TRAFFIC MANAGEMENT AND BENEFIT ANALYSIS OF KORAL INTERCHANGE

Final Year Project (2016-17)

By:

Roman Masood (NUST201304567)

Muhammad Hassaan Haider (NUST201305522)

Jamal Haider (NUST201306893)

Waqas Ashraf (NUST201304645)

Project Advisor: A/P. Malik Saqib Mahmood

NUST Institute of Civil Engineering (NICE)

School of Civil and Environmental Engineering (SCEE)

National University of Sciences and Technology (NUST)

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CERTIFICATION

This is to certify that thesis entitled

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Submitted by

Roman Masood	(NUST201304567)
Muhammad Hassaan Haider	(NUST201305522)
Jamal Haider	(NUST201306893)
Waqas Ashraf	(NUST201304645)

Has been accepted towards fulfillment

Of the requirements

For Bachelors in Civil Engineering

Malik Saqib Mahmood

Assistant Professor

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Sciences and Technology, Islamabad, Pakistan

ABSTRACT

Purpose of this project is to do the benefit analysis of Koral interchange and traffic management during construction of KORAL Interchange. For benefit analysis the data collected is Classified Intersection Counts and Traffic Approaching Interchange, Bidding Document and Tender Drawing. Then by using above mentioned data traffic analysis was done by using **SYNCHRO** and **VISSIM**. Then the comparison of results of both softwares in term of average vehicular delays, fuel consumptions and vehicular emissions was done. The payback period of the capital cost of interchange in terms of public benefits by calculating savings due to fuel consumption and vehicular emissions reduction due to conversion of this intersection into interchange was also determined.

To mitigate congestion, pollution and accidents problems to the road users during construction of interchange, first of all a stage wise work execution plan is proposed and then traffic management plan for each stage of construction is also proposed. This work is done using AutoCAD. These management plans can be used for future similar projects in order to avoid congestion, pollution and accidents problems which happened during construction of koral interchange.

LOS on intersection was F and it is improved to B by construction of the interchange and it will remain B even in 2032. Similarly fuel consumption reduced from 589 gal/hr to 373 gal/hr. Vehicular Emissions (i.e. CO, NOX, VOCs) also reduced to a large extent by conversion of intersection into interchange. The payback period of the capital cost of interchange in terms of public benefits is 3.21 years (3 years and 2.5 months). The construction of KORAL Interchange had been actually executed in two stages due to which there was poor traffic management during construction. In order to manage the traffic efficiently a seven stages work execution plan was proposed.

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DECLARATION

It is hereby solemnly and sincerely declared that the work referred to this thesis project has not been used by any other university or institute of learning as part of another qualification or degree. The research carried out and dissertation prepared was consistent with normal supervisory practice and all the external sources of information used have been acknowledged.

DEDICATION

Dedicated to our parents, teachers and colleagues.

ACKNOWLEDGMENT

We thank The Almighty Allah for giving us the wisdom, strength and belief in ourselves for the undertaking of this final year project. Our heartiest thanks, gratitude and respect to our parents, without their prayers and wishes we would never have been able to come this far in our project

We are grateful to our advisor A/P Malik Saqib Mahmood for his admirable direction, guidance, assistance and motivation for the successful completion of our project. It is with his support that we have been successful in achieving our objectives.

We are absolutely grateful to our HOD Transportation Engineering Dr. Muhammad Jawed Iqbal for his as noteworthy support, which in fact became the crux in the progress of this project. We would also like to mention and thank all those contractors, consultants and specially CDA who provided us with their time, assistance and data. Without their cooperation this project would not have seen the light of dawn.

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LIST OF FIGURES:

LIST OF ACRONYMS

NBT	- North Bound Through
NBL	- North Bound Left
NBR	- North Bound Right
SBT	- South Bound Through
SBL	- South Bound Left
SBR	- South Bound Right
SBU	- South Bound U-Turn
EBT	- East Bound Through
EBL	- East Bound Left
EBR	- East Bound Right
EBU	- East Bound U-Turn
WBT	- West Bound Through
WBR	- West Bound Right
LOS	- Level of Service
ICU	- Intersection Capacity Utilization
CO	- Carbon Monoxide
NOX	- Nitrogen Oxides
VOC's	- Volatile Organic Compounds

CHAPTER 1

INTRODUCTION

1.1 Background

Traffic Congestion and delays on an at-grade urban signalized intersection are a major problem in traffic engineering. Islamabad Highway is the main hub of traffic in Islamabad and Rawalpindi. Traffic coming from GT road and from different sectors of Islamabad use Islamabad Expressway, due to this heavy movement congestion was a major problem at Islamabad Highway. Due to congestion, delays and traffic issues started to rise on Islamabad Highway CDA has started to build a signal free corridor on Islamabad Highway. Koral Interchange is one of the major interchange that is being built on Islamabad Expressway. In this project complete study of Koral Interchange and previous Intersection has done to analyze traffic variables and their effect before and after the construction of Interchange on economy. For this purpose delays, LOS, fuel Consumption, vehicular emissions of before and after the construction of this interchange had been compared. Future traffic analysis had been also done in order to predict performance of interchange in future. The economical analysis of the project is done in terms of fuel consumption and vehicular emissions. Economical Analysis comprises of cost recovery which is actually the time period required for the project to pay back its construction cost in term of public benefit.

Construction should be done in stages as it is very important to manage a large volume of traffic running on the road during working of labor, heavy machinery etc. If it is not done it may result into serious accidents, which may result into a greater crash i.e. project delayed, stopped, death of driver etc. Traffic management during construction of a road is well planned before starting any stage of the project which can disturb any movement of already running traffic. Traffic management plan is decided keeping in view that none of the movement is stopped, interrupted or delayed due to construction. For this purpose temporary ramps and U-turns are also constructed. Some length along the road is tapered to avoid accidents due to construction. Along the road, some signs and control devices should be erected using standards provided by Manual On Uniform Control Devices (MUTCD) for managing Temporary Traffic Control Zone (TTC).

1.2 Project Aims and Objectives

Aims and objectives of this dissertation is summarized as follows:

- Traffic Analysis before and after construction.
- Future traffic Analysis of projected traffic counts
- To purpose stage wise work execution plan.
- To purpose traffic management plan for each stage of construction.
- Capital cost recovery of interchange in terms of public benefits.

1.3 Project Scope

Scope of this dissertation is summarized as follows:

- Traffic Delays, Fuel consumption, Vehicular emissions before and after construction by using SYNCHRO and VISSIM.
- Literature review about parameters and features involved in managing the traffic during construction at road.
- Stage wise work execution plan on AutoCAD.
- Traffic Management plan for each stage of construction on AutoCAD.
- Capital Cost recovery of interchange in terms of public benefits due to fuel consumption and vehicular emissions reduction because of conversion of intersection into interchange.

CHAPTER 2

LITERATURE REVIEW

2.1 Traffic Analysis

Traffic analysis is done in order to calculate different variables including Average vehicular Delays, Stop delays, Stops, Fuel consumption and Vehicular Emissions.

2.1.1 Traffic Delays

Traffic Delay is the extra travel time consumed by vehicle due to congestion and other traffic related interruptions. It is calculated in seconds per vehicle. Traffic delays were used to determine level of service by using following tables.

Table 1 LOS Criteria for Signalized Intersection (From HCM 2000)

EXHIBIT 16-2. LOS CRITERIA FOR SIGNALIZED INTERSECTIONS

LOS	Control Delay per Vehicle (s/veh)
A	≤ 10
B	> 10–20
C	> 20–35
D	> 35–55
E	> 55–80
F	> 80

Table 2 LOS Criteria for Interchange (From HCM 2000)

EXHIBIT 26-8. LOS CRITERIA FOR INTERCHANGES

Level of Service	Delay (s/veh)
A	≤ 10
B	> 10–20
C	> 20–35
D	> 35–55
E	> 55–80
F	> 80

2.1.2 Level of Service

Level of Service is used to calculate quality of traffic Flow in any traffic System. Level of Service is used to calculate quality of different traffic systems by using delays, speed and density. It determines the performance of any traffic system.

Table 3 LOS Classification

LOS	Type of Flow
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced flow

2.1.3 Fuel Consumption

Fuel consumption is the amount of fuel that is consumed by vehicle during its movement on the road. It Can be calculated by using traffic Simulation software such as VISSIM. It is measured in gallons per hour. Fuel consumption is effected by Delays ,average Speed and vehicle composition.

2.1.4 Vehicular Emissions

Vehicular emissions are the release of different residual gasses from the tail pipe of vehicle. Different gases are released which include carbon mono-oxide, Carbon di oxide, Nitrogen Oxides, Volatile Organic Compounds, Sulphur oxides etc. CO, NOX and VOC can be calculated by using VISSIM. It is measured in Grams per hour. It is affected by delays, average speed and vehicle composition. In order to find damage cost due to vehicular emissions following table can be used.

Table 4 Damage Cost of Emissions (From HERS-ST Technical Report (2005))

Table 33. HERS-ST estimates of air pollutant damage costs in 2000 dollars.			
Pollutant	**Damage Costs ($/ton)**	**Adjustment Factors**	
		Urban	**Rural**
Carbon Monoxide	$100	1	0.5
Volatile Organic Compounds	$2,750	1.5	1
Nitrogen Oxides	$3,625	1.5	1
Sulfur Dioxide	$8,400	1.5	1
Fine Particulate Matter (PM2.5)	$4,825	1	0.5
Road Dust	$4,825	1	0.5

2.2 Case Studies

For Literature Review different case studies which were similar to this project were studied these case studies include different projects which were similar to this project. Some case studies of expressways are enlisted which were constructed in Philippine.

2.2.1 Cavite-Laguna (CALA) Expressway Project

The Cavite–Laguna Expressway (CALAX) is a proposed expressway that will cross the provinces of Cavite and Laguna in the Philippines. The project is a 4-lane **44.20 km** long consist of **8 interchanges** and 1 toll barrier.

Benefits

- Travel time will be reduced by about 45 minutes from Cavitex to Slex.
- Traffic congestion will be reduced specially in Governor Drive, Aguinaldo Highway, Sta. Rosa-Tagaytay road which are heavily congested.

2.2.2 Tarlac-Pangasinan-La Union Expressway (TPLEX)

Tarlac-Pangasinan-La Union Expressway (TPLEX) is a four-lane expressway under construction in the Manila region of Philippines. The 88.5km expressway will start from the southern terminal in Tarlac City and end at the northern terminal at Rosario in La Union which consist of 9 interchanges and 10 toll plazas.

Benefits

- Reduce travel time from Tarlac to Rosario from 3.5 hours to 1 hour. From this project **20,000 vehicles per day** will be benefited.

2.3 Traffic Management During Construction

This includes the review of literature that describes and analyzes the studies that are directly related to managing traffic at an interchange during construction. This chapter contains studies about purpose of using traffic control devices, types, location of roadside signs used for temporary traffic control zone. This chapter also includes the studies about the calculations of distances to be tapered for some diversions i.e distances of U-turns from any approach, channelization provided to traffic due to some construction works alongside the road. This chapter explains the standards and formulas provided by Manual on Uniform Traffic Control Devices (MUTCD) for Temporary Traffic Control Zones (TTC) at any highway. Brief introduction about working of AutoCAD is also provided.

2.3.1 Temporary Traffic Control Zones (TTC)

In case of construction works alongside some facility i.e road, market, plaza etc, a specific area is prohibited to control any traffic incidents, natural disaster or special event. To achieve this prohibition at some high level certain sign boards, channelizing devices, barriers, pavement markings, flashing lights are used. In case of construction alongside the road this zone starts from first sign, light or cone to a point where a driver return to original lane alignment and is clear of any incident due to construction works taking place at that site.

2.3.1.1 Traffic Control Devices

Purpose: During management of traffic at **Temporary Traffic Control Zones (TTC)** it is necessary to place some boards containing text alongside the road so that traffic can move safely and efficiently. Their main purpose is to provide information, guidance and regulations to the driver.

Principles*:* Use of Traffic Control Devices is such that their design, placement, operation, maintenance, and uniformity is specially considered to take maximum benefit out of it.

2.3.1.2 Components of Temporary Traffic Control Zones (TTC)

Figure of Components of temporary Traffic zone have been attached in **Annex A**.

Activity area

It is one of the components of a Temporary Traffic Control Zones (TTC) activity area where the work actually takes place. It consists of the work space, traffic space and one or more buffer spaces.

Advance Warning Area

It is that part of a **Temporary Traffic Control Zones (TTC)** used to inform the motorist what to expect ahead. This area may contain anywhere from a single sign or a rotating/strobe light on a vehicle to a series of signs and the use of a portable changeable message sign (PCMS). The location of the beginning of the TTC zone is dependent on its visibility to motorists. Good visibility is achieved where the sight distance is sufficient to meet decision sight distance.

Table 5 Recommended Advance Warning Sign Minimum Spacing

Table 6C-1. Recommended Advance Warning Sign Minimum Spacing

Road Type	Distance Between Signs**		
	A	B	C
Urban (low speed)*	100 feet	100 feet	100 feet
Urban (high speed)*	350 feet	350 feet	350 feet
Rural	500 feet	500 feet	500 feet
Expressway / Freeway	1,000 feet	1,500 feet	2,640 feet

* Speed category to be determined by the highway agency

** The column headings A, B, and C are the dimensions shown in Figures 6H-1 through 6H-46. The A dimension is the distance from the transition or point of restriction to the first sign. The B dimension is the distance between the first and second signs. The C dimension is the distance between the second and third signs. (The "first sign" is the sign in a three-sign series that is closest to the TTC zone. The "third sign" is the sign that is furthest upstream from the TTC zone.)

