INTERSECTION OPERATIONAL ANALYSIS AND NECESSARY RECOMMENDATIONS

CIVL 440 Project

INTERSECTION: 16TH AVENUE & EAST MALL

FOR AM PEAK HOUR

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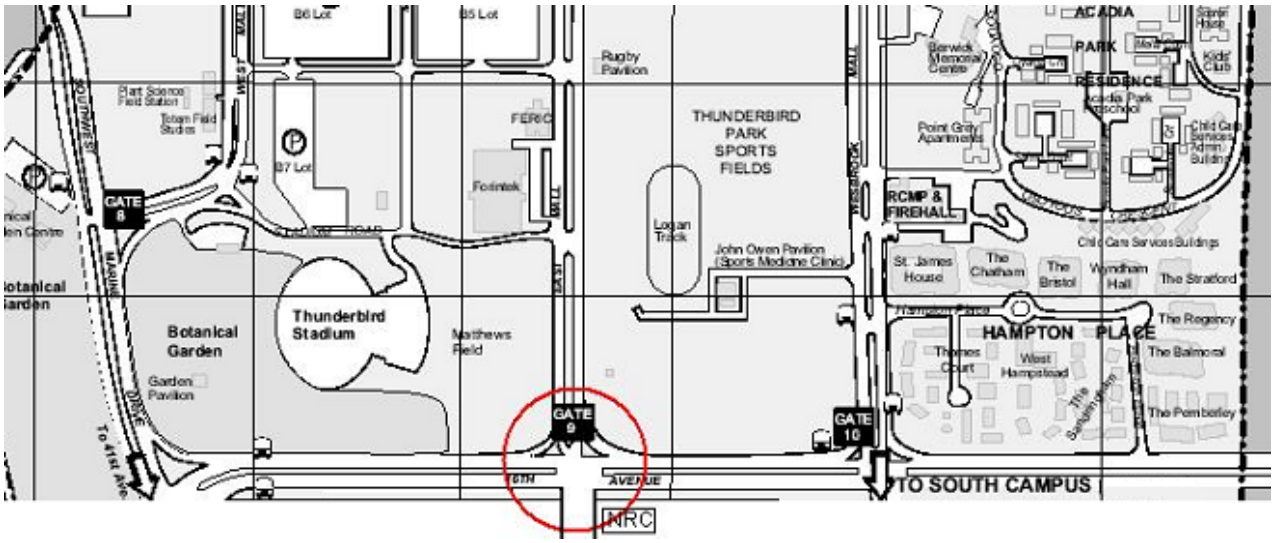
BACKGROUND

The intersection under the focus of this study is established and maintained by the BC Ministry of Transportation. There are four similar intersections in and around the University of British Columbia. The cost of installation of a controller of such devices was around $1,500. First modification of the intersection of the 16th Avenue and East Mall took place in 1993 as a result of the extension of East Mall to the NRC facility. Modification to the Signalization was made based on UBC traffic for 1993 and projected NRC traffic. An analysis done by ND Lea and Shaflik Engineering in 1996 showed that UBC traffic volumes had dropped and the NRC did not generate anticipated increased traffic volume because of unchanged employee total as a result of Federal funding cutbacks. It was recommended to remove the unnecessary delays that the east/west bound traffic were subjected to. Again the signal plan was reviewed in 1999 by UBC's consultants to incorporate the future change in NRC traffic, the proposal was not accepted by the MoT as the intersection was operating at 'acceptable' level of service. However, under present traffic conditions it was perceived that modifications to the signal operation was necessary for a better level of service and an over all reduction in delay.

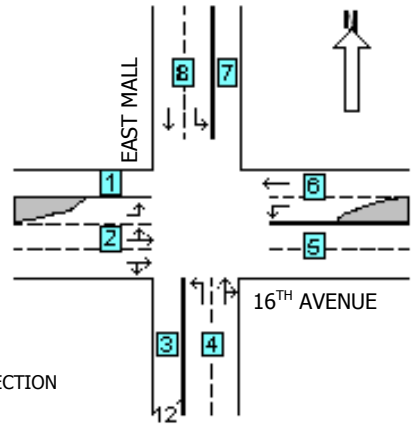
OBJECTIVE

The major focus of this study was to measure the current level of operation of the target intersection and attempt for establishing improved signal plan(s). The analysis of the performance of the intersection under the existing signal system was necessary using the present traffic data. Since it is obvious that there can be better alternates, the options were sought with existing phasing/laning layouts but changed timing and also with a change in over all plan (phasing/laning and timing). A graphical and tabular comparative study was also intended to highlight the present condition and proposed changes.

