategy, as shown in Figure 5-5 (a1) and (a2), a total of 20 fuzzy rules are selected by the GFLC and 23 fuzzy rules by the AGFLC. While implementing red truncation strategy, as shown in Figure 5-5 (b1) and (b2), a total of 17 fuzzy rules are selected by the GFLC and 23 fuzzy rules by the AGFLC.



(a)



(b)

Figure 5-4 Evolving process of GFLC and AGFCL of the exemplified example at two consecutive intersections (progressive coordinated system): (a) green extension strategy, (b) red truncation strategy.

y (NE)		*x_1(TF)*				
		NL	*NS*	*ZE*	*PS*	*PL*
x_2(QL)	*NL*	*NS*	*NL*			*PS*
	NS	*NS*	*PL*	*ZE*	*ZE*	*NL*
	ZE		*PL*	*PS*	*PS*	
	PS	*NS*	*PS*	*NL*	*NL*	*ZE*
	PL		*PS*	*NL*	*NL*	*PL*

(a1)

y (NE)		*x_1(TF)*				
		NL	*NS*	*ZE*	*PS*	*PL*
x_2(QL)	*NL*	*PL*	*PS*	*PL*	*PL*	*PL*
	NS	*ZE*	*NS*	*PL*	*PS*	*NS*
	ZE	*NL*	*NS*	*ZE*		*PL*
	PS	*NS*		*ZE*	*ZE*	*PS*
	PL	*NS*	*NL*	*NL*	*NS*	*ZE*

(a2)

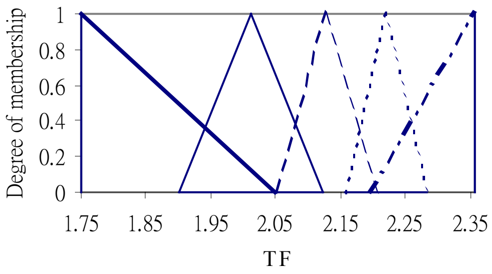
y (NE)		*x_1(TF)*				
		NL	*NS*	*ZE*	*PS*	*PL*
x_2(QL)	*NL*			*ZE*		*NL*
	NS	*PL*	*NL*		*NS*	
	ZE	*ZE*	*PL*	*ZE*	*PL*	*ZE*
	PS		*PS*		*NL*	*PS*
	PL	*PS*	*PS*	*ZE*		*PL*

(b1)

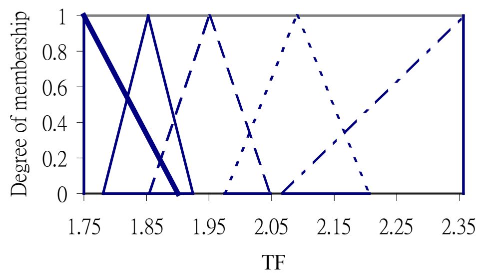
y (NE)		*x_1(TF)*				
		NL	*NS*	*ZE*	*PS*	*PL*
x_2(QL)	*NL*	*ZE*	*PS*		*ZE*	*ZE*
	NS	*NL*	*PL*	*PS*	*PS*	*PS*
	ZE	*PL*	*NL*	*ZE*	*PS*	
	PS	*NL*	*NL*	*NS*	*PS*	*PL*
	PL	*ZE*	*NL*	*NL*	*ZE*	*PS*

(b2)

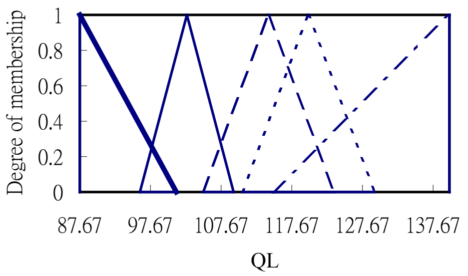
Figure 5-5 Selected fuzzy rules of the exemplified example at two consecutive intersections (progressive coordinated system): (a1) green extension with GFLC, (a2) green extension with AGFLC, (b1) red truncation with GFLC, (b2) red truncation with AGFLC. Note: *NL*: negative large, *NS*: negative small, *ZE*: zero, *PS*: positive small, *PL*: positive large.



