A Design for Silver Star Integrated Green Bus Terminal

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Abstract: A Design for Silver Star Integrated Green Bus Terminal is the project planned by the researchers which takes place in the vicinity of Silver Star and Tours Incorporated located in Gil Puyat along Taft Avenue in Manila. Having a vision of how polluted the air in Manila, the researchers have thought possible ways to lessen the air pollution by targeting where most of pollution is emitted and regulated, which is in the transportation sector. Traffic Impact Assessment (TIA) has been one of the solutions to foresee what will be the impact of the proposed project be after several years. TIA is also a criterion for a proposed design to be labelled as a sustainable design. The outcome of study would be utilized by the researchers to have an idea how a green design be a big difference in the society not only environmentally but also through transportation and social aspects.

Keywords: *Transportation Engineering, TIA, mitigating measures, sustainable design*

1. INTRODUCTION

Traffic and environment degradation are the main concerns of the present generation. These are considered as consequences of every developing country, like the Philippines, where in transportation of goods and services are always in demand. Transportation of individuals, products and services goes on all the time and such problems in congestion can give a negative effect in all kinds of transactions.

Undeniably, this problem affects the environment as pollution arises in busy roads and destinations. Different transportation vehicles and bus stations contributes air, solid waste, water, and noise pollution. As generations will go by, struggles in these matters will further rise since we are aiming further economical improvements but insignificant actions regarding these concerns. Resolving these matters are considered as urgent since this problem might hold the economy in moving forward. All other improving countries developed their sense of discipline and solutions in this field, the reason for their good economy and stable environment condition.

The negative effect of a bus terminal in the community is a challenge for the affiliate to be able to come up with a design that will lessen the damaging contribution of it. Traffic impact assessment will further aid in forecasting the future traffic to be able to formulate the possible solutions in traffic congestions by assessing the impact of the facility in the environment and community.

1.1 Problem Statement

Transportation sector has been considered as one of the main contributors of pollution in all parts of the globe. Upon having this in mind, the group came up with the idea of minimizing the effects of the pollution generated by the transportation sector through having a greener facility for their terminals. The proposed facility will have ticketing system, comfort rooms, food stalls and waiting area that will give comfort and security to the passengers. Traffic Impact assessment would be considered to know how the project would affect the flow of traffic since the location is near a road, university and food establishments. Mitigating measures that will address the issues in environment and traffic within the vicinity, will be researched and further studied.

1.2. Project Objective

To design a two (2) storey with roof deck Integrated Green Bus Terminal that will provide comfort, security and convenience through its facilities. The research aims to know the traffic and environmental impact of the proposed project in the society using Traffic Impact Assessment (TIA). Included in the discussion are the establishments' impact in the society through traffic measures and the possible mitigating solutions to be followed to address the difficulties.

1.3 Design Norms Considered

The project is set to use economical materials available in Manila. Economical in such way that the cost of the material will be maximized with the quality it will offer. A green design will be adopted in the project where it will help in lessening the Heat Island Effect caused by the buses in the area. Mitigating measures set by the TIA will be taken into account to have a better flow of traffic in the area. All of the design norms considered above will contribute to have a safe and sound facility, allowing for the bus terminal to provide a high level of service for the passengers.

1.4 Research Component

The group aims to find solutions to the present and possible problems in the future that deals with the traffic flow and environment degradation in the vicinity. With the knowledge of TIA the researchers will forecast the future traffic and also formulate a sound estimate on the impact of the facility in environment, land use and community. The research will reflect the disadvantages and advantages of having green design as a sustainable element for structures. The urgency of having a green design for transportation facility specifically bus terminal, will be one of the main research of this project

1.5 Sustainable Development

For this project, the group will be conducting Traffic Impact Assessment (TIA) that will give sustainable mitigating solutions for the traffic congestion that is caused by the bus terminal in the area. In addition, in order to say that the design is a green and sustainable design, the proposed project should have gone through Traffic Impact Assessment.