Transition Area

The transition area is that section of highway where road users are redirected out of their normal path. Transition areas usually involve strategic use of tapers. Tapers may be used in both the transition and termination areas. Tapers are created by using a series of channelizing devices and/or pavement markings to move traffic out of or into the normal path.

Downstream Taper

The taper at the end of the activity area which guides traffic back into its original lane.

Taper types

Figure of the types of Taper have been attached in Annex **B**.

Taper Calculations:

Table 6 Formulas for Determining Taper Length

Table 6C-4. Formulas for Determining Taper Length

Speed (S)	Taper Length (L) in feet
40 mph or less	$L = \frac{WS^2}{60}$
45 mph or more	$L = WS$

Where: L = taper length in feet
W = width of offset in feet
S = posted speed limit, or off-peak 85th-percentile speed prior to work starting, or the anticipated operating speed in mph

Table 7 Taper Length Criteria for Temporary Traffic Control Zones

Table 6C-3. Taper Length Criteria for Temporary Traffic Control Zones

Type of Taper	Taper Length
Merging Taper	at least L
Shifting Taper	at least 0.5 L
Shoulder Taper	at least 0.33 L
One-Lane, Two-Way Traffic Taper	50 feet minimum, 100 feet maximum
Downstream Taper	50 feet minimum, 100 feet maximum

Buffer Space

The space which provides a margin of safety for both the driver and the workers. It is important that the buffer space be free of equipment, workers, material and vehicles.

Termination Area

The termination area is the section of the highway where road users are returned to their normal driving path. The termination area extends from the downstream end of the work area to the last TTC device such as END ROAD WORK signs, if posted.

CHAPTER 3

RESEARCH METHODOLOGY AND DATA COLLECTION

3.1 General

This chapter explains the methodology used for the research. The data collection procedure which comprises of turning movements of Airport/koral intersection and traffic approaching Airport/Koral interchange. These measures are taken to ultimately reach the comparison of intersection and interchange in term of LOS (Level of service), traffic delays , fuel consumption and emissions.

The data source of turning movements of Airport/Koral intersection is "National Institute of Transportation, NUST , Islamabad , Pakistan". For traffic approaching interchange data collection locations are:

- Near Khanna pull (point 1: for traffic coming from Islamabad side (SB))
- Near PWD (point 2: for traffic coming from Rawat side (NB))
- Near Airport (point 3: for traffic coming from Airport side (EB))

This chapter also explains the overall framework, methods, and underlying assumptions to make stagewise work execution plan and traffic management plans for each stage of construction at an interchange. It includes methods used to channelize and divert all interrupted traffic movements during construction at each stage of construction.

Figure 1 Project Location

3.2 Working Methodology:

The work started with Literature review and the following flow chart represents the further working methodology of the project. The project consist of four parts i.e.

- Before and after traffic analysis
- Future traffic analysis
- Capital cost recovery in terms of public benefits
- Traffic management plans

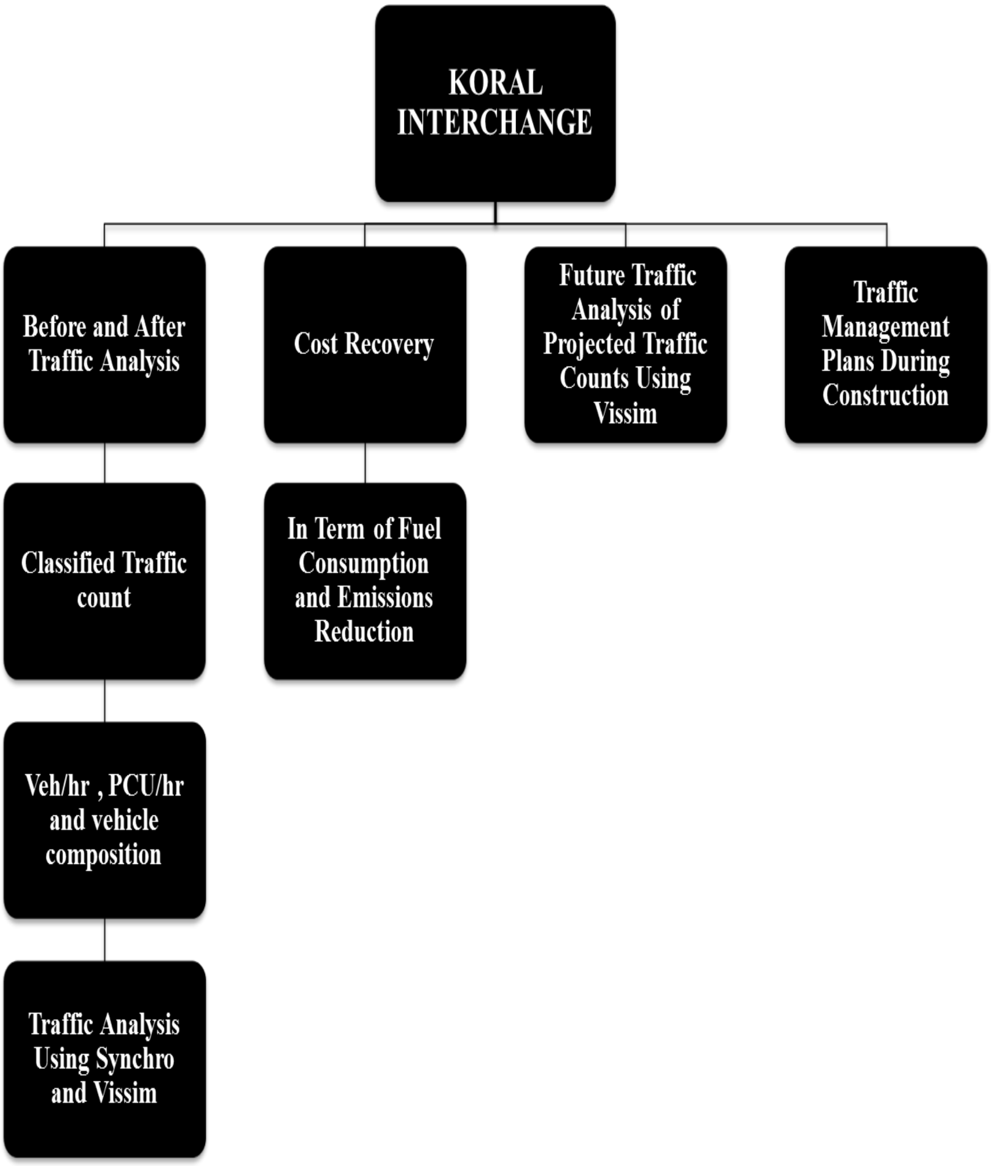


Figure 2 Working Methodology

3.2.1 Before And After Traffic Analysis:

In before and after traffic analysis , the first step is the collection of classified traffic counts by using Jamar counter. For interchange, the days selected for traffic counts are Thursday and Sunday and the timings are 8 AM - 10 AM , 12 PM - 2 PM and 4PM - 9 PM. Vehicle classifications are:

- Cars
- Trucks
- Motorcycles
- Buses
- Hiaces
- Coasters

The second step is the determination of peak hour volume in the form of PCU/hr and Veh/hr and vehicles composition. The third step is the calculation of percentages of turning and through movements on interchange using Airport/Koral intersection traffic counts and then by using these percentages and traffic approaching interchange we calculate PHV of turning and through movements on interchange . The final step is the traffic analysis of intersection and interchange using SYNCHRO and VISSIM. PCU are obtained from following table:

Table 8 Passenger Car Unit

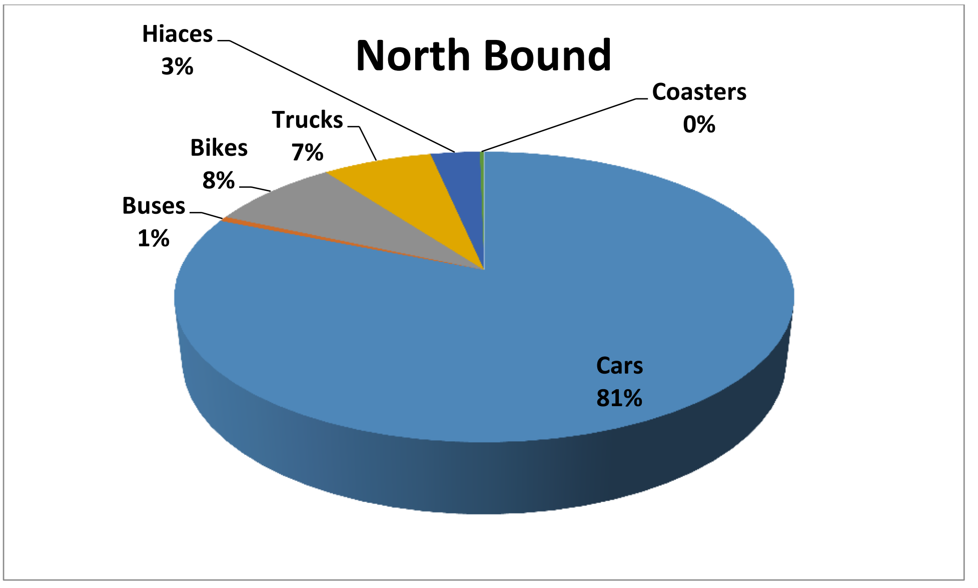
Vehicle Type	PCU
Car	1
Truck	2.3
Motorcycle	0.4
Bus	2
Hiace	1.5
Coaster	1.8

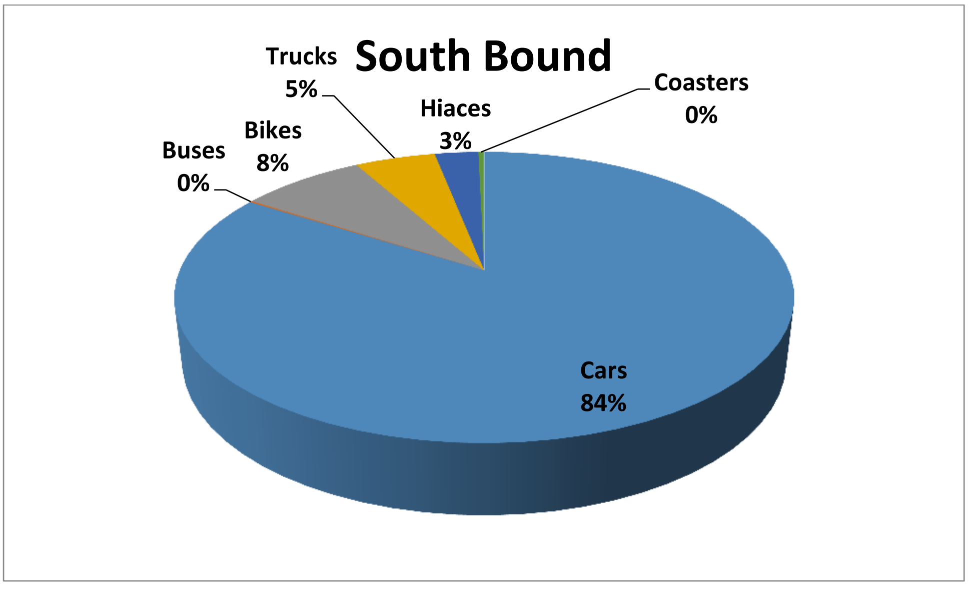
3.2.1.1 Summary of PHV and Vehicle Composition on Intersection