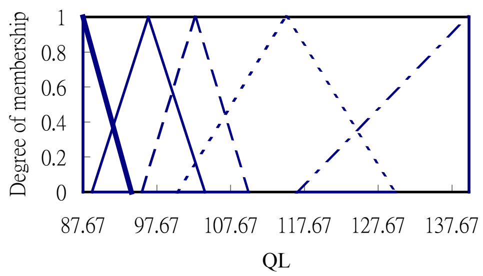
(a1)



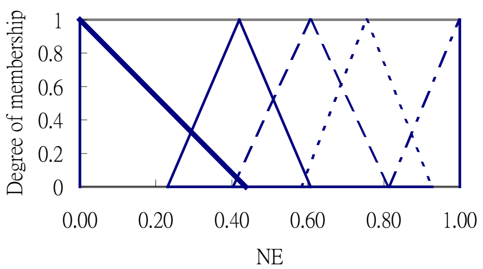
(b1)



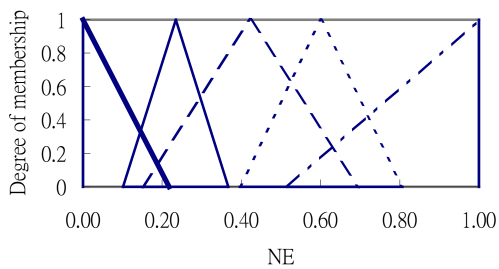
(a2)



(b2)



(a3)



(b3)

Figure 5-6 Tuned membership functions for green extension strategy of the exemplified example at two consecutive intersections (progressive coordinated system): (a1) *TF* by GFLC, (b1) *TF* by AGFLC, (a2) *QL* by GFLC, (b2) *QL* by AGFLC, (a3) *NE* by GFLC, (b3) *NE* by AGFLC.