LOCATION PLAN



EXISTING LAYOUT



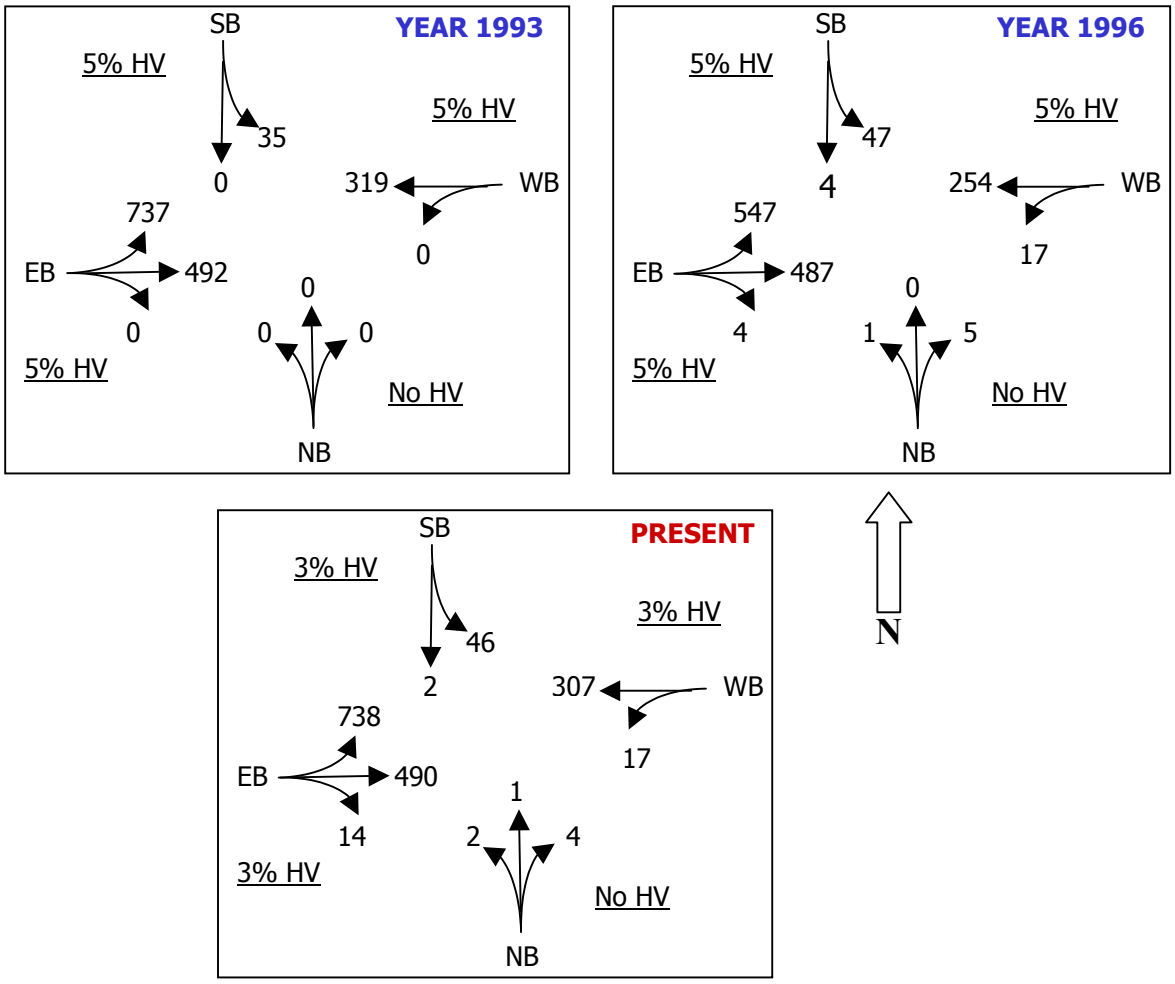
MAJOR MOVEMENTS:
- EB TURNING LEFT AT AM PEAK
- EB BUSES STOPPING AT FAR SIDE OF THE INTERSECTION
- SB TURNING LEFT AT PM PEAK