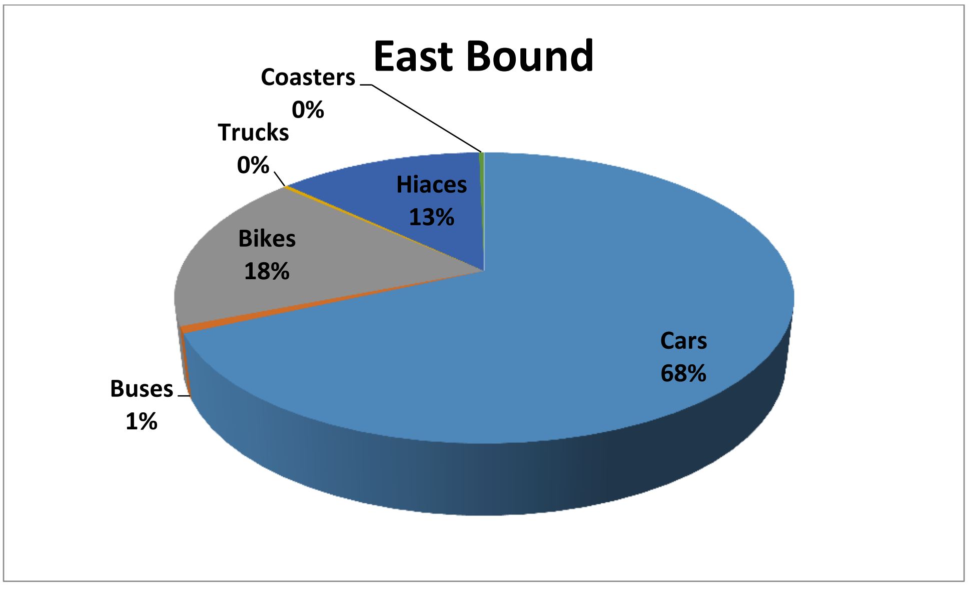
Table 9 Summary of PHV on Intersection

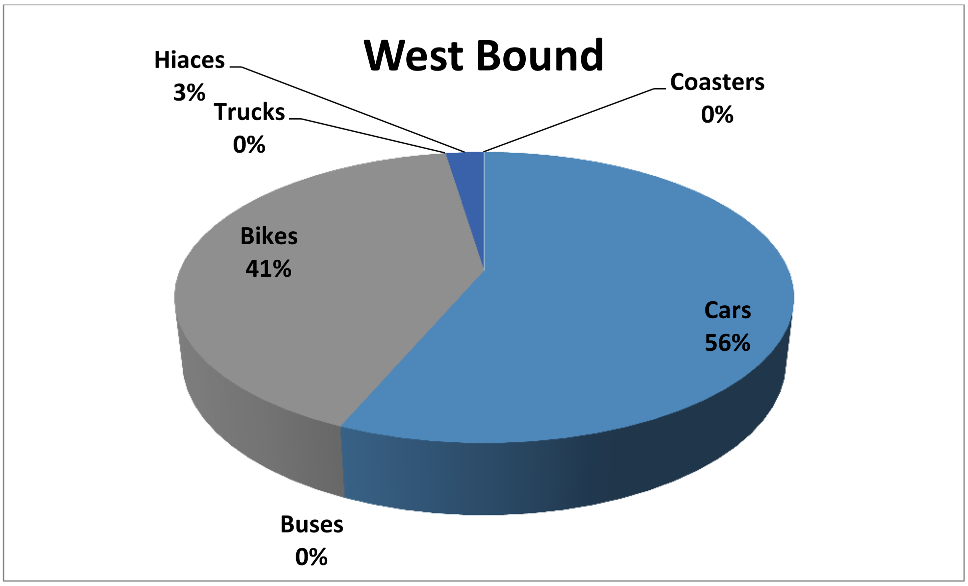
Approach	Movements	PCU/hr	Veh/hr
NB (From Rawat Side)	NBT	6524.42	4735
	NBL	473.69	481
	NBR	151.18	207
SB (From Islamabad Side)	SBT	5182.7	4912
	SBL	134.41	143
	SBR	336.19	394
	SBU	50.92	52
EB (From Airport Side)	EBT	134.30	137
	EBL	140.03	186
	EBR	562.80	547
	EBU	103.33	104
WB (From koral Side)	WBT	57.92	64
	WBR	144.91	202

The vehicle composition of the traffic approaching intersection is shown in following pie-charts;


North Bound
Hiaces 3%
Coasters 0%
Trucks 7%
Bikes 8%
Buses 1%
Cars 81%


South Bound
Trucks 5%
Coasters 0%
Hiaces 3%
Bikes 8%
Buses 0%
Cars 84%


East Bound
Coasters 0%
Trucks 0%
Hiaces 13%
Bikes 18%
Cars 68%
Buses 1%

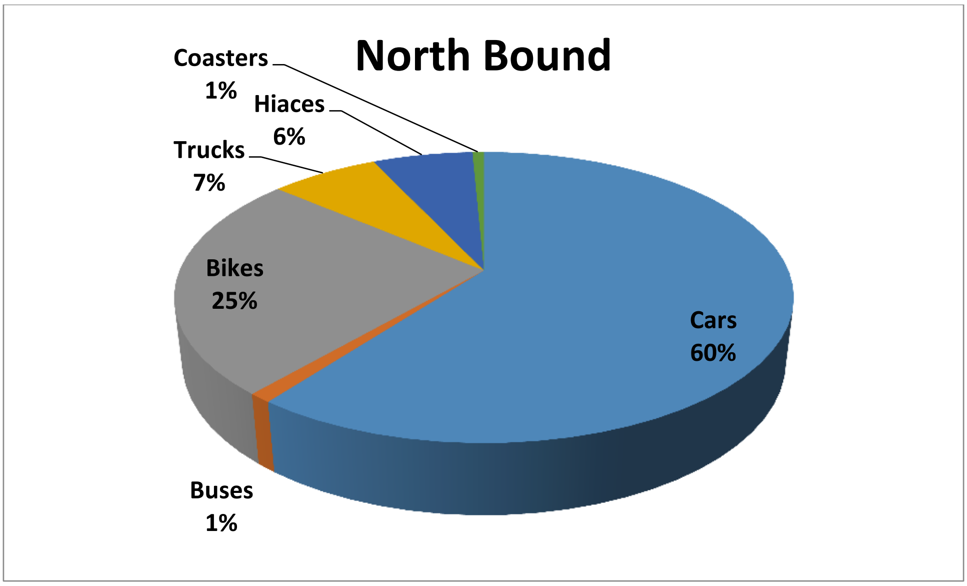


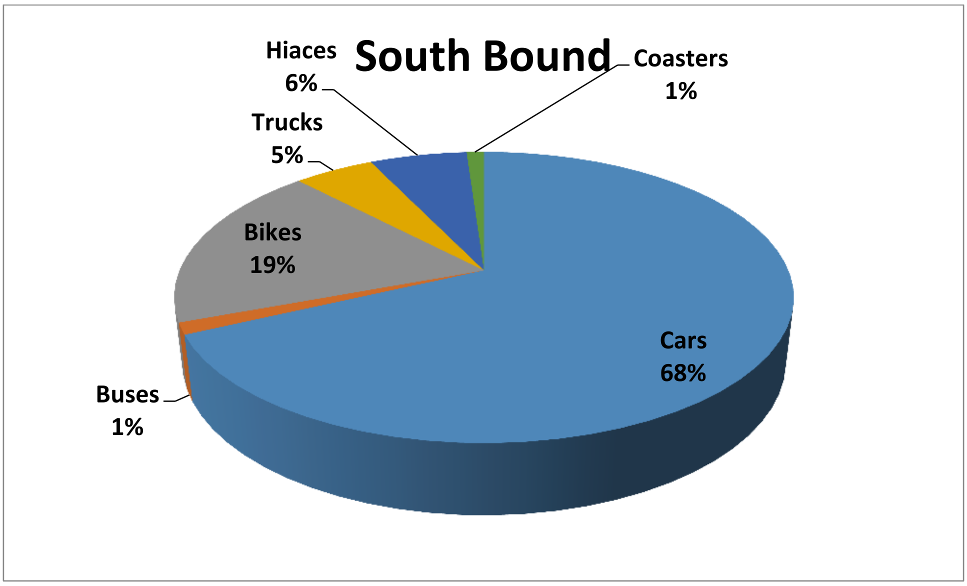
3.2.1.2 Summary of PHV and Vehicle Composition on Interchange

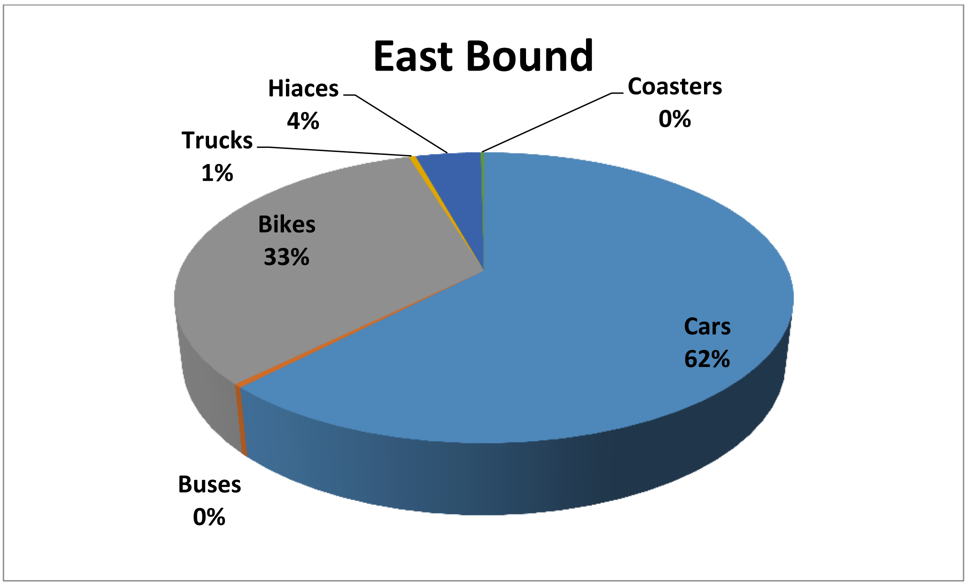
Table 10 PHV Approaching Interchange

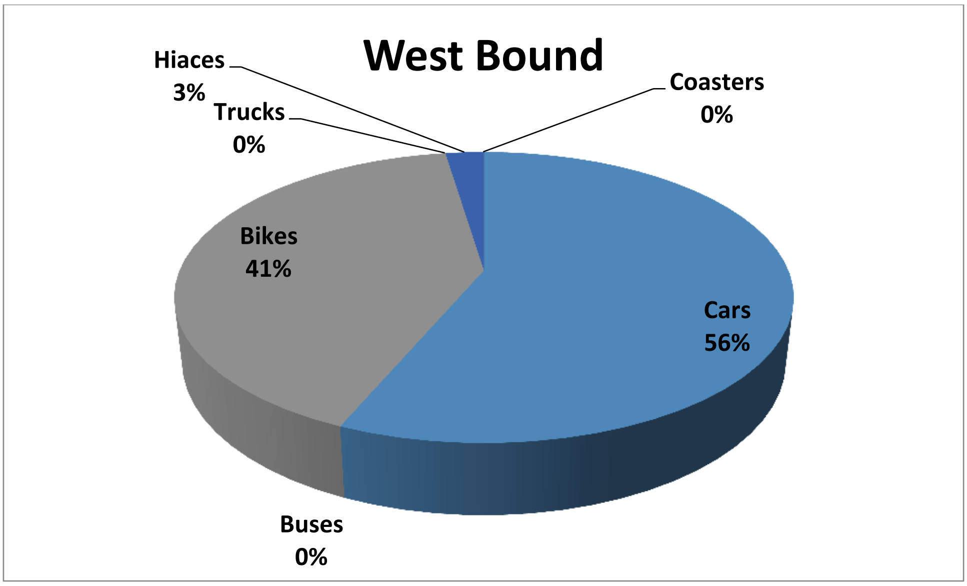
Approach	PCU/hr	Veh/hr
NB (From Rawat Side)	4352.4	4441
SB (From Islamabad Side)	6327.2	6291
EB (From Airport Side)	2919	3501
WB (From koral Side)	191	203

The vehicle composition of the traffic approaching interchange is shown in following pie-charts;


North Bound
Coasters 1%
Hiaces 6%
Trucks 7%
Bikes 25%
Cars 60%
Buses 1%


South Bound
Hiaces 6%
Coasters 1%
Trucks 5%
Bikes 19%
Cars 68%
Buses 1%


East Bound
Hiaces 4%
Coasters 0%
Trucks 1%
Bikes 33%
Cars 62%
Buses 0%



The percentages of turning and through movements of the traffic approaching interchange are calculated by using traffic counts of intersection and are shown in following table;

Table 11 Percentages of Turning and Through Movements on Interchange

Approach	Movements	Percentage (%)
NB (From Rawat Side)	**NBT**	91.259
	NBL	6.625
	NBR	2.107
SB (From Islamabad Side)	**SBT**	90.857
	SBL	2.356
	SBR	5.894
	SBU	0.893
EB (From Airport Side)	**EBT**	14.281
	EBL	14.890

	EBR	59.842
	EBU	10.987
WB (From koral Side)	**WBT**	28.556
	WBR	71.444

By using these percentages and traffic approaching interchange PHV of turning and through movements on interchange had calculated and are shown in following table;

Table 12 Summary of PHV on Interchange

Approach	Movements	PCU/hr	Veh/hr
NB (From Rawat Side)	**NBT**	3971.95	4053
	NBL	288.30	295
	NBR	91.70	93
SB (From Islamabad Side)	**SBT**	5748.70	5716
	SBL	149.07	148
	SBR	372.90	371
	SBU	56.50	56
EB (From Airport Side)	**EBT**	416.90	500
	EBL	434.64	521
	EBR	1746.78	2095
	EBU	320.71	385

WB (From koral Side)	**WBT**	54.54	58
	WBR	136.45	145

3.2.2 Future Traffic Analysis:

The purpose of future traffic analysis is to evaluate the performance of interchange in future and to calculate capital cost recovery period. In future traffic analysis , the first step is the determination of projected traffic counts. In order to find projected traffic counts traffic growth at rate of 3% per year was used. The final step is the traffic analysis using VISSIM. We have done future traffic analysis for the year 2022, 2027, 2030 and 2032. Traffic growth factor is calculated by following method:

Traffic growth factor = $(1+3/100)^n = 1.03^n$, where n is number of years from now. So,

For 2022 traffic growth factor = 1.03^5 = 1.1592

For 2027 traffic growth factor = 1.03^5 = 1.3439

For 2030 traffic growth factor = 1.03^{13} = 1.4685

For 2032 traffic growth factor = 1.03^{15} = 1.5579

These traffic growth factors are multiplied with present (2017) traffic counts to get projected traffic counts for the years mentioned above.