2. REVIEW OF RELATED LITERATURE

2.1 Introduction to Traffic Impact Assessment

Traffic Impact Assessment (TIA) is needed to be able to foresee traffic operational problems and to readily set mitigating measures to be adopted. As a result of the TIA, mitigating measures are formulated and some of these are: (1) Rerouting of movement in the recommended entrance and exits of the proposed project; (2) Adding in the right-of-way; (3) Reducing the expected vehicle trips daily; (4) Giving attention to developing transportation facilities like intersection improvements and road signals. TIA is a tool that summarizes the projected results and classifies works and its modifications necessary to meet the desired effects and development of traffic in an area. In general, most of the developments affect the movement of goods, pedestrians and vehicles. For projects near arterial roads, the level of service the road is offering is below the satisfactory percentage of the community. In line with this the efficiency and safety of the road is not maximize to its full potential.[1]

In an article in Manila Bulletin, it discussed that traffic itself causes degradation of the benefits and growth of a community. Transportation is essential in exchange of goods and in exchanging of goods there would be a clear source of assets and income. Due to the present set up of traffic in Metro Manila, it had caused the country to lose Php140 billion annually. Promoting and adapting the right mitigating measures will be of big help to increase the economic growth and hence reduce the monetary and opportunity losses in the Metro.[2]

In every proposed project it will be very ideal that a full traffic impact analysis will be performed, but then such study is costly and time consuming. The developers try to restrain the components of the study having only the traffic management plan which typically consists of description of the present conditions and an elaborated idea on measures to be monitored during the construction phase. TIA gives emphasis to the following minimum components to be considered as per required by the EIA Review Committee: (a) Description of impact area; (b) Categorization of baseline traffic; (c) Estimation of traffic generation caused by the proposal; (d) Preparation of Traffic Management Plan; (e) Egress points and Routing Analysis; (f) Study of Parking requirement; (g) Preparation of implementation process for recommended countermeasures.[3]

2.2 Traffic Flow Solutions

The company CSC was one of those who helped in redesigning CHART system last 1999. On that event, they started establishing their reputation in innovating Intelligent Transportation System (ITS). They introduced Closed-Circuit Television (CCTV) which served as traffic operator's traffic-surveillance cameras and destination monitors. The additional features were importing weather and road data from state's weather or pavement sensor system. [4] According to Modern Transit Society their traffic congestion solutions are the following: (1) Implementation of employee parking cash-out. A brief description of this program is that the employers will pay their employees not to drive. This will lessen the commuting car by 25%. (2) Raising the tax in a revenue neutral manner. This implies that the gas taxes will go into funding different programs that goal in reducing sales and property taxes. (3) Abolishing automobile subsidies both direct and indirect and letting the gas tax and other auto user fees pay it. (4) Instituting fare lanes.[5]

Basically they have three more recommendation but the summary of them is giving fees to other elements that can cause congestion in traffic to promote lesser utilization of

private cars. Writer, Tom Don, also shares his solutions in traffic congestion such as using public transportation, carpooling, raising gasoline taxes, road toll tax, following live traffic updates, use of flyovers, one-way lanes and highways.[6]

2.3 Green Design

Greenhomesphilippines.com revealed that in site considerations the biggest deliberation in developing a certain design is the relationship of the land to its surrounding features. Every detail on the land's topography and shape will certainly drive a share on certain design decisions. The factors that can be affected are illumination, sound, dimness, airstream, sight, privacy, rainfall, utilities and decision on accessing sites and integrating management decisions for a final output. To be able to respond on the pollution problems there are a lot of suggested solutions such as "cross-ventilation" which will be utilized to maximize cooling. Maximizing the natural lighting by being able to use window openings and known translucent materials can also be facilitated. Using an appropriate type of glass is recommended since an ordinary glass can absolutely absorb heat and UV rays which is really unpleasant.[7]

There is also a very constructive idea that the Department of Transportation and Communications in the Republic of the Philippines had shared during their conference last June 2009. The speaker stated that: "*The DOTC green transport strategy highlights the current programs and projects of the Department that are related to EST. These include initiatives pertaining to motor vehicle inspection and maintenance, emission reduction, mass transport, road traffic safety, alternative fuels, carbon reduction and EST advocacy"*.[8]

2.4 Advantages of Green Building

First advantage is, Efficient Technology. The technology integrates energy and water efficient methods. These promote a healthier and comfortable environment. This utilizes renewable energies from the nature itself, reduces waste and decreases heating and cooling operating cost. Second, Easier Maintenance. Naturally, maintenance is less in a green building design concept. This consumes both time and energy as well as saving the environment for a greater degradation. Third, Improved Indoor Air Quality. It uses clean energy sources such as solar and wind power. Fourth, Return on Investment. A green building inspired structures are on demand and gives favorable deal to any investor. Lastly, Energy Efficiency. As imposed by the Department of Energy, the methods in green design should make most out of the available resources and materials. The professionals involve must follow the energy code requirements given.[9]