Table-1: CHANGES IN VOLUMES SINCE 1993

STREETS	APPROACH	Lane	1993 Count	1996 Count	2002 Count (group work)
16th Ave	East Bound	L	737	547	738
		T	492	487	490
		R	NOT/EXIST	4	14
	West Bound	L	NOT/EXIST	17	17
		T	319	254	307
		R	446	191	Excl RT Lane
East Mall	North Bound	L	NOT/EXIST	1	2
		T	NOT/EXIST	0	1
		R	NOT/EXIST	5	4
	South Bound	L	35	47	46
		T	NOT/EXIST	4	2
		R	36	36	Excl RT Lane

1993: AM Peak Hour (7:45-8:45), October
1996: AM Peak Hour (8:00-9:00), March
2002: AM Peak Hour (7:30-8:30), November

GRAPHICAL LAYOUT OF TRAFFIC VOLUMES AND % HEAVY VEHICLES



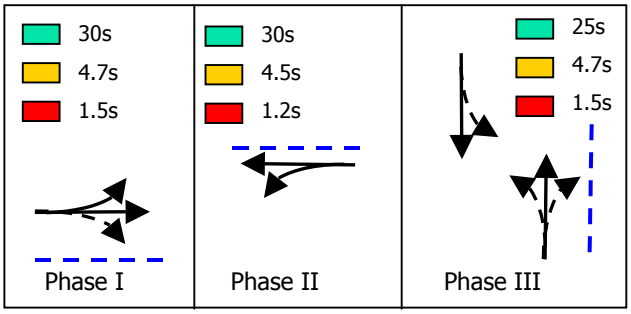
METHODOLOGY

From the site observation, it was obvious that intersection capacity was not exceeded and lead to a conclusion that performance could be improved by making some modifications to the signal timing, phasing and/or laning. Average vehicle delay for lane groups and the intersection as a whole and resulting level of service have been used as the measures of performance. In the methodology for the traffic signal analyses the Highway Capacity Software (HCS 2000) was extensively used besides manual calculation of Optimum Cycle lengths using Webster's method. The calculation sheets and printed out reports are attached in the Appendices Chapter. The scope of work was divided into the following steps-

- AM Peak Hour traffic volume count
- Study of the current conditions under present traffic volume
- Look for an improvement by signal timing change alone
- Determination of an improved Level Of Service(LOS) with changed timing/phasing/laning
- Presentation of the findings in graphical and tabular formats
- Comparison of the above options and recommendation

STUDY OF EXISTING CONDITION

At present the traffic signal is operated in three phases. It is semi-actuated with green extension of three seconds. Pedestrian buttons are also there. In our study we have considered the green timings for the AM Peak only. It was understood that safe pedestrian crossing time was governing the minimum green timings for the approaches. It was also notable that although the intersection had the layout as shown below, there has been a provision left for possible future upgrading. As a consequence, pedestrians have to walk more distances than can be assumed from the layout. The recommended pedestrian movement in N-S directions is in Westside considering a smaller distance for walking (80ft). The performance of prevailing system is summarized in Table 2. It can be seen that the LOS is (E) with an over all delay of 70.3 seconds.