3.2.3 Capital Cost Recovery In Terms Of Public Benefits

In capital cost recovery, the first step is to find out the reduction of following parameters per year due to conversion of intersection into interchange:

- Fuel consumption
- Vehicular Emissions

These parameters change every year due to increasing traffic. The second step is the determination of savings per year by using above reduction parameters. The final step is to find out the capital cost recovery period by using capital cost and savings per year.The fuel cost is Rs. 80/litre and in order to convert emissions into cost following table was used;

Table 13 Damage Cost of Emissions(From HERS-ST Technical Report (2005))

Table 33. HERS-ST estimates of air pollutant damage costs in 2000 dollars.			
Pollutant	**Damage Costs ($/ton)**	**Adjustment Factors**	
		Urban	**Rural**
Carbon Monoxide	$100	1	0.5
Volatile Organic Compounds	$2,750	1.5	1
Nitrogen Oxides	$3,625	1.5	1
Sulfur Dioxide	$8,400	1.5	1
Fine Particulate Matter (PM2.5)	$4,825	1	0.5
Road Dust	$4,825	1	0.5

3.2.4 Traffic Management Plans:

The following steps shows the methodology for making stage wise work execution plans and traffic management plans for each stage of construction.

- ➢ The layout plan of an interchange was obtained from Capital Development Authority.

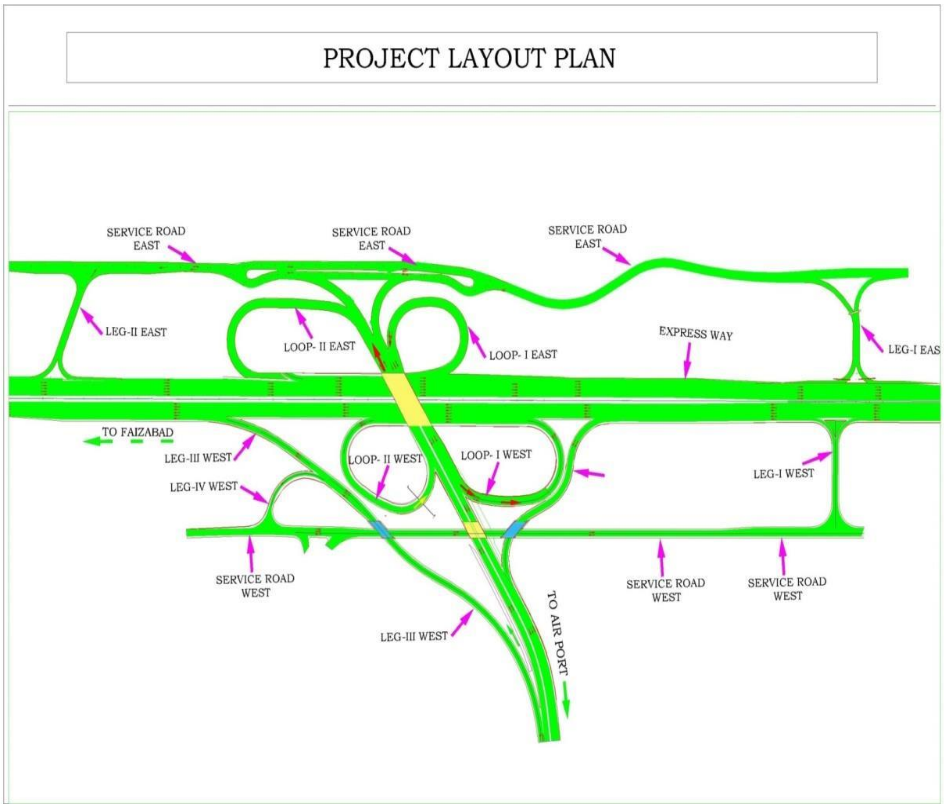


Figure 3 Layout Plan of Interchange

- This layout plan of project was traced using **AutoCAD 2017** to work with it.
- An **AutoCAD** drawing file was further modified to make stage wise work execution plan.
- Traffic management plan for each stage of construction was proposed by Using Temporary Traffic Control Zone (TTC) studies from Manual on Uniform Control Devices (MUTCD), types and locations for all the signs and control devices used during construction.

CHAPTER 4

ANALYSIS AND RESULTS

4.1 General

This chapter includes the results obtained for stage wise work execution plan and the traffic management plans during construction of each stage at koral interchange and brief notes or instructions to be followed. This chapter also includes the output/results of analysis performed. First of all intersection was analyzed and then analysis was performed on interchange.

For analysis purposes two softwares were used:

1-SYNCHRO

2-PTV-VISSIM

Both the intersection and interchange were analyzed using SYNCHRO and VISSIM. Future traffic analysis was performed using VISSIM.

4.1.1 SYNCHRO:

SYNCHRO is traffic signal timing software, developed by Traffic ware Inc., is used to optimize or coordinate signal timing parameters for isolated intersections and also generate coordinated signal timings plans for arteries and networks. Most commonly used program to optimize the signal is SYNCHRO. SYNCHRO was used for this project. SYNCHRO facilitates the design and analysis of an intersection or arterial. Primary objective of this program is to minimize the traffic delay by selecting the optimal timing.

SYNCHRO is basically designed to optimize cycle lengths, split times, intersection delays and phase orders. In coordinating signals, SYNCHRO determines which signal should have to run free and which to coordinate. It helps to decide what type of intersection should be constructed or modified.

SYNCHRO has a unique visual display including a set of diagrams. User can change the offsets and delays and observe the impacts on delays, stops and LOS by those changes. User can compare those alternatives and select the best for their intersection or for the entire network. SYNCHRO allows user to quickly generate optimum timing plans. Thus, whenever user changes input values, it changes the result automatically.

4.1.2 PTV-VISSIM:

PTV-Vissim is basically a microscopic and multi modal software for traffic simulations developed by PTV Planning transport Verkher A.G, A German based company. In this software micro-simulation is done, Each traffic entity like car, tram, pedestrians is simulated individually. i.e. it can evaluate and present all the real life entities and condition for traffic simulations.

A salient feature in this software is the multi-modality, means more than one kind of traffic can be simulated by this software. Such as:

- Vehicles (Cars, Buses, Trucks, Oil tankers)
- Public Transport (Trams, Buses)
- Cycles (Bicycle, Motorcycles)
- Pedestrians
- Rickshaws

4.1.3 Benefits of VISSIM:

Other Than multi modeling, there are some other features that make this software more effective.

Maximum Accuracy:

With the help of this software maximum accuracy can be achieved. In this software, map network and any desired geometry can be achieved, i.e. from a standard node to a complex intersection. Realistic behavior of all road users within the existing and planned infrastructure is possible in this software.

Ease of Use and Productivity:

Model can be built efficiently by using various inter-faces (Driver Model, Driving simulator etc.) to import existing networks. The interface with flexible dockable windows allows for efficiently creating and editing network objects and their attributes as well as gives results for numerous variables, which makes it more users friendly.

Flexibility and Integration Capacity:

The Generic COM interface allows interacting with external applications. It enables manual settings for drivers and vehicle properties at different levels. For current studies it helps to test the environment. Besides this, you can connect your work to any other PTV software.

Visualization in 2D and 3D:

Switch perspective helps you to display you analysis results in both 2D and 3D. This assists in public decision-making processes with the help of detailed reports. This salient feature makes the traffic simulations more appealing and understandable to all.

4.2 Analysis of Intersection

The analysis of intersection was performed using SYNCHRO and VISSIM. The Airport/Koral 4-legged intersection was located at the junction of airport road and Islamabad highway. This was a Signalized intersection with the cycle length of 150 seconds. When analysis is performed on this intersection using SYNCHRO and VISSIM, It gives LOS F.

Figure 4 Four legged Intersection (Airport)

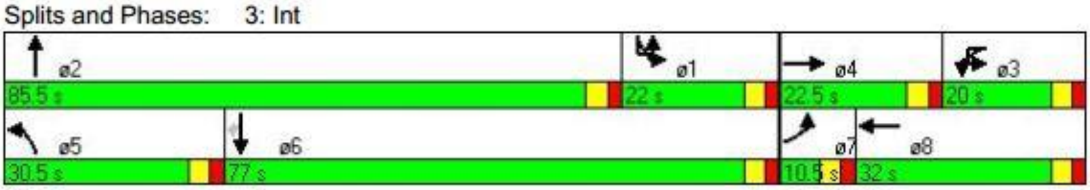
4.2.1 SYNCHRO Analysis:

The analysis was performed using PHV in the form of PCU/hr and the results are;

Table 14 SYNCHRO Results of Intersection

Intersection Summary	
Area Type: Other	
Cycle Length: 150	
Actuated Cycle Length: 150	
Offset: 0 (0%), Referenced to phase 2:NBT and 6:SBT, Start of Green	
Control Type: Pretimed	
Maximum v/c Ratio: 2.23	
Intersection Signal Delay: 494.0	Intersection LOS: F
Intersection Capacity Utilization 156.3%	ICU Level of Service H
Analysis Period (min) 15	
dl Defacto Left Lane. Recode with 1 though lane as a left lane.	

Splits and Phases: 3: Int



The above table is the result summary of intersection developed on **SYNCHRO.** According to these results cycle length is 150 seconds, the intersection signal delay is 494 sec/vehicle, LOS is F and the intersection capacity utilization is 156.3 %.

4.2.2 VISSIM Analysis:

The analysis was performed by using PHV in the form of Veh/hr. vehicle classes and composition is also used in this analysis.

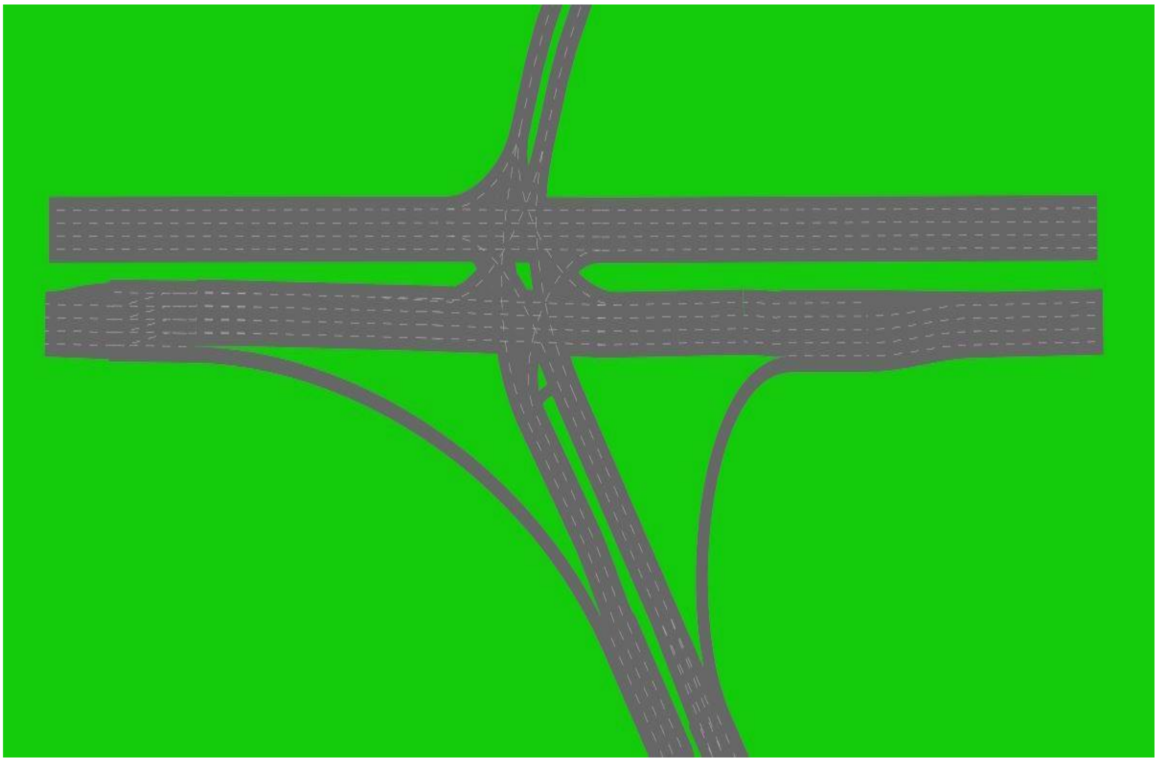


Figure 5 VISSIM Model of Intersection

The results are shown in following table;

Table 15 VISSIM Results of Intersection

Delays(s/veh)	172.19
LOS	F
Stop Delays(s/veh)	140.39
Stops	4.93
Fuel consumption(gal/hr)	589.57

Emission CO(grams/hr)	41210.92
Emission NOX(grams/hr)	8018.148
Emission VOC(grams/hr)	9551.029

The above table is the result summary of intersection developed on **VISSIM.** According to this table delays are **172.19 s/veh.** , LOS is **F**, Stop delays are **140.39 s/veh.** fuel consumption is 589.57 gal/hr. emissions of CO, NOX and VOC's are **41210.92, 8018 and 9551 grams/hr** respectively.

LOS of intersection is determined by following table;

Table 16 LOS Criteria for Signalized Intersection (From HCM 2000)

EXHIBIT 16-2. LOS CRITERIA FOR SIGNALIZED INTERSECTIONS

LOS	Control Delay per Vehicle (s/veh)
A	≤ 10
B	> 10–20
C	> 20–35
D	> 35–55
E	> 55–80
F	> 80

The figure below is the map window of intersection developed on VISSIM.

Figure 6 VISSIM Result of Intersection

4.3 Analysis of Interchange

The analysis of interchange was performed using SYNCHRO and VISSIM.