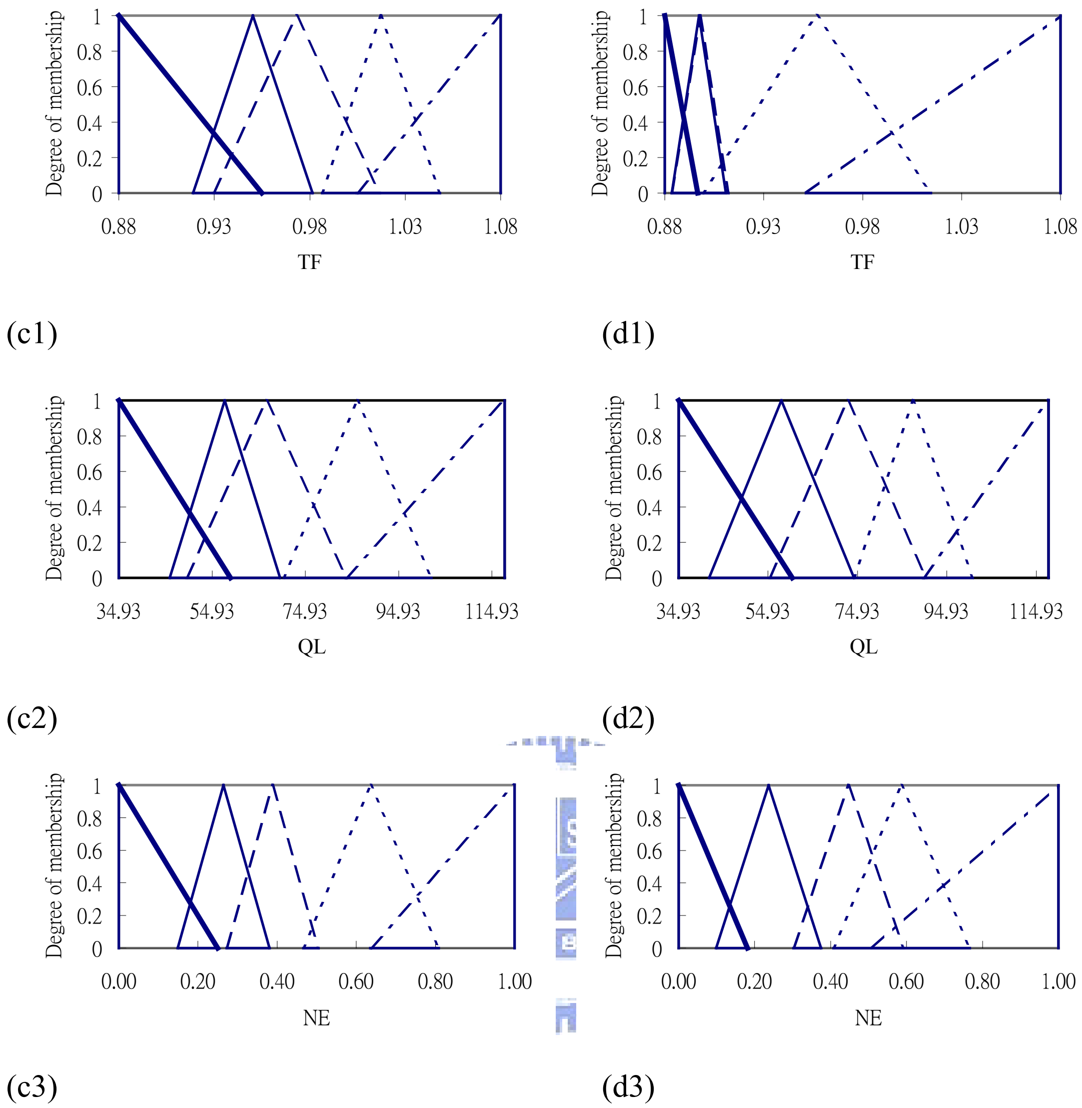


Figure 5-7 Tuned membership functions for red truncation strategy of the exemplified example at two consecutive intersections (progressive coordinated system): (c1) *TF* by GFLC, (d1) *TF* by AGFLC, (c2) *QL* by GFLC, (d2) *QL* by AGFLC, (c3) *NE* by GFLC, (d3) *NE* by AGFLC.

5.1.4 Comparisons

To compare the control performances of the proposed GFLC and AGFLC models, pre-timed signal without TPS and unconditional TPS are also simulated with the same traffic data under simultaneous, progressive, and alternate coordinated signal systems. Table 5.1 shows the simulation results of green extension and red truncation, respectively. In terms of total person delay, progressive system outperforms, followed by simultaneous system, and then by alternate system. As comparing to the pre-timed signal without TPS, the AGFLC can curtail the largest *TPD*, followed by the GFLC under simultaneous and progressive systems. While under alternate system, the compromising control results determined by the GFLC and AGFLC are the same as the result of the pre-timed signal because providing priority to buses would not improve the system performance. These results reveal that the proposed GFLC and AGFLC models could achieve an compromising control under the three coordinated signal systems and at least would not deteriorate the system performance of the pre-timed signal timing plan. The results also show that unconditional TPS would even deteriorate the system performance under three coordinated signal systems. Furthermore, the unconditional TPS gives buses priority without any restriction would obviously increase vehicle delays of the competing approaches. By contrast, the GFLC and AGFLC models provide the priority to the buses considering the traffic situations of the whole intersection would have a smaller impact on the vehicles from the competing approaches.

Table 5.1 Comparisons of different TPS models under various coordinated systems (the exemplified example at two consecutive intersections)

TPS Strategy	Coordinated systems	Types of Vehicles	Without TPS	With TPS: Unconditional	With TPS: Conditional GFLC	With TPS: Conditional AGFLC
Green Extension	Simultaneous	Buses	915.1	886.3 (-3.15%)	840.6 (-8.14%)	837.1 (-8.52%)
		Benefit cars (1)	553.2	517.0 (-6.54%)	523.7 (-5.33%)	521.2 (-5.78%)
		Impact veh. (2)	956.1	1118.8 (17.02%)	1020.7 (6.76%)	1025.8 (7.29%)
		(1)+(2)	1509.3	1635.8 (8.38%)	1544.4 (2.33%)	1547.0 (2.50%)
		All vehicles	2424.4	2522.1 (4.03%)	2385.0 (-1.63%)	2384.1 (-1.66%)
	Progressive	Buses	563.2	446.7 (-20.69%)	450.2 (-20.06%)	415.3 (-26.26%)
		Benefit cars (1)	559.8	514.8 (-8.04%)	521.9 (-6.77%)	497.5 (-11.13%)
		Impact veh. (2)	956.2	1119.2 (17.05%)	1024.8 (7.17%)	1079.3 (12.87%)
		(1)+(2)	1516.0	1634.0 (7.78%)	1546.7 (2.03%)	1576.8 (4.01%)
		All vehicles	2079.2	2080.7 (0.07%)	1996.9 (-3.96%)	1992.1 (-4.19%)
	Alternate	Buses	3588.9	3705.3 (3.24%)	3588.9 (0.00%)	3588.9 (0.00%)
		Benefit cars (1)	134189.2	694.9 (-99.48%)	134189.2 (0.00%)	134189.2 (0.00%)
		Impact veh. (2)	617.9	149921.6 (24163%)	617.9 (0.00%)	617.9 (0.00%)
		(1)+(2)	134807.1	150616.5 (11.73%)	134807.1 (0.00%)	134807.1 (0.00%)
		All vehicles	138396.0	154321.8 (11.51%)	138396.0 (0.00%)	138396.0 (0.00%)
Red Truncation	Simultaneous	Buses	915.1	530.5 (-42.03%)	717.7 (-21.57%)	727.1 (-20.54%)
		Benefit cars (1)	553.2	332.5 (-39.90%)	439.9 (-20.48%)	445.3 (-19.50%)
		Impact veh. (2)	956.1	16422.3 (1617%)	1080.4 (13.00%)	1063.8 (11.26%)
		(1)+(2)	1509.3	16754.8 (1010%)	1520.3 (0.73%)	1509.1 (-0.01%)
		All vehicles	2424.4	17285.3 (612%)	2238.0 (-7.69%)	2236.2 (-7.76%)
	Progressive	Buses	563.2	314.4 (-44.18%)	448.1 (-20.44%)	418.9 (-25.62%)
		Benefit cars (1)	559.8	319.6 (-42.91%)	456.2 (-18.51%)	427.1 (-23.70%)
		Impact veh. (2)	956.2	16422.4 (1617%)	1029.3 (7.64%)	1087.4 (13.72%)
		(1)+(2)	1516.0	16742.0 (1004%)	1485.5 (-2.01%)	1514.5 (-0.10%)
		All vehicles	2079.2	17056.4 (720%)	1933.6 (-7.00%)	1933.4 (-7.01%)
	Alternate	Buses	3588.9	3277.5 (-8.68%)	3588.9 (0.00%)	3588.9 (0.00%)
		Benefit cars (1)	134189.2	192427.0 (43.40%)	134189.2 (0.00%)	134189.2 (0.00%)
		Impact veh. (2)	617.9	10247.5 (1558%)	617.9 (0.00%)	617.9 (0.00%)
		(1)+(2)	134807.1	212674.5 (57.76%)	134807.1 (0.00%)	134807.1 (0.00%)
		All vehicles	138396.0	215952.0 (56.04%)	138396.0 (0.00%)	138396.0 (0.00%)