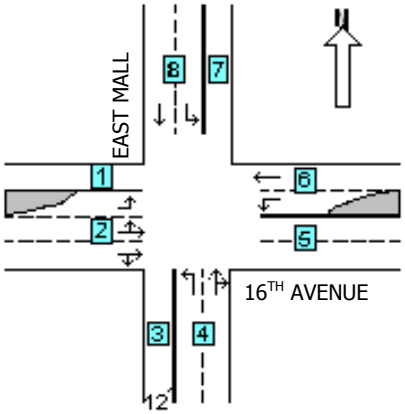


Table-2: Summary of Existing Intersection Signal System Performance

Cycle Length: 103.1 secs

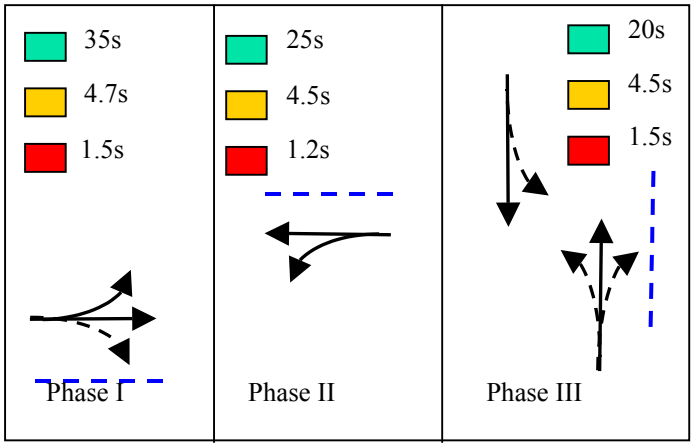
Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
L	520	1787	0.71	0.29	40.6	D		
LTR	973	3343	1.10	0.29	95.5	F	81.4	F
Westbound								
L	525	1805	0.05	0.29	26.5	C		
T	527	1810	0.71	0.29	40.4	D	39.4	D
Northbound								
L	347	1430	0.02	0.24	29.9	C		
TR	409	1686	0.04	0.24	30.0	C	30.0	C
Southbound								
L	316	1302	0.19	0.24	31.3	C		
T	461	1900	0.02	0.24	29.7	C	31.1	C

Intersection Delay = 70.3 (sec/veh) Intersection LOS = E

ALTERNATE SIGNAL PLAN: OPTION 1

It should be kept in mind that major cost is associated whenever a signal plan is modified in terms of preparation of electrical drawings, removal of pavement markings, change of signal heads and its wirings, change of controller and so on. Therefore, we have considered this plan of improving the performance with change in timing only. Finally, we reached at an over all level of service of D and average delay of 41.2 seconds (Table-3), with an improvement in delay reduction of about 41%. The basic idea was to lower green allocation for NB/SB and increase the green time for the EB traffic. The constraint in changing the green timings is the pedestrian safe crossing times. Although there is extremely low pedestrian traffic volume, provisions are kept in the design.



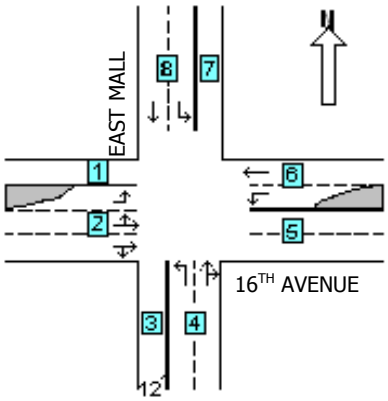


Table-3: Summary of Intersection Performance with Alternate Signal Plan Option 1

Cycle Length: 97.9secs

Intersection Performance Summary

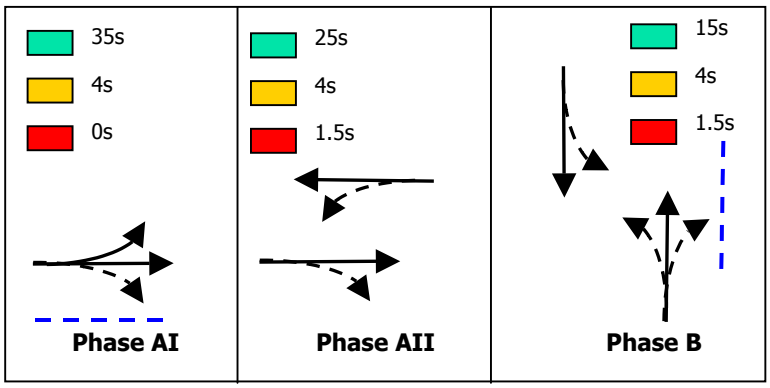
Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
L	639	1787	0.58	0.36	29.4	C		
LTR	1190	3328	0.91	0.36	42.2	D	38.9	D
Westbound								
L	461	1805	0.06	0.26	27.8	C		
T	458	1792	0.86	0.26	53.0	D	51.3	D
Northbound								
L	292	1430	0.03	0.20	31.3	C		
TR	344	1686	0.05	0.20	31.5	C	31.5	C
Southbound								
L	266	1302	0.23	0.20	32.9	C		
T	388	1900	0.02	0.20	31.1	C	32.7	C