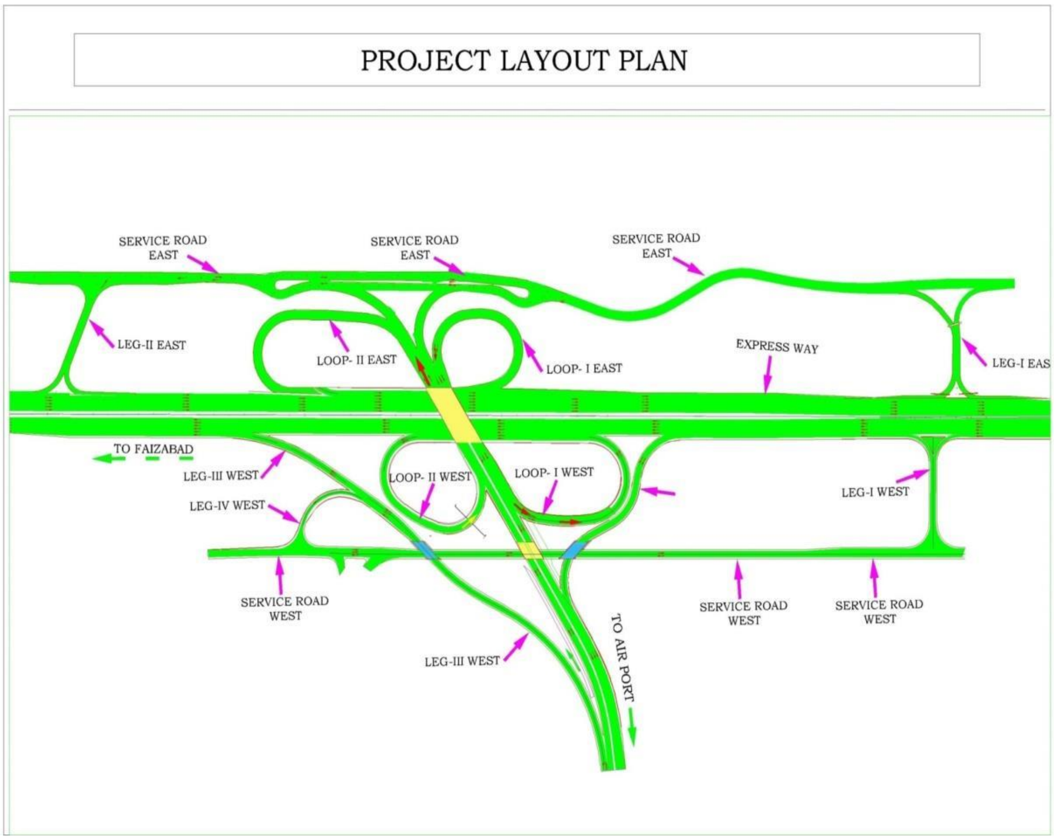


Figure 7 Koral interchange Layout

4.3.1 SYNCHRO Analysis:

The analysis was performed using PHV in the form of PCU/hr and the results are;

Table 17 SYNCHRO Results of Interchange

Network Totals	
Number of Intersections	13
Total Delay / Veh (s/v)	18
Stops / Veh	1.00
Fuel Consumed (gal)	1316
Fuel Economy (mpg)	6.6
CO Emissions (kg)	91.99
NOx Emissions (kg)	17.90
VOC Emissions (kg)	21.32

The above table show the result summary of interchange developed on **SYNCHRO.** According to these results total delay is 18 sec/vehicle.

4.3.2 VISSIM Analysis:

The analysis was performed by using PHV in the form of Veh/hr. vehicle classes and composition is also used in this analysis.

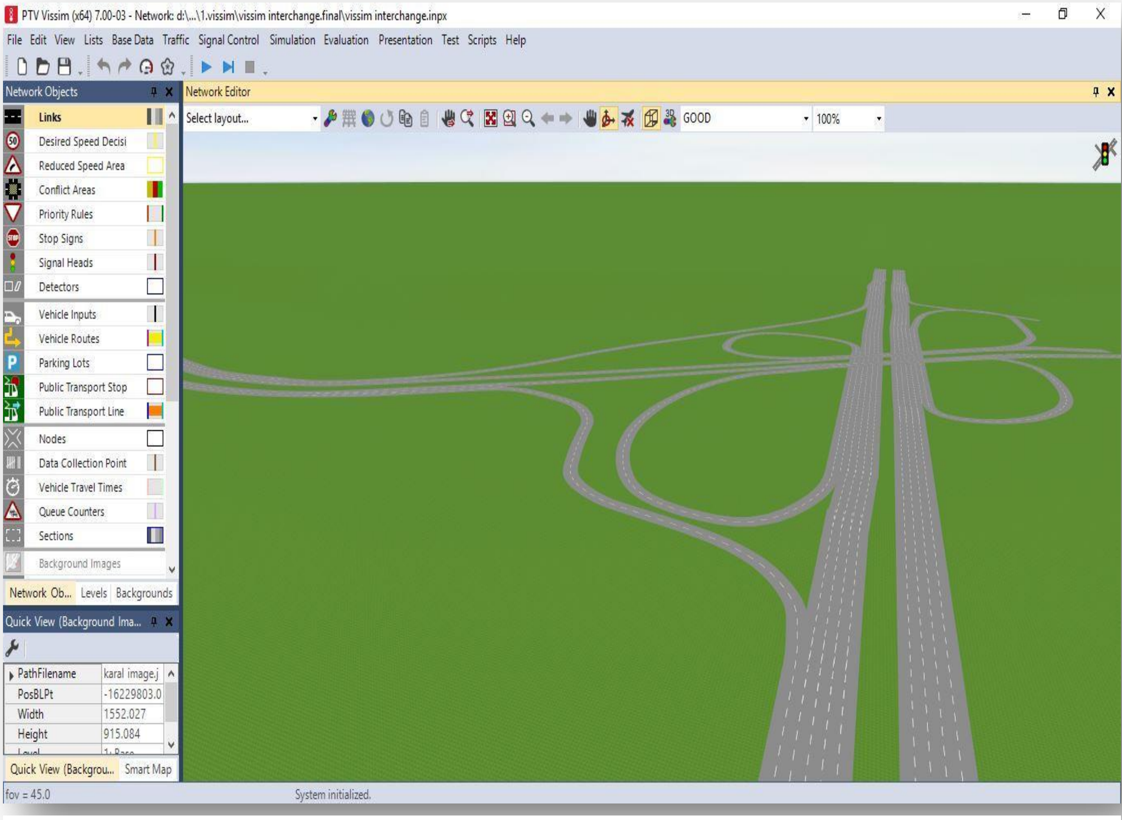


Figure 8 VISSIM Model of Interchange

The results are shown in following table;

Table 18 VISSIM Results of Interchange (2017)

Delays(s/veh)	11.92
LOS	B
Stop Delays(s/veh)	0.7
Stops	0.48

Fuel consumption(gal/hr)	373.719
Emission CO(grams/hr)	26122.93
Emission NOX(grams/hr)	5082.573
Emission VOC(grams/hr)	6054.241

The above table is the result summary of interchange (2017) developed on **VISSIM.** According to this table delays are **11.92 s/veh.** , LOS is **B**, Stop delays are **0.7 s/veh.** fuel consumption is **373.719** gal/hr. emissions of CO, NOX and VOC’s are **26122, 5082 and 6054 grams/hr** respectively.

LOS of interchange is determined by following table;

Table 19 LOS Criteria for Interchange (From HCM 2000)

EXHIBIT 26-8. LOS CRITERIA FOR INTERCHANGES

Level of Service	Delay (s/veh)
A	≤ 10
B	> 10–20
C	> 20–35
D	> 35–55
E	> 55–80
F	> 80

The figure below is the map window of interchange (2017) developed on VISSIM.

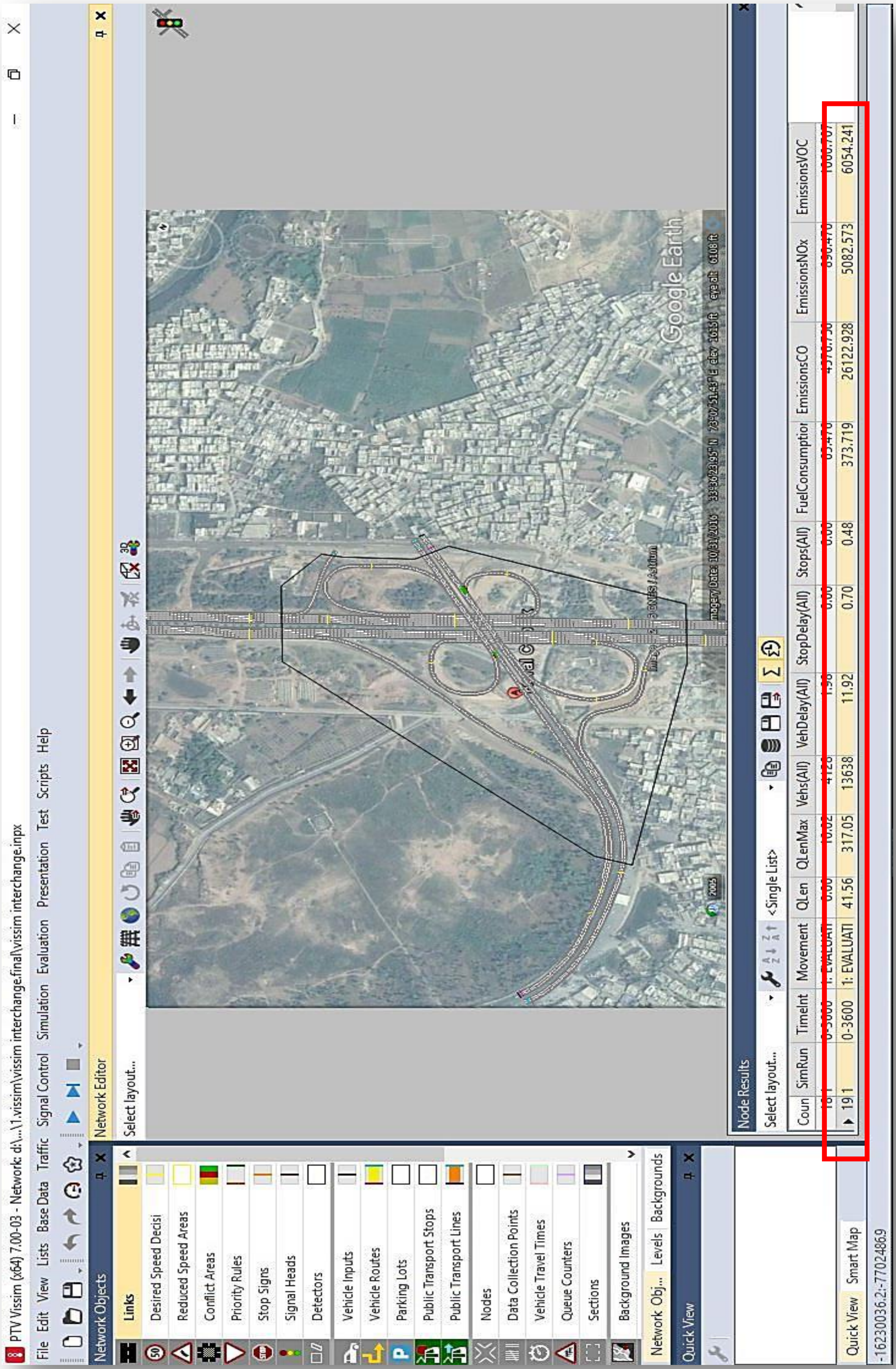


Figure 9 VISSIM Results of Interchange (2017)

4.4 Future Traffic Analysis

Future traffic analysis for the years 2022 , 2027 , 2030 and 2032 is performed by using VISSIM. Projected traffic is calculated by using growth rate of 3% per year. LOS is determined by using table above.

4.4.1 Future Traffic Analysis for 2022

The results are shown in following table;

Table 20 VISSIM Results of Interchange (2022)

Delays(s/veh)	14.86
LOS	B
Stop Delays(s/veh)	1.19
Stops	0.67
Fuel consumption(gal/hr)	466.597
Emission CO(grams/hr)	32615.12
Emission NOX(grams/hr)	6345.718
Emission VOC(grams/hr)	7558.87

The above table is the result summary of interchange (2022) developed on **VISSIM.** According to this table delays are **14.86 s/veh.** , LOS is **B**, Stop delays are **1.19 s/veh.** fuel consumption is **467** gal/hr. emissions of CO, NOX and VOC's are **32615, 6345 and 6345 grams/hr** respectively.

The figure below is the map window of interchange (2022) developed on VISSIM.