Note: The unit of person delay is person-hour. Figures in parenthesis represent the percentages of person delay difference in comparing to that of without TPS model. Benefit cars: the vehicles except buses in the TPS direction. Impact veh.: the vehicles in the competitive direction.

Figures 5-8 and 5-9 illustrate the comparisons of green time and red time at the first intersection of the first 100 cycles for implementing green extension and red truncation under progressive system along an arterial. As anticipated, unconditional TPS has longer green time and shorter red time in general than the GFLC and AGFLC have, because the latter two TPS models conclude the preemption decisions with the consideration of traffic situation at all intersections.

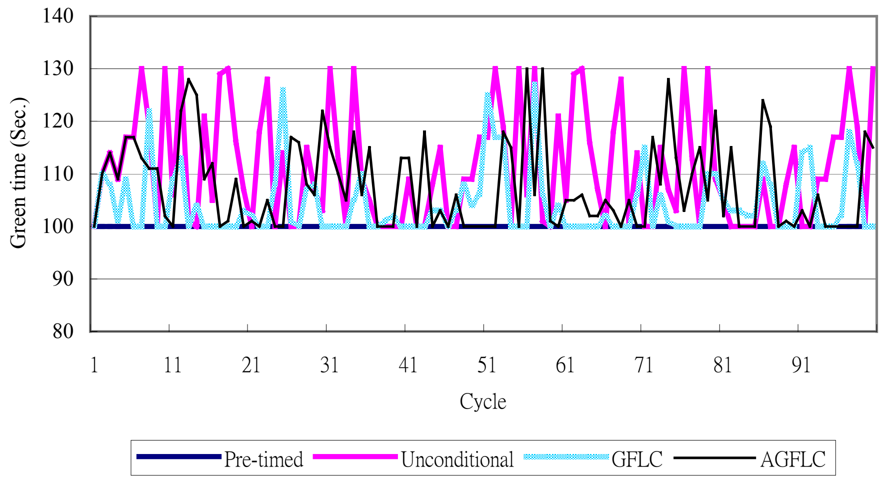


Figure 5-8 Green time at the first intersection of different TPS models with green extension strategy of the exemplified example at two consecutive intersections (progressive coordinated system).

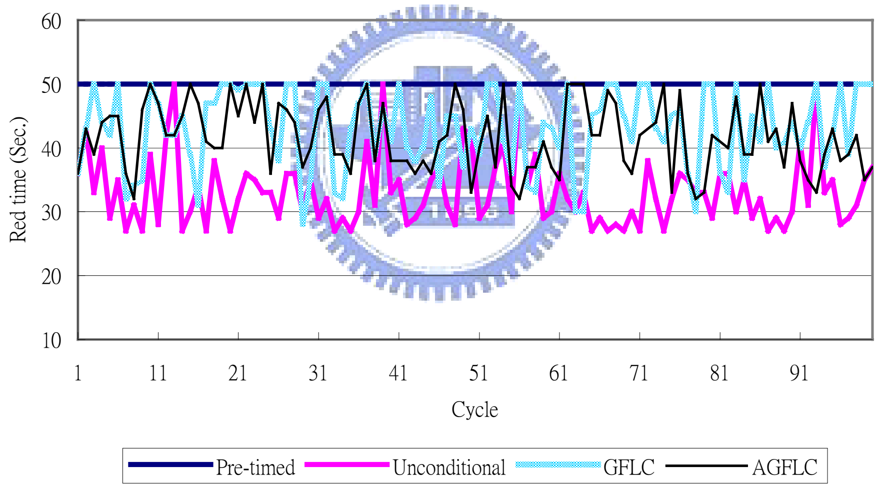


Figure 5-9 Red time at the first intersection of different TPS with red truncation strategy of the exemplified example at two consecutive intersections (progressive coordinated system).