Intersection Delay = 41.2 (sec/veh) Intersection LOS = D

ALTERNATE SIGNAL PLAN: OPTION 2

This plan was intended to explore the best possible combination of green timings, phasing and lanings for the approaches/ lane groups. Due to the great difference in traffic volumes among the approaches it was obvious that split phasing can handle the situation most efficiently. This led to a

two split movements for the EB traffic with left turning vehicles using two lanes exclusively. The outcome of the analysis is shown in Table-4. It is remarkable that the LOS has improved to C and the delay has dropped to about 24.2 seconds, suggesting almost 66% improvement. It is also clear that there has been a reduction in cycle time. It is also worth mentioning that Webster's formula had supplied a much lower optimum cycle length, which could not be considered, as the pedestrian minimum green was governing in this case.



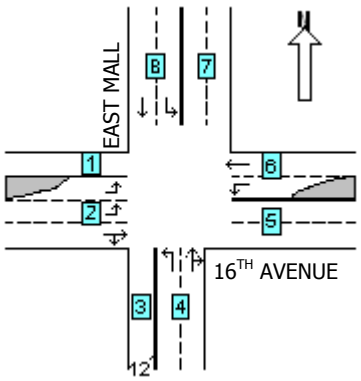


Table-4: Summary of Intersection Performance with Alternate Signal Plan Option 2

Cycle Length: 90.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
L	1348	3467	0.69	0.39	25.9	C		
TR	1218	1713	0.43	0.71	6.6	A	18.9	B
Westbound								
L	247	889	0.11	0.28	25.2	C		
T	498	1792	0.79	0.28	41.9	D	40.8	D
Northbound								
L	238	1430	0.03	0.17	31.7	C		
TR	281	1686	0.06	0.17	31.9	C	31.9	C
Southbound								
L	217	1302	0.28	0.17	33.5	C		
T	317	1900	0.03	0.17	31.4	C	33.2	C

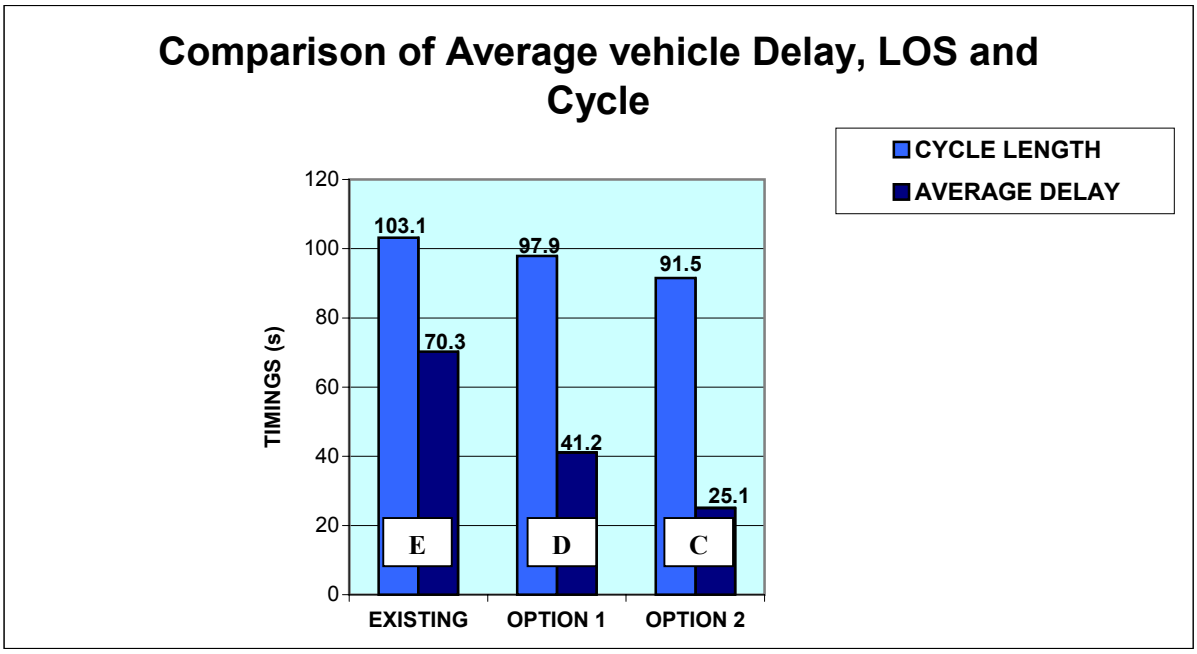
Intersection Delay = 24.2 (sec/veh) Intersection LOS = C