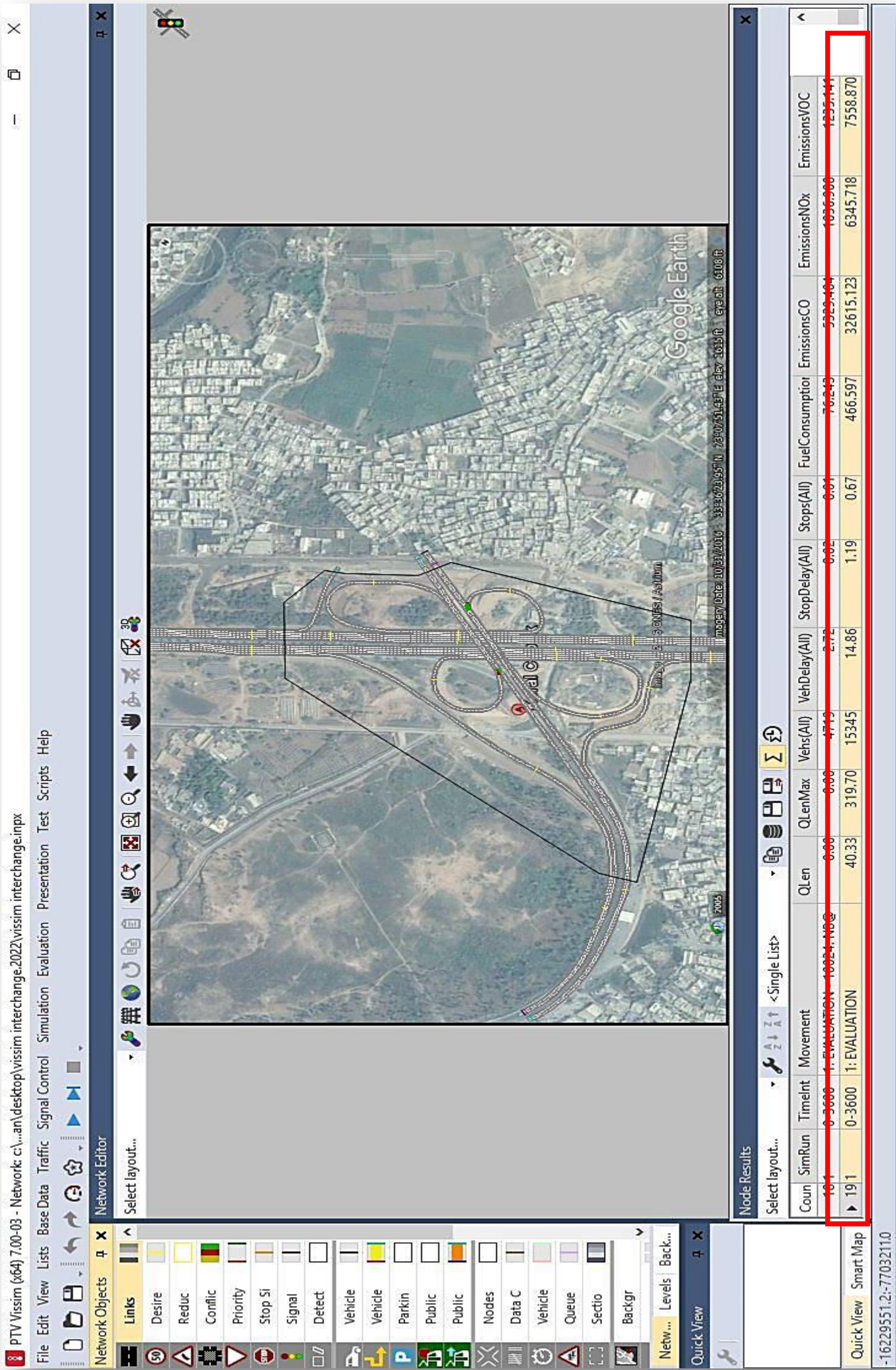


Figure 10 VISSIM Results of Interchange (2022

4.4.2 Future Traffic Analysis for 2027

The results are shown in following table;

Table 21 VISSIM Results of Interchange (2027)

Delays(s/veh)	18.11
LOS	B
Stop Delays(s/veh)	1.43
Stops	0.87
Fuel consumption(gal/hr)	560.671
Emission CO(grams/hr)	39190.89
Emission NOX(grams/hr)	7625.123
Emission VOC(grams/hr)	9082.868

The above table is the result summary of interchange (2027) developed on **VISSIM.** According to this table delays are **18.11 s/veh.** , LOS is **B**, Stop delays are **1.43 s/veh.** fuel consumption is **560.671** gal/hr. emissions of CO, NOX and VOC's are **39190, 7625 and 9083 grams/hr** respectively.

The figure below is the map window of interchange (2027) developed on VISSIM.

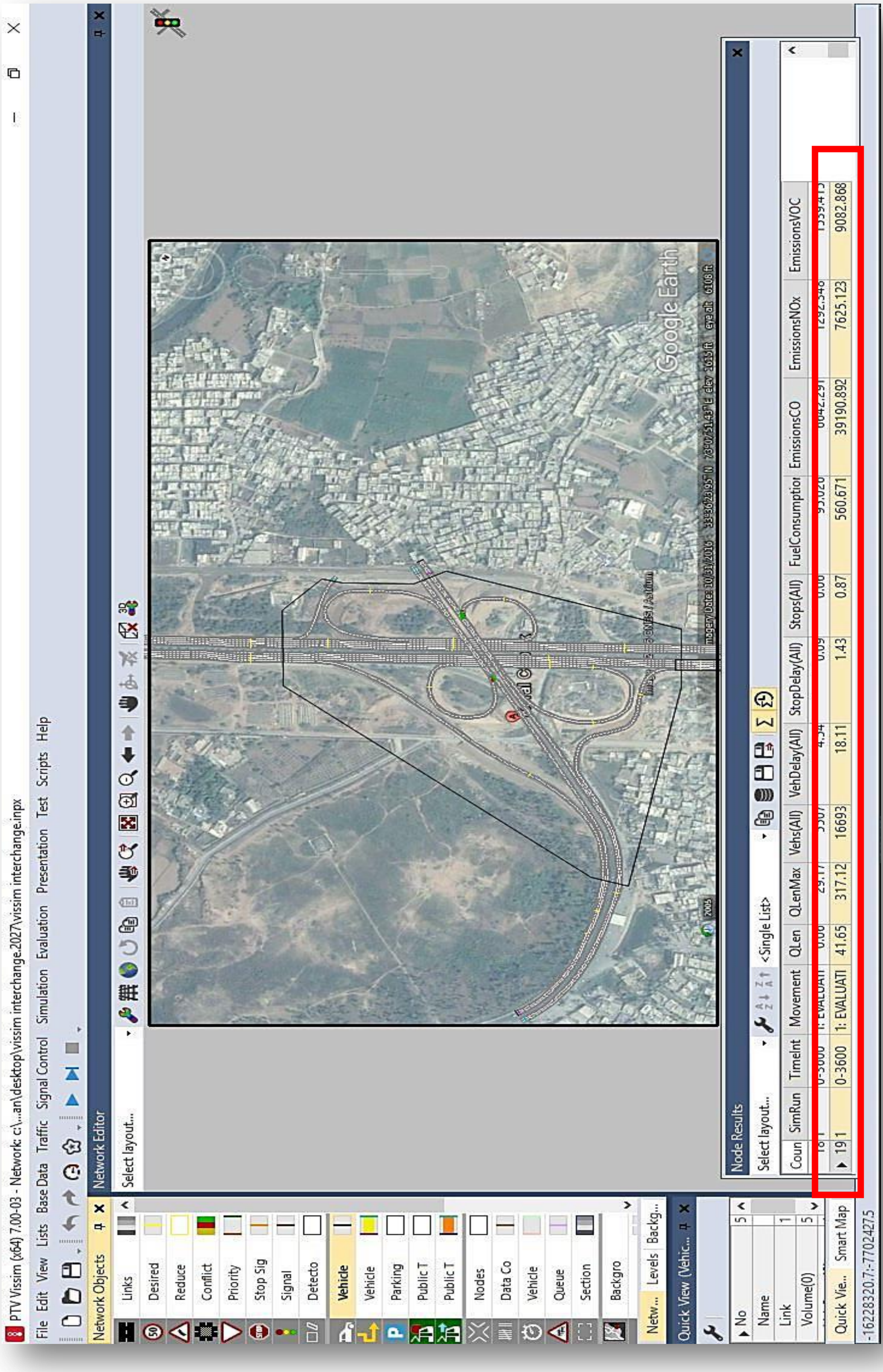


Figure 11 VISSIM Results of Interchange (2027)

4.4.3 Future Traffic Analysis for 2030

The results are shown in following table;

Table 22 VISSIM Results of Interchange (2030)

Delays(s/veh)	18.49
LOS	B
Stop Delays(s/veh)	1.46
Stops	0.91
Fuel consumption(gal/hr)	590.976
Emission CO(grams/hr)	41309.25
Emission NOX(grams/hr)	8037.278
Emission VOC(grams/hr)	9573.817

The above table is the result summary of interchange (2030) developed on **VISSIM.** According to this table delays are **18.49 s/veh.** , LOS is **B**, Stop delays are **1.46 s/veh.** fuel consumption is **591** gal/hr. emissions of CO, NOX and VOC's are **41309, 8037 and 9574 grams/hr** respectively.

The figure below is the map window of interchange (2030) developed on VISSIM.

Figure 12 VISSIM Results of Interchange (2030)

4.4.4 Future Traffic Analysis for 2032

The results are shown in following table;

Table 23 VISSIM Results of Interchange (2032)

Delays(s/veh)	19.6
LOS	B
Stop Delays(s/veh)	1.57
Stops	0.95
Fuel consumption(gal/hr)	615.261
Emission CO(grams/hr)	43006.75
Emission NOX(grams/hr)	8367.551
Emission VOC(grams/hr)	9967.23

The above table is the result summary of interchange (2032) developed on **VISSIM.** According to this table delays are **19.6 s/veh.** , LOS is **B**, Stop delays are **1.57 s/veh.** fuel consumption is **615.26** gal/hr. emissions of CO, NOX and VOC's are **43007, 8367 and 9967 grams/hr** respectively.

The figure below is the map window of interchange (2032) developed on VISSIM.

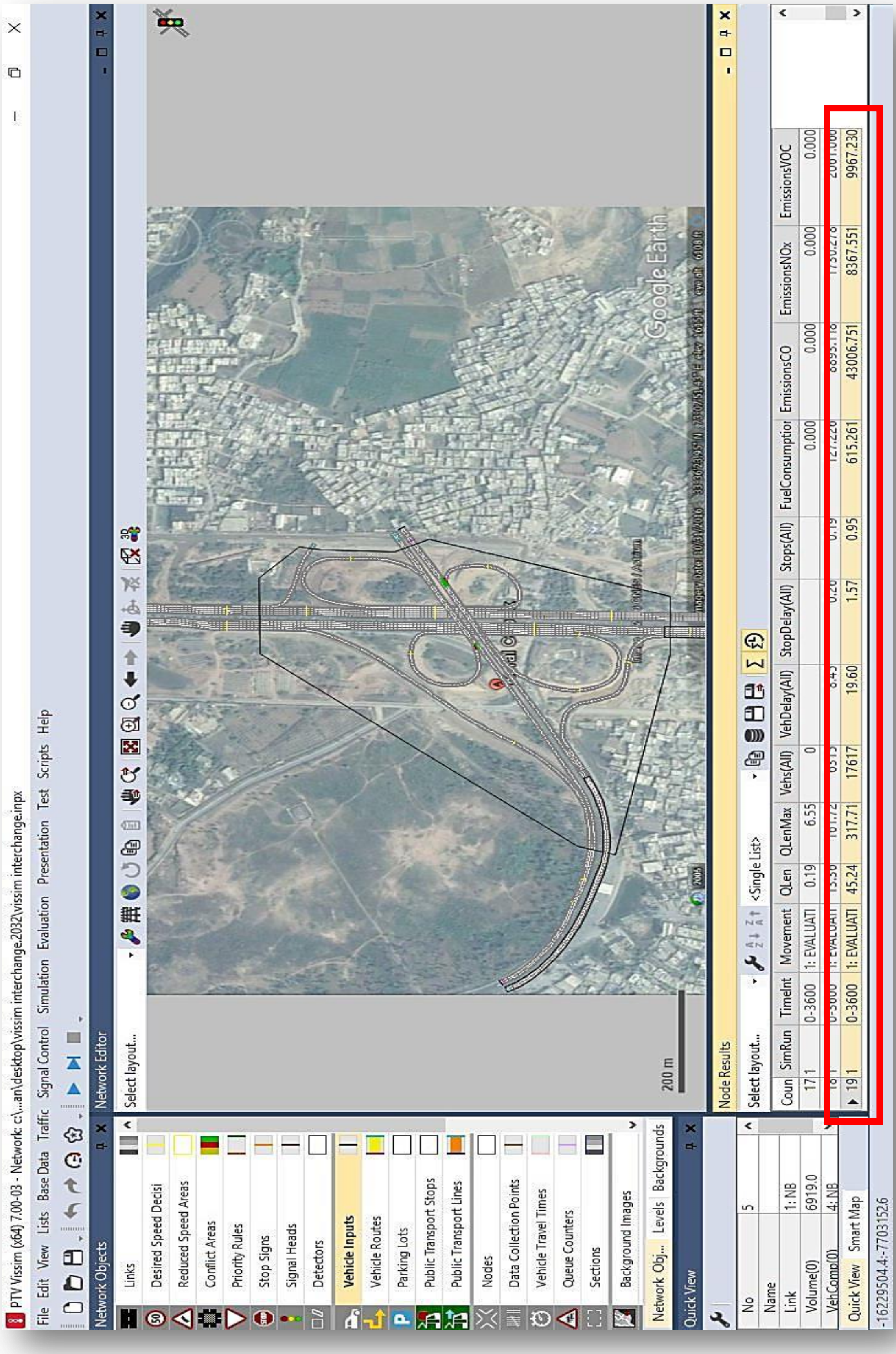


Figure 13 VISSIM Results of Interchange (2032)

4.5 Comparison of intersection and Interchange

This includes comparison of intersection and interchange in term of delays, fuel consumption and emissions. The analysis shows that LOS of the intersection is **F** while the LOS of the interchange is **B** and it remain **B** even in 2032. The fuel consumption and emissions stand till 2030. This chapter also include capital cost recovery of interchange in term of public benefits.

The following tables and bar charts show comparison of VISSIM results of intersection and interchange;

Delay and stop delay is **in sec/veh**, fuel consumption is in **US gallon/hr** and emissions are in **gram/hr**.