5.1.5 Sensitivity Analyses

Sensitivity analyses on various traffic scenarios and bus loading factors are also conducted under progressive coordinated system in this case. The same variations of traffic flow rates and bus loading factors as the case of the isolated intersection are examined. Table 5.2 shows the simulation results of green extension and red truncation for various traffic scenarios and Figure 5-10 shows the *TPD* comparisons of green extension strategy. With green extension strategy, the AGFLC outperforms for all scenarios, followed by the GFLC. Note that the AGFLC performs the same as the GFLC does under low traffic scenario. Unconditional TPS can achieve a reduction of *TPD* only under low traffic. Unconditional TPS, the GFLC and the AGFLC models all perform better in low traffic than in high traffic. Similar results can be obtained with red truncation strategy. Moreover, focusing on the difference between green extension and red truncation, the performance of green extension is still superior to red truncation as traffic increases. This indicates the advantage of implementing green extension under high traffic and red truncation under low traffic.

Table 5.3 further shows the person delay of green extension and red truncation for different average bus loading factors under progressive coordinated system and Figure 5-11 shows the *TPD* comparisons of green extension strategy. As comparing to the pre-timed signal without TPS, the AGFLC can curtail the largest percentage of *TPD*, followed by the GFLC under both green extension and red truncation. Unconditional TPS even increases *TPD* for all the bus loading factors when implementing red truncation and for bus loading factor which is less than 40 when implementing green extension. As expected, when bus loading factor gets higher, the effectiveness in reducing *TPD* would be enhanced for all unconditional and conditional TPS examined. It reveals the advantage of implementing TPS in a high bus loading factor situation in the case of two consecutive intersections.

Table 5.2 Comparisons of different TPS models under various traffic scenarios (the exemplified example at two consecutive intersections under progressive coordinated system)

TPS Strategy	Traffic Scenarios	Types of Vehicles	Without TPS	With TPS: Unconditional	With TPS: Conditional GFLC	With TPS: Conditional AGFLC
Green Extension	High Traffic	Buses	685.9	488.2 (-28.82%)	561.5 (-18.14%)	558.9 (-18.52%)
		Other vehicles	2812.7	4906.4 (74.44%)	2813.3 (0.02%)	2815.4 (0.10%)
		All vehicles	3498.6	5394.6 (54.19%)	3374.8 (-3.54%)	3374.3 (-3.55%)
	Medium Traffic	Buses	563.2	446.7 (-20.69%)	450.2 (-20.06%)	415.3 (-26.26%)
		Other vehicles	1516.0	1634.0 (7.78%)	1546.7 (2.03%)	1576.8 (4.01%)
		All vehicles	2079.2	2080.7 (0.07%)	1996.9 (-3.96%)	1992.1 (-4.19%)
	Low Traffic	Buses	465.6	334.0 (-28.26%)	330.6 (-28.99%)	330.6 (-28.99%)
		Other vehicles	903.4	977.1 (8.16%)	959.0 (6.15%)	959.0 (6.15%)
		All vehicles	1369.0	1311.1 (-4.23%)	1289.6 (-5.80%)	1289.6 (-5.80%)
Red Truncation	High Traffic	Buses	685.9	280.9 (-59.05%)	639.0 (-6.84%)	637.2 (-7.10%)
		Other vehicles	2812.7	126408.0 (4394%)	2810.2 (-0.09%)	2807.1 (-0.20%)
		All vehicles	3498.6	126688.9 (3521%)	3449.2 (-1.41%)	3444.3 (-1.55%)
	Medium Traffic	Buses	563.2	314.4 (-44.18%)	448.1 (-20.44%)	418.9 (-25.62%)
		Other vehicles	1516.0	16742.0 (1004%)	1485.5 (-2.01%)	1514.5 (-0.10%)
		All vehicles	2079.2	17056.4 (720%)	1933.6 (-7.00%)	1933.4 (-7.01%)
	Low Traffic	Buses	465.6	377.1 (-19.01%)	352.8 (-24.23%)	352.1 (-24.38%)
		Other vehicles	903.4	869.6 (-3.74%)	869.4 (-3.76%)	869.8 (-3.72%)
		All vehicles	1369.0	1246.7 (-8.93%)	1222.2 (-10.72%)	1221.9 (-10.75%)

Note: The unit of person delay is person-hour. Figures in parenthesis represent the percentages of person delay difference in comparing to that of without TPS model.