2.5 Disadvantages of Green Building

First in the list of the disadvantages of green Building is the cost. Cost is the primary disadvantage since it is beyond the traditional equipment. Second, Air Cooling Features. Air comes from nature, it cannot be control. This is one of the dilemmas of many green building occupants. Third, Structural Orientation. Optimizing sun exposure demands proper positioning of the building. But since it is uncontrollable installation of overhangs, blinds or shades are often the solution. Fourth, Green Roofs. To be able to support the load given by the layers of the green roof the strength of the roof must be emphasize. And Lastly, Labor law compliance requirements.[9]

Architect Paulo Alcazaren certainly believe in the idea that in a congested urban area, the simple rule for making it green is that, ": What you lose on the ground you replace with greenery on top". This has been a simple but very bold solution. [10]

An article on ehow.com entitled Disadvantages of Green Roofs emphasizes that the Philippines just like all the developing countries must look forward on developing the idea of green roofing. This is an advantage in our country since we are having a tropical climate. Certain problem such as snow can be eliminated in our worries. In addition to it, having in mind the appalling effect of the global warming, the assurance of having a necessity to cooperate in helping our only home, earth, is a responsibility of everyone. The advantages of green roofing are overpowering its disadvantages and it is very practical that we adopt it here in our country.[11]

2.6 Advantages of Green Roof

The following are the advantages of green roof: (1) Increased Roof Life, (2) Reduced Noise Levels, (3) Thermal Insulation, (4) Heat Shield, (5) Use of Space, (6) Habitat for Animals and Plants, (7) Storm water Retention, (8) Urban Heat Island Effect, (9) Reduction of Dust and Smog Levels. (10) Cities and Landscapes[12]

2.7 Disadvantages of Green Roof

Given that Green Roof may cost more than any traditional roof materials. However it serves as a great investment for the later period because their cost and maintenance can be less costly which leads to saving more money. Dependent on the amount of the type of green roof (and plants), they do require maintenance but as a minimal annual maintenance will only be essential to remove the unwanted self-seeding plants.[12]

3. METHODOLOGY

3.1 Research Design

Traffic Impact Assessment is the research to be conducted, since this study is essential to be performed whenever a proposed development will generate a 100 or more new peak hour vehicle trips to or from the site. Institute of Transportation Engineers also suggests that TIA be performed when a specified amount of area is being rezoned, the development contains a specified number of dwelling units of square footage, when the development occur in the sensitive area, and when financial assessments are required and the extent of impact must be determined. In addition to the stated thresholds needed in conducting TIA, the location of the site project is also one of the typical locations where the study is appropriate, these locations includes zoning and rezoning application, environmental assessment, special-purpose district, land subdivision application.