COMPARISON OF THE OPTIONS WITH EXISTING CONDITIONS

This study was aimed at investigating possible alternates to the existing inefficient signal plan operation at the intersection between the 16th Avenue and East Mall. In our study it has been found to be operating at a level of service of F with average vehicle delay of about 70 seconds.

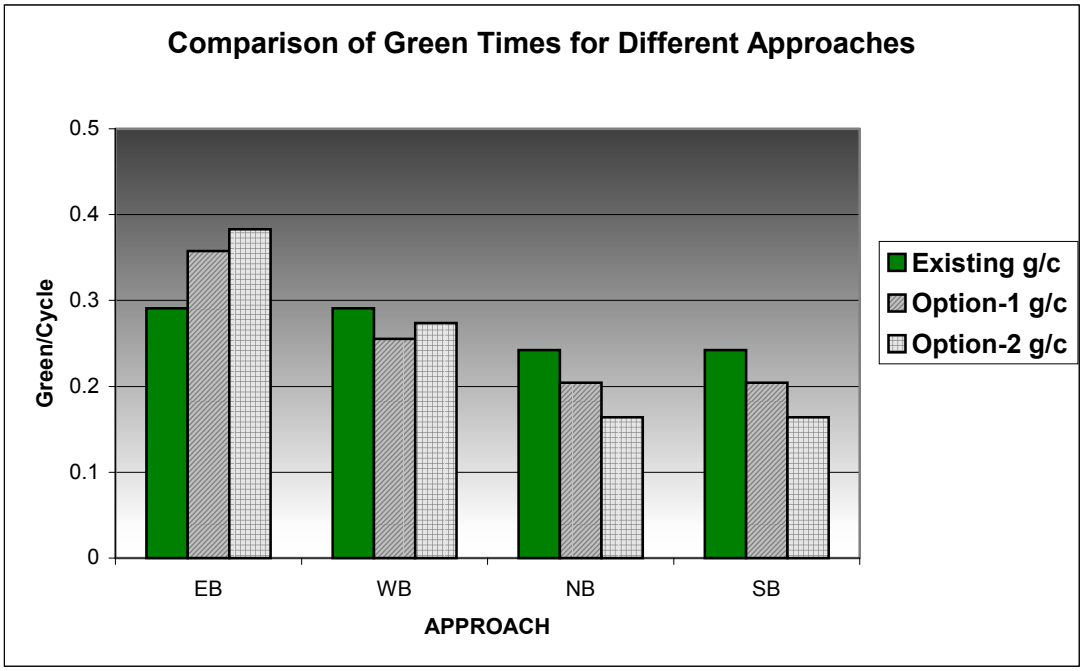
The study has also revealed two possible alternates with or without recommended changes in the existing phasing and or laning conditions. Although it has been understood that pedestrian traffic

for this intersection is almost nil, for design purposes and as a general component, provision for safe pedestrian crossing time has to be provided. This governs the signal timings in all of the analyzed options. This has been more prominent due to the fact that the crossing walks distances are great in all sides (70, 80 and 84 ft). This subsequently leads to a green time of about 20 sec. However, instead of providing equal green allocations to the EB, WB and NB/SB it is more justified to provide more green to the predominant traffic lane group, i.e. EB turning left. This was the investigated Option 1, which resulted in a delay reduction of about 41%. Further improvement was possible when the LT exclusive lane was increased to two and EB through movement was compensated with a split phase movement. This arrangement was termed as Option 2, it led to a delay reduction by 64% and LOS was raised to grade C. The comparisons are depicted in the following graphs also.