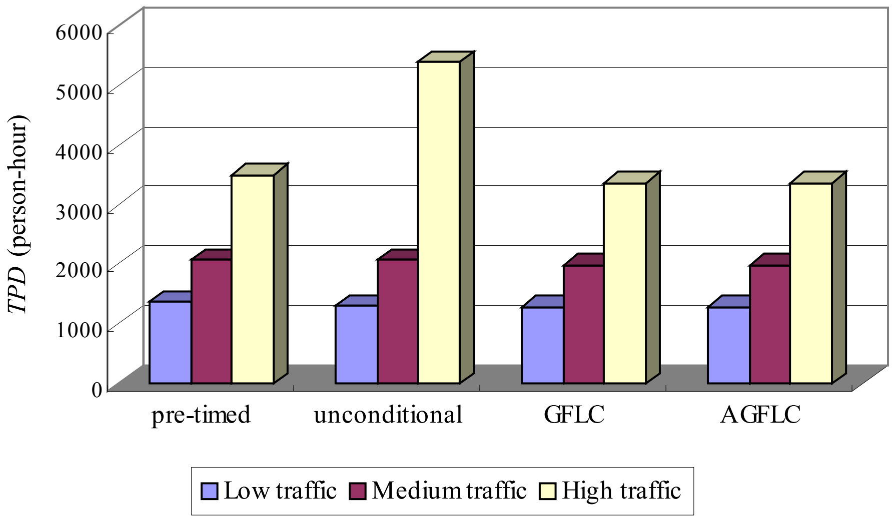


Figure 5-10 *TPD* Comparisons for different TPS models under various traffic scenarios (the exemplified example at two consecutive intersections under progressive coordinated system)

Table 5.3 Comparisons of difference TPS models under various bus loading factors (the field case at two consecutive intersections under progressive coordinated system)

TPS Strategy	Loading Factor	Types of Vehicles	Without TPS	With TPS		
				Unconditional	Conditional	
					GFLC	AGFLC
Green Extension	20	Buses	281.6	223.4 (-20.69%	230.9 (-18.00%)	227.1 (-19.35%)
		Other vehicles	1516.0	1634.0 (7.78%)	1541.6 (1.69%)	1544.7 (1.89%)
		All vehicles	1797.6	1857.4 (3.32%)	1772.5 (-1.40%)	1771.8 (-1.44%)
	30	Buses	422.4	335.0 (-20.69%	347.8 (-17.66%)	310.1 (-26.59%)
		Other vehicles	1516.0	1634.0 (7.78%)	1544.0 (1.85%)	1577.9 (4.08%)
		All vehicles	1938.4	1969.0 (1.58%)	1891.8 (-2.40%)	1888.0 (-2.60%)
	40	Buses	563.2	446.7 (-20.69%	450.2 (-20.06%)	415.3 (-26.26%)
		Other vehicles	1516.0	1634.0 (7.78%)	1546.7 (2.03%)	1576.8 (4.01%)
		All vehicles	2079.2	2080.7 (0.07%)	1996.9 (-3.96%)	1992.1 (-4.19%)
	50	Buses	704.0	558.4 (-20.69%	519.8 (-26.16%)	515.0 (-26.85%)
		Other vehicles	1516.0	1634.0 (7.78%)	1579.3 (4.18%)	1583.8 (4.47%)
		All vehicles	2220.0	2192.4 (-1.24%)	2099.1 (-5.45%)	2098.8 (-5.46%)
	60	Buses	844.8	670.1 (-20.69%	624.3 (-26.10%)	622.3 (-26.34%)
		Other vehicles	1516.0	1634.0 (7.78%)	1577.1 (4.03%)	1577.7 (4.07%)
		All vehicles	2360.8	2304.1 (-2.40%)	2201.4 (-6.75%)	2200.0 (-6.81%)
Red Truncation	20	Buses	281.6	157.2 (-44.18%	231.6 (-17.76%)	227.3 (-19.28%)
		Other vehicles	1516.0	16742.0 (1004%)	1476.2 (-2.63%)	1476.2 (-2.63%)
		All vehicles	1797.6	16899.2 (840%)	1707.8 (-5.00%)	1703.5 (-5.23%)
	30	Buses	422.4	235.8 (-44.18%	338.7 (-19.82%)	332.5 (-21.28%)
		Other vehicles	1516.0	16742.0 (1004%)	1486.3 (-1.96%)	1486.3 (-1.96%)
		All vehicles	1938.4	16977.8 (775%)	1825.0 (-5.85%)	1818.8 (-6.17%)
	40	Buses	563.2	314.4 (-44.18%	448.1 (-20.44%)	418.9 (-25.62%)
		Other vehicles	1516.0	16742.0 (1004%)	1485.5 (-2.01%)	1514.5 (-0.10%)
		All vehicles	2079.2	17056.4 (720%)	1933.6 (-7.00%)	1933.4 (-7.01%)
	50	Buses	704.0	393.0 (-44.18%	528.6 (-24.91%)	529.9 (-24.73%)
		Other vehicles	1516.0	16742.0 (1004%)	1518.0 (0.13%)	1512.5 (-0.23%)
		All vehicles	2220.0	17135.0 (671%)	2046.6 (-7.81%)	2042.4 (-8.00%)
	60	Buses	844.8	471.6 (-44.18%	634.7 (-24.87%)	629.4 (-25.50%)
		Other vehicles	1516.0	16742.0 (1004%)	1507.7 (-0.55%)	1500.5 (-1.02%)
		All vehicles	2360.8	17213.6 (629%)	2142.4 (-9.25%)	2129.9 (-9.78%)