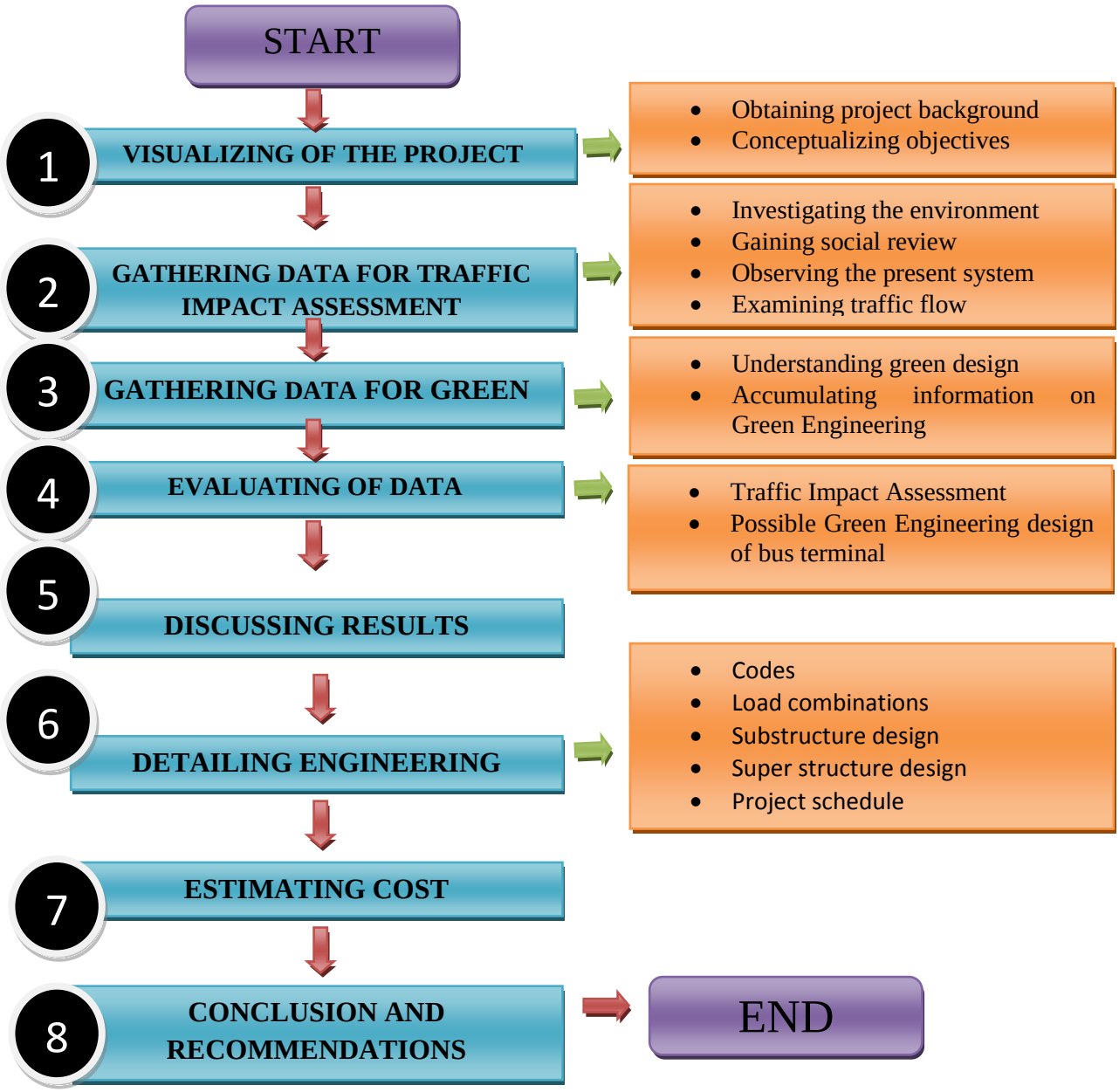
Since the project is a transportation facility itself, the TIA will cover many aspects in the transportation network of the city that includes: transportation improvements, traffic safety, site circulation and parking, transportation facilities, transportation demand management and funding for countermeasures. The researchers documented a TIA that contains the impacts of the proposed development. This includes data such as description of the study area, purpose and objective of the analysis, identification of the area of influence of development, description of existing roadway and transportation conditions, identification of traffic

congestion, anticipated nearby development, trip distribution and assignment of site traffic, protection of existing traffic.

The researchers also considered the capacity analysis of intersections and arterials, the basic scenarios taken into account are: existing conditions, background conditions (existing + approved project), project conditions (existing+ approved projects + project), expected growth conditions (existing + approved projects + project + expected growth). Also, the significance of the traffic impacts is identified by the researchers.

For this study, the researchers considered 30 years span of duration in forecasting the impact of the project in the society. Upon considering the impact of the establishment in the present air quality in the area the group had focused on enhancing one of the counter-measures that we had, which is Green Engineering.

4.4.2 Conceptual Framework



4. DATA COLLECTION

4.1 Preliminary Survey

The preliminary survey was conducted to collect more data about the project development, its environment, and the establishments near it. On the first stage of this assessment, letters addressed to the project manager of the bus terminal, Department of Public Works and Highways (DPWH), Department of Transportation and Communications (DOTC), and Metro Manila Development Authority were given for the formalization of the traffic count.

4.1.1 Traffic conditions

The Silver Star Shuttle and Tours Incorporated Bus Terminal is located along Taft Avenue in Buendia