Table 24 Overall Comparison of Intersection and Interchange

Parameters	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
Delays	172.19	11.92	14.86	18.11	18.49	19.6
LOS	F	B	B	B	B	B
Stop Delays	140.39	0.7	1.19	1.43	1.46	1.57
Stops	4.93	0.48	0.67	0.87	0.91	0.95
Fuel consumption	589.57	373.719	466.597	560.671	590.976	615.261
Emission CO	41210.92	26122.93	32615.12	39190.89	41309.25	43006.75
Emission NOX	8018.148	5082.573	6345.718	7625.123	8037.278	8367.551
Emission VOC	9551.029	6054.241	7558.87	9082.868	9573.817	9967.23

Above table shows the overall comparison of intersection and interchange in terms of delays, LOS, Stop delays, stops, fuel consumption, CO, NOX and VOC's emissions. All these described factors reduces to a large extent due to conversion of this intersection to interchange.

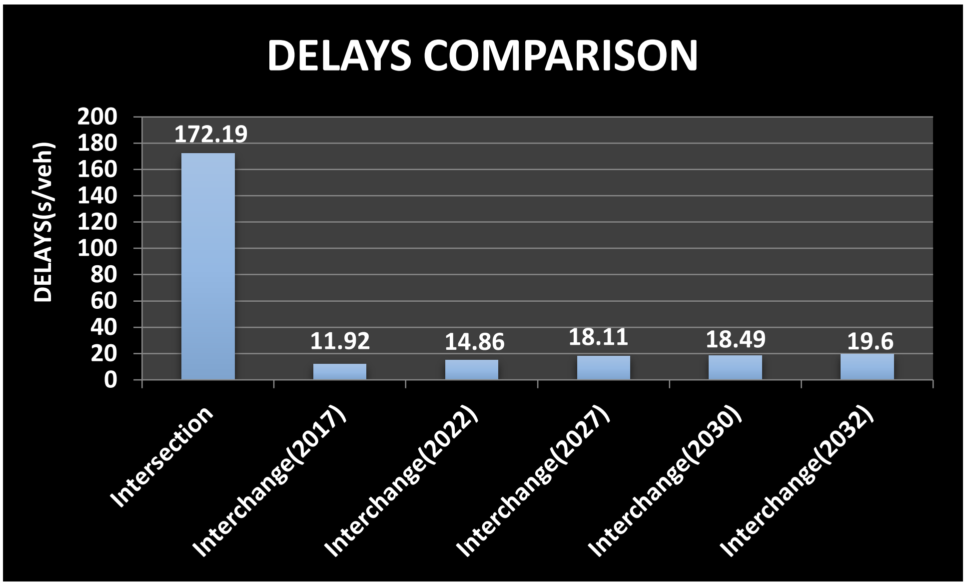


Figure 14 Vehicular Delays Comparison

The above graph shows the delay comparison of intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030, interchange 2032. According to this graph, the delays on intersection were **172 sec/veh** which reduced to **11.92 sec/veh** on interchange.

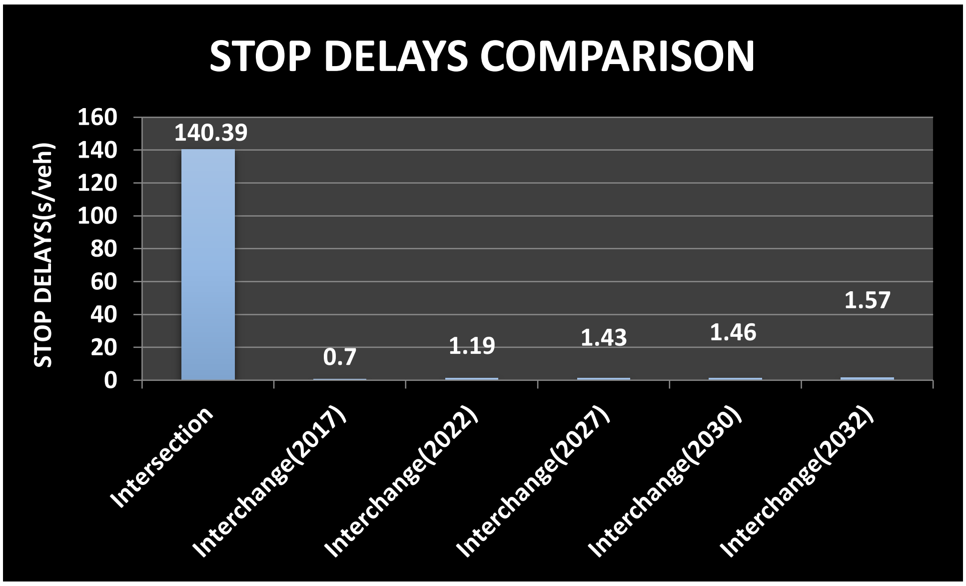


Figure 15 Stop Delay Comparison

The above graph shows the stop delay comparison of intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030, interchange 2032. According to this graph, the stop delays on intersection were **140.39 sec/veh** which reduced to **0.7 sec/veh** on interchange

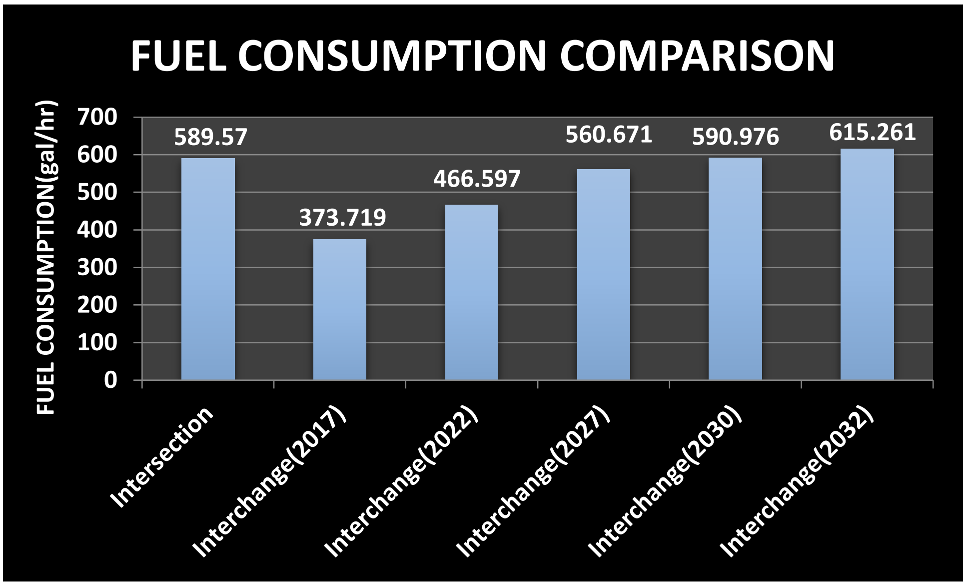


Figure 16 Vehicular Fuel Consumption Comparison

The above graph shows the fuel consumption comparison of intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030, interchange 2032. According to this graph, the fuel consumption on intersection were **589.57 gal/hr** which reduced to **373.72 gal/hr** on interchange. This reduced consumption of fuel will become equal to that of intersection-2016 in year 2030. The unit for fuel consumption is **US gal/hr**. (Note: 1 US gal = 3.78541 litres)

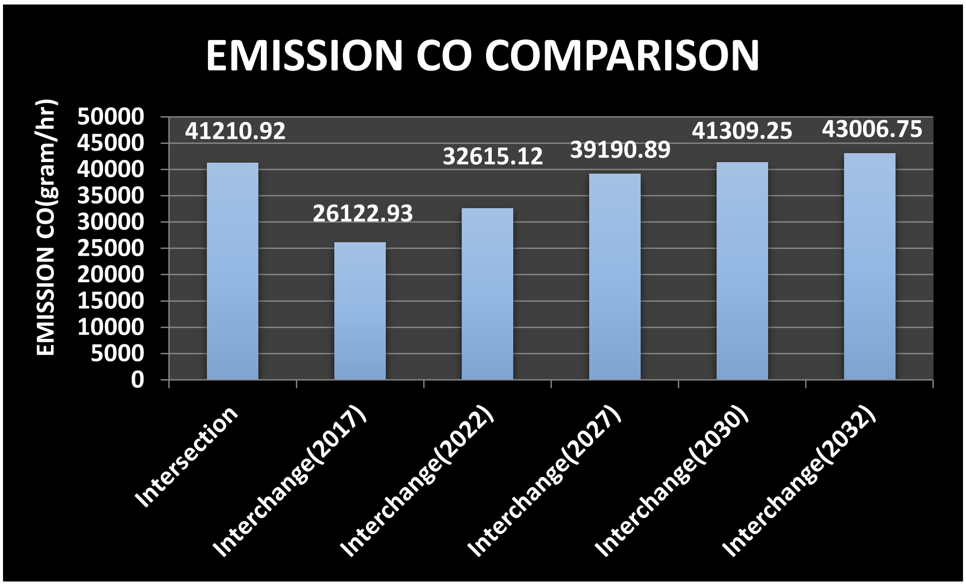


Figure 17 Vehicular Emission CO Comparison

The above graph shows the CO emission comparison of intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030, interchange 2032. According to this graph, the CO emission on intersection were **41211 gram/hr** which reduced to **26122 gram/hr** on interchange.

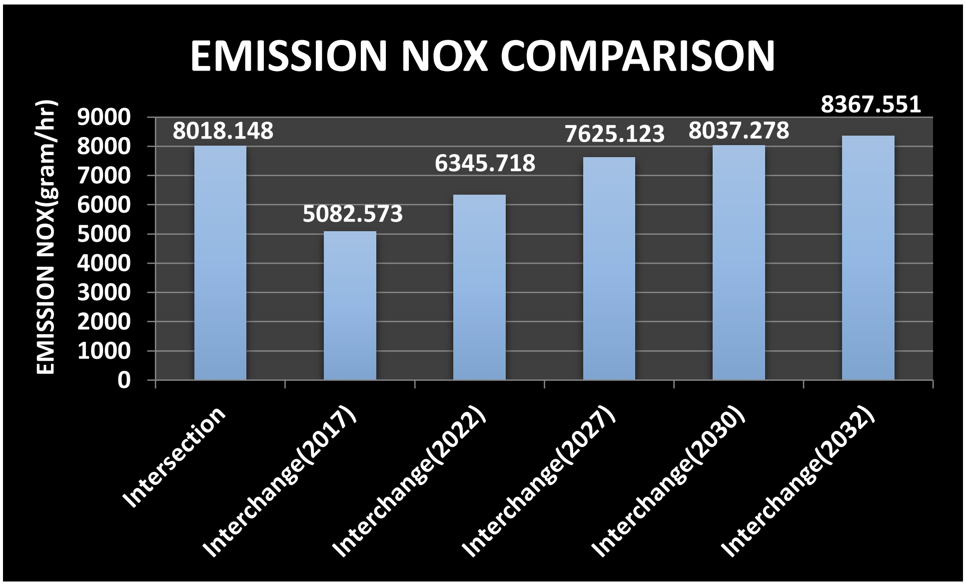


Figure 18 Vehicular Emission NOX Comparison

The above graph shows the NOX emission comparison of intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030, interchange 2032. According to this graph, the NOX emission on intersection were **8018 gram/hr** which reduced to **5082 gram/hr** on interchange.

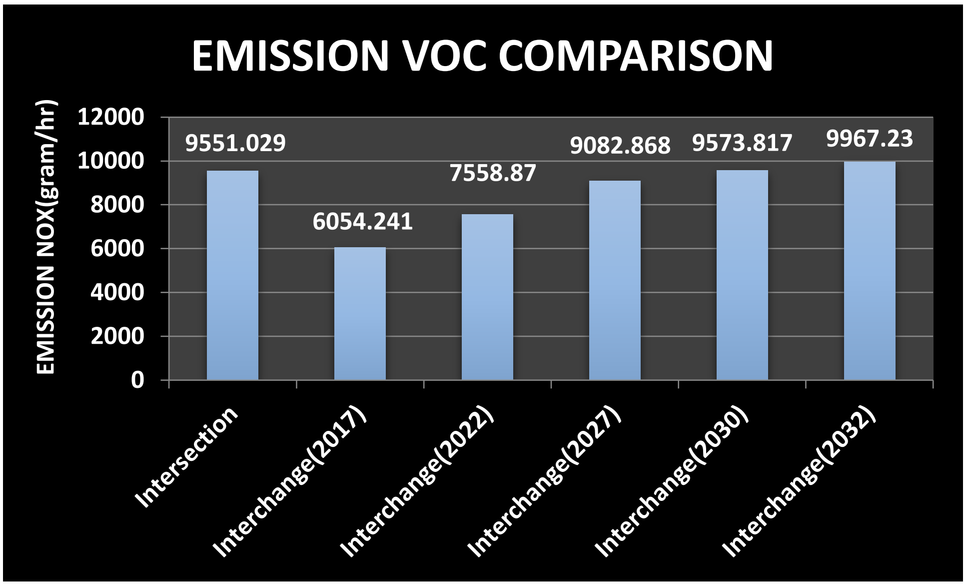


Figure 19 Vehicular Emission VOC Comparison

The above graph shows the VOC's emission comparison of intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030, interchange 2032. According to this graph, the VOC's emission on intersection were **9551 gram/hr** which reduced to **6054 gram/hr** on interchange.

Table 25 Delays (sec/veh) Comparison for Every Movement

Movement	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	159.62	1.98	2.72	4.54	6.90	8.45
NBL	84.59	6.58	6.26	8.00	7.73	10.39
NBR	164.26	4.93	6.95	6.67	9.18	11.21
SBT	156.41	11.19	17.33	21.94	22.61	25.11
SBL	161.42	9.43	13.72	15.24	15.18	14.15
SBR	171.81	25.75	38.3	49.9	48.79	51.26

EBT	231.82	5.77	5.08	5.4	4.64	4.46
EBL	34.88	6.65	6.14	6.82	5.79	6.19
EBR	322.64	39.78	40.75	48.84	46.26	43.56
WBT	195.21	1.06	1.48	1.7	1.44	1.34
WBR	211.95	2.73	3.98	4.41	5.02	4.87

The above table is the result summary of delays by **VISSIM.** This table compares the values of delays for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement. According to these results there is a drastic reduction in delays due to construction of interchange, the delays at interchange are gradually increasing.

Table 26 LOS Comparison for Every Movement

Movement	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	F	A	A	A	A	A
NBL	F	A	A	A	A	B
NBR	F	A	A	A	A	B
SBT	F	B	B	C	C	C
SBL	F	A	B	B	B	B
SBR	F	C	D	D	D	D
EBT	F	A	A	A	A	A
EBL	C	A	A	A	A	A

EBR	F	D	D	D	D	D
WBT	F	A	A	A	A	A
WBR	F	A	A	A	A	A

The above table is the result summary of LOS by **VISSIM.** This table compares the values of LOS for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement. According to these results there is an abrupt improvement in LOS from intersection to interchange.

Table 27 Stop Delays (sec/veh) Comparison for Every Movement

Movement	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	126.27	0.00	0.02	0.09	0.28	0.26
NBL	60.02	1.42	0.98	1.5	1.23	1.20
NBR	137.29	1.25	1.4	1.77	1.85	1.94
SBT	132.6	0.64	1.66	1.67	1.81	2.40
SBL	138.01	2.75	4.69	3.71	3.54	3.16
SBR	147.86	1.96	3.7	4.89	5.46	5.34
EBT	180.88	0.41	0.15	0.31	0.23	0.12
EBL	15.13	0.13	0.12	0.15	0.07	0.10
EBR	261.64	2.21	2.37	4.27	3.73	2.94

WBT	173.00	0.00	0.00	0.00	0.00	0.00
WBR	189.86	0.00	0.02	0.04	0.08	0.21

The above table is the result summary of stop delays by **VISSIM.** This table compares the values of stop delays for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement. According to these results there is an abrupt decrease in stop delays from intersection to interchange.

Table 28 Stops Comparison for Every Movement

Movement	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	4.69	0.00	0.01	0.06	0.14	0.19
NBL	2.92	0.3	0.23	0.30	0.28	0.44
NBR	4.04	0.18	0.26	0.22	0.27	0.43
SBT	3.61	0.42	0.82	1.03	1.15	1.33
SBL	3.13	0.44	0.60	0.70	0.79	0.74
SBR	3.33	1.21	2.16	3.15	3.39	3.51
EBT	8.76	0.14	0.09	0.09	0.09	0.06
EBL	1.34	0.07	0.06	0.09	0.02	0.06
EBR	12.44	1.87	2.04	2.89	2.75	2.33
WBT	3.52	0.00	0.00	0.00	0.00	0.00

WBR	3.61	0.00	0.03	0.04	0.05	0.04

The above table is the result summary of stops by **VISSIM.** This table compares the values of stops for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement. According to these results there is an abrupt decrease in stops from intersection to interchange.

Table 29 Fuel Consumption (gal/hr) Comparison for Every Movement

Movements	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	191.967	65.476	76.243	95.026	113.277	127.226
NBL	9.541	5.992	6.646	7.829	8.37	9.601
NBR	4.112	2.355	2.726	3.114	3.614	3.914
SBT	196.38	132.492	200.503	243.48	257.248	277.286
SBL	3.039	2.307	3.097	3.70	3.905	3.773
SBR	11.984	17.872	23.471	28.592	29.226	29.366
EBT	19.775	8.153	8.015	7.828	7.91	7.789
EBL	4.937	9.141	9.246	9.209	9.085	9.178
EBR	126.195	101.647	106.239	122.803	120.709	111.406
WBT	4.982	1.019	1.203	1.361	1.405	1.486
WBR	8.28	3.338	4.112	4.858	5.32	5.601

The above table is the result summary of fuel consumption by **VISSIM.** This table compares the values of fuel consumption for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement. According to these results there is an abrupt decrease in fuel consumption from intersection to interchange..

Table 30 Emission CO (gram/hr) Comparison for Every Movement

Movements	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	13418.5	4576.76	5329.4	6642.29	7918.08	8893.12
NBL	666.906	418.814	464.559	547.242	585.051	671.125
NBR	287.436	164.61	190.543	217.676	252.64	273.617
SBT	13726.9	9261.21	14015.1	17019.3	17981.7	19382.3
SBL	212.405	161.282	216.484	258.644	272.978	263.706
SBR	837.691	1249.25	1640.61	1998.58	2042.9	2052.7
EBT	1382.26	569.905	560.275	547.169	552.921	544.436
EBL	345.088	638.937	646.278	643.682	635.034	641.521
EBR	8821.05	7105.1	7426.14	8583.93	8437.57	7787.31
WBT	348.258	71.261	84.105	95.167	98.201	103.851
WBR	578.774	233.34	287.401	339.542	371.841	391.529

The above table is the result summary of CO emissions by **VISSIM.** This table compares the values of CO emissions for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement.

According to these results there is an abrupt decrease in CO emissions from intersection to interchange.

Table 31 Emission NOX (gram/hr) Comparison for Every Movement

Movements	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	2610.75	890.47	1036.91	1292.35	1540.57	730.28
NBL	129.756	81.486	90.386	106.473	113.83	130.577
NBR	55.925	32.027	37.073	42.352	49.155	53.236
SBT	2670.76	1801.89	2726.84	3311.33	3498.58	3771.09
SBL	41.326	31.38	42.12	50.323	53.112	51.308
SBR	162.984	243.058	319.206	388.851	379.473	399.381
EBT	268.937	110.883	109.009	106.459	107.578	105.928
EBL	67.142	124.314	125.742	125.237	123.555	124.817
EBR	1716.26	1382.39	1444.86	1670.12	1641.65	1515.13
WBT	67.758	13.865	16.364	18.516	19.106	20.206
WBR	112.608	45.399	55.918	66.063	72.347	76.177

The above table is the result summary of NOX emissions by VISSIM. This table compares the values of NOX emissions for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement. According to these results there is an abrupt decrease in NOX emissions from intersection to interchange.

Table 32 Emission VOC (gram/hr) Comparison for Every Movement

Movements	Intersection	Interchange (2017)	Interchange (2022)	Interchange (2027)	Interchange (2030)	Interchange (2032)
NBT	3109.87	1060.707	1235.141	1539.415	1835.092	2061.66
NBL	154.562	97.064	107.666	126.829	135.591	155.54
NBR	66.616	38.15	44.16	50.448	58.552	64.413
SBT	3181.35	2146.374	3248.146	3944.376	4167.422	4492.029
SBL	49.227	37.379	50.172	59.943	63.265	61.116
SBR	194.143	289.525	380.227	463.19	473.461	475.734
EBT	320.351	132.081	129.849	126.812	128.145	126.178
EBL	79.977	148.08	149.781	149.18	147.175	148.679
EBR	2044.36	1646.675	1721.079	1989.409	1955.488	1804.784
WBT	80.712	16.515	19.492	22.056	22.759	24.068
WBR	134.136	54.079	66.608	78.692	86.178	90.741

The above table is the result summary of VOC's emissions by **VISSIM.** This table compares the values of VOC's emissions for intersection, interchange 2017, interchange 2022, interchange 2027, interchange 2030 and interchange 2032 for every movement. According to these results there is an abrupt decrease in VOC's emissions from intersection to interchange.

4.6 Cost Recovery in Term of Public Benefits

The method of calculating cost recovery is explained in **chapter 3 section 3.2.3** .

4.6.1 Savings due to Fuel Consumption Reduction

Table 33 Savings (In million RS.) due to Fuel Consumption Reduction

Year	Fuel cost at Intersection	Fuel cost at Interchange	Savings
2017	1564.03	991.41	572.62
2018	1595.94	1036.42	559.52
2019	1628.49	1083.47	545.02
2020	1661.71	1132.66	529.05
2021	1695.61	1184.07	511.54
2022	1730.52	1237.80	492.72

The above table shows savings in million Rs./year due to reduction of fuel consumption because of conversion of intersection into interchange.

4.6.2 Savings due to Emission CO Reduction

Table 34 Savings (In million RS.) due to Emission CO Reduction

Year	Intersection Cost	Interchange Cost	Savings
2017	4.17	2.65	1.52
2018	4.26	2.77	1.49
2019	4.35	2.90	1.45
2020	4.44	3.03	1.41
2021	4.53	3.16	1.37
2022	4.62	3.30	1.32

The above table shows savings in million Rs./year due to reduction of vehicular CO emissions because of conversion of intersection into interchange

4.6.3 Savings due to Emission NOX Reduction

Table 35 Savings (In million RS.) due to Emission NOX Reduction

Year	Intersection Cost	Interchange Cost	Savings
2017	44.13	27.97	16.16
2018	45.03	29.24	15.79
2019	45.95	30.57	15.38
2020	46.89	31.96	14.93
2021	47.85	33.41	14.44
2022	48.82	34.92	13.90

The above table shows savings in million Rs./year due to reduction of vehicular NOX emissions because of conversion of intersection into interchange**.**

4.6.4 Savings due to Emission VOC Reduction

Table 36 Savings (In million RS.) due to Emission VOC Reduction

Year	Intersection Cost	Interchange Cost	Savings
2017	39.87	25.28	14.59
2018	40.69	26.43	14.26
2019	41.53	27.63	13.90
2020	42.38	28.89	13.49
2021	43.25	30.20	13.05
2022	44.12	31.56	12.56

The above table shows savings in million Rs./year due to reduction of vehicular VOC's emissions because of conversion of intersection into interchange.

4.6.5 Calculation of Payback Period In Terms of Public Benefits

The following table shows the calculations of payback period in term of public benefits. The capital cost of interchange is 2441.87 million Rs. Total savings includes saving due fuel consumption and vehicular emissions reduction because of conversion of intersection into interchange

Table 37 Calculation of Payback Period

Year	Cost(Outflow) In Millions	Total Savings In Millions Rs.	Cumulative Cash Flows
2017	(2441.87)	604.89	(1836.98)
2018		591.06	(1245.92)
2019		575.75	(670.17)
2020		558.88	(111.29)
2021		540.40	429.11
2022		520.50	949.61

From above table it is clear that capital cost of interchange will be recover in between year 2020 and 2021 so in order to calculate exact duration following calculation is used

Payback Period

$= 3 + (|-111.29| \div 540.40)$

$= 3 + (111.29 \div 540.40)$

$\approx 3 + 0.21$

≈ 3.21 years

4.7 Traffic Management Plans

A seven stages work execution plan for the construction of interchange was proposed, after that traffic management plan for each stage of construction was also proposed.

4.7.1 Stage wise Work Execution Plan

The stage wise construction plan have been attached in **Annex-C1**

4.7.2 Traffic Management Plan for each stage

4.7.2.1 Stage 1

The traffic management plan for stage 1 have been attached in **Annex-C2**

Solid hatched area is constructed while line hatched area is under construction

4.7.2.2 Stage 2

The traffic management plan for stage 2 have been attached in **Annex-C3**

Solid hatched area is constructed while line hatched area is under construction

4.7.2.3 Stage 3

The traffic management plan for stage 3 have been attached in **Annex-C4**

Solid hatched area is constructed while line hatched area is under construction

4.7.2.4 Stage 4

The traffic management plan for stage 4 have been attached in **Annex-C5**

Solid hatched area is constructed while line hatched area is under construction

4.7.2.5 Stage 5

The traffic management plan for stage 5 have been attached in **Annex-C6**

Solid hatched area is constructed while line hatched area is under construction

4.7.2.6 Stage 6

The traffic management plan for stage 6 have been attached in **Annex-C7**

Solid hatched area is constructed while line hatched area is under construction

4.7.2.7 Stage 7

The traffic management plan for stage 7 have been attached in **Annex-C8**

Solid hatched area is constructed while line hatched area is under construction

4.8 Conclusions

- LOS from F to B due to construction of interchange and it will remain B even in 2032
- Delay ,Fuel consumption and vehicular emissions reduces by a large extent which is a benefit for public and Fuel consumption and vehicular emissions become equal to intersection-2016 in 2030
- Payback Period(in terms of public benefits) due to reduction of fuel consumption and vehicular emissions because of construction of interchange = 3.21 years.
- Construction Area Traffic Management plans made during construction has helped to manage smooth flow of traffic during construction which lacks in most of construction sites in Pakistan. It can reduce accidents, pollution and congestion at construction site

4.9 Utilization

- Construction Area Traffic Management can be used for future similar projects in order to avoid problems like congestion, pollution and accidents which happened during construction of Koral interchange.

- To develop a mechanized way which can be used for the benefit analysis of any suggested improvement of Traffic system in Future.

- Benefit Analysis performed in this project can encourage government organizations to do projects of similar kind to increase mobility and reduce delays ,fuel consumption and vehicular emissions.

REFERENCES

Manual on Uniform Traffic Control Devices (MUTCD) - FHWA

Highway Capacity Manual (HCM 2000)

HERS-ST Technical Report (2005) on Damage Cost of Air Pollutants