Note: The unit of person delay is person-hour. Figures in parenthesis represent the percentages of person delay difference in comparing to that of without TPS model.

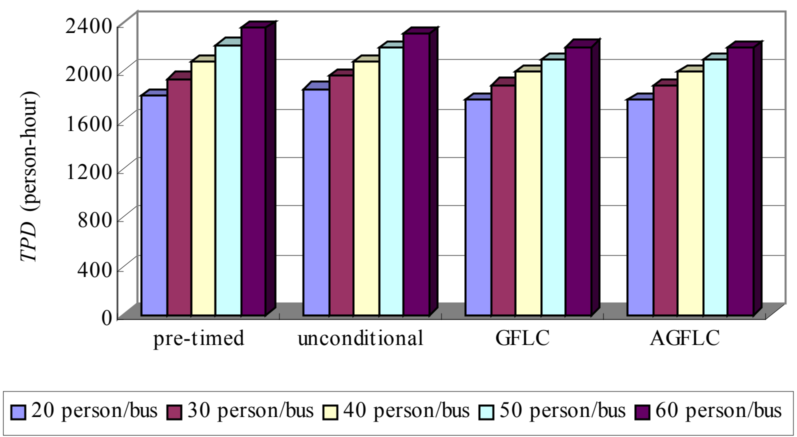


Figure 5-11 *TPD* Comparisons for different TPS models under various bus loading factors (the field case at two consecutive intersections under progressive coordinated system)

5.2 Field Case

5.2.1 Data and Parameters

To examine the applicability of the proposed GFLC and AGFLC, a field case study is conducted at a two-adjacent intersection in Ren-ai arterial intersected at Jinshan South Road and Hangzhou South Road of Taipei City. Figure 5-12 depicts the configuration of this arterial and two minor streets, in which Ren-ai Road is a westbound one-way arterial with 8 lanes including two bus-exclusive lanes (one of which is in contra-flow direction), Jinshan S. Rd. has 3 northbound lanes and 4 southbound lanes, while Hangzhou S. Rd. is a northbound one-way street with 3 lanes. Five-minute flow rates during the morning peak hours from 7:00 a.m. to 9:00 a.m. are surveyed as shown in Figure 5-13. The current timing plan in Ren-ai arterial is a progressive coordinated system with 60 seconds green, 50 seconds red, and 3 seconds all-red with 20 seconds offset.

The parameters of GA and ACO algorithms, like population size, crossover rate, mutation rate, a, h, δ, ε, NE_t, α, β, ξ, ρ, q_0, θ_{i6}, τ^0, K, and t_{max} are set the same as those in the exemplified example. The predetermined rule table for ACO algorithm and average loading factors of private cars and buses are also assumed the same as those in the exemplified example. Referring to the current timing plan at the field intersection, the maximal and minimal green time is set to be 90 seconds and 20 seconds, respectively.

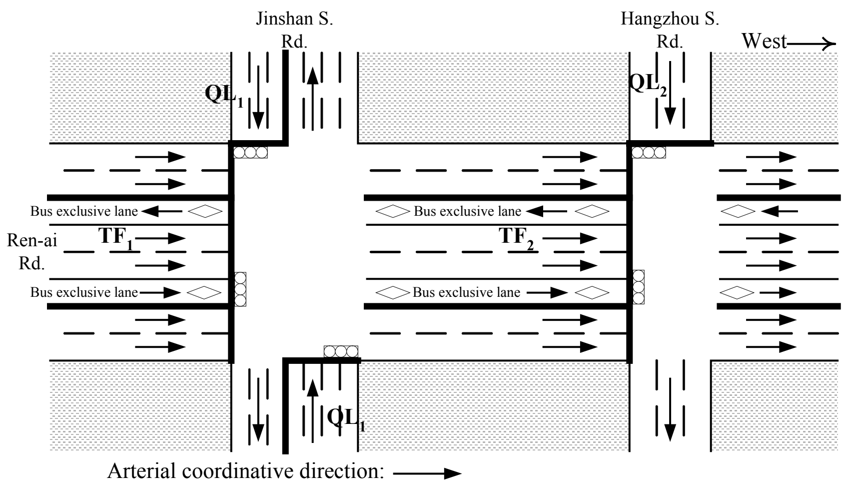


Figure 5-12 Configuration of the exemplified example at two consecutive intersections.

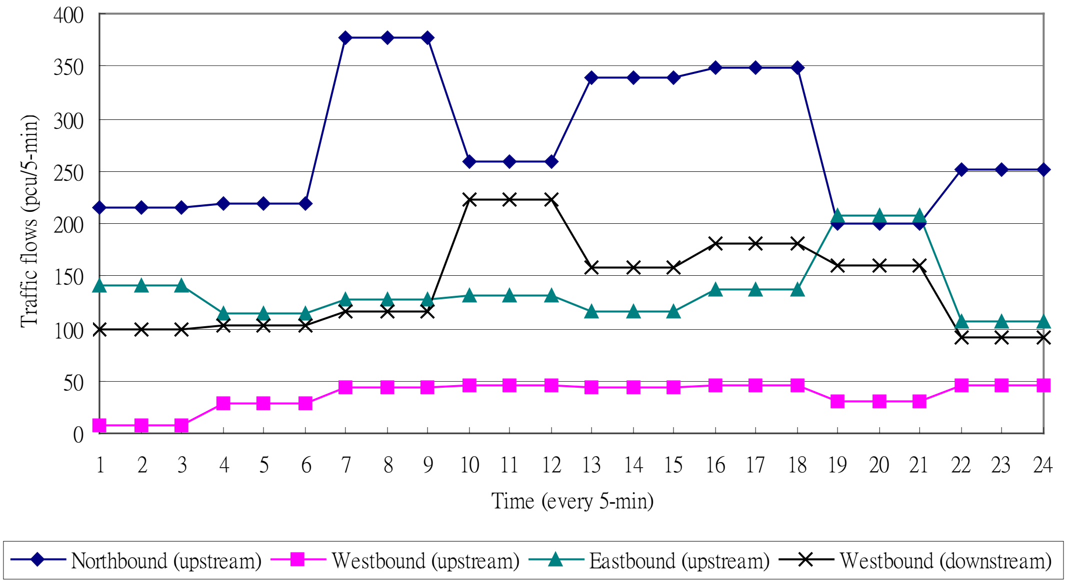


Figure 5-13 Observed flow rates of the field case at two consecutive intersections.

5.2.2 Results

The simulated results are shown in Table 5.4. Comparing to the current progressive coordinated timing plan of the field case, the unconditional TPS model can curtail considerable amount of person delay for buses; however, the overall performance is deteriorated by 13.70% (green extension) and by 94.09% (red truncation) if all vehicles (buses and cars) are taken into account. In contrast, the AGFLC can curtail *TPD* by 7.60% and 11.30% in green extension and red truncation, respectively, while the GFLC can reduce *TPD* by 7.10% and 10.61%. The results indicate that the AGFLC outperforms, followed by the GFLC for green extension and red truncation strategies.

Table 5.4 Comparisons of difference TPS models (the field case at two consecutive intersections under progressive coordinated system)

TPS Strategy	Types of Vehicles	Current Timing (Without TPS)	With TPS		
			Unconditional	Conditional	
				GFLC	AGFLC
Green Extension	Buses	101.3	71.2 (-29.71%)	71.6 (-29.32%)	72.1 (28.83%)
	Other vehicles	260.7	340.3 (30.53%)	264.7 (1.53%)	262.4 (-0.65%)
	All vehicles	362.0	411.5 (13.67%)	336.3 (-7.10%)	334.5 (7.60%)
Red Truncation	Buses	101.3	58.9 (-41.86%)	75.3 (-25.67%)	73.6 (27.34%)
	Other vehicles	260.7	643.7 (146%)	248.2 (-4.79%)	247.5 (5.06%)
	All vehicles	362.0	702.6 (94.09%)	323.5 (-10.64%)	321.1 (11.30%)

Note: The unit of person delay is person-hour. Figures in parenthesis represent the percentages of person delay difference in comparing to that of without TPS model.