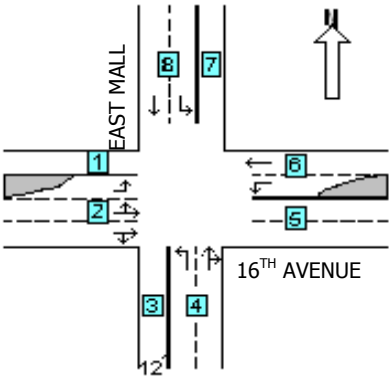


LOS	DELAY/VEH (s)
A	< 10.0
B	>10.0 – 20.0
C	>20.0 – 35.0
D	>35.0 – 55.0
E	>55.1 – 80.0
F	> 80.0

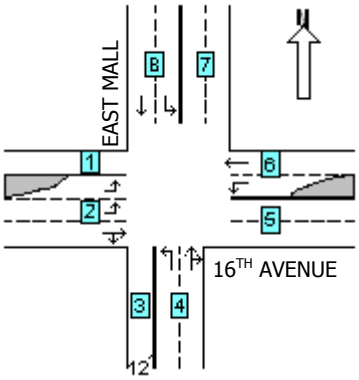
Source: TRB 2000



INTERSECTION LAYOUT



Existing

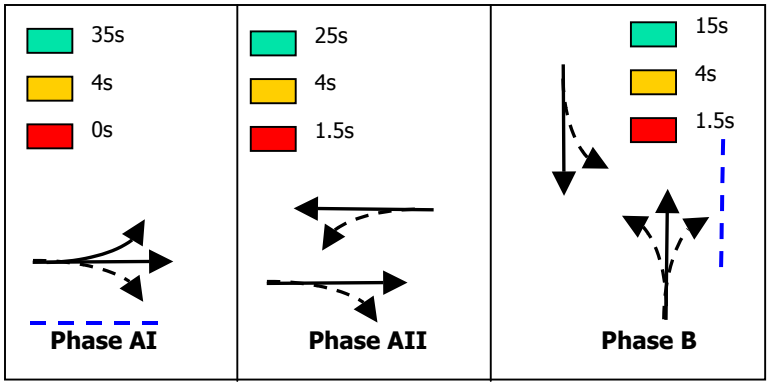


Recommended

SIGNAL TIMINGS COMPARISON

	Existing					Recommended				
Phase	**Gmin**	**Gap**	**G (AM Peak)**	**A**	**AR**	**Gmin**	**Gap**	**G (AM Peak)**	**A**	**AR**
EB	7	3	30	4.7	1.5	7	3	35	4	1.5
Walk	7					7				
FDW	13					13				
WB	7	3	30	4.5	1.2	7	3	25	4	1.5
Walk	7					7				
FDW	17					17				
NB/SB	7	3	25	4.7	1.5	7	3	15	4	1.5
Walk	7					7				
FDW	17/19					17/19				
Cycle	**103.1**					**91.5**				
LOS/Delay	**F/70.3**					**C/25.1**				

PHASE DIAGRAM



CONCLUSIONS AND RECOMMENDATIONS

The intersection under discussion is presently operating at an unacceptable level of service. During the morning peak the predominant traffic movement in the EB direction turning left is subjected to unnecessary delays. It cannot be justified to allocate 25 second green to the NB/SB approach during the morning peak for almost no vehicle and when there are queues of about 30 vehicles building up on three lanes of the EB approach. Unfortunately they are getting 30 seconds to clear up in their turn. With the increasing traffic the situation is feared to aggravate further.

In this study the results and comparative evaluations have been made to improve the performance of the intersection. FHWA recommends a signalized intersection to be reviewed for modifications every 2/3 years. It has been quite some time that work has been done to improve the operational efficiency of the intersection.

The study has investigated two alternate signal plans, the second plan is expected to improve the performance remarkably, and therefore, is more preferable. Other than the controller changes there is insignificant lane change warranted. The through lane marking on the middle lane has to be eradicated. However, change of phasing from three to two would require some obvious attention.

Pedestrian movements in the N-S directions are recommended only in the west side to reduce the time and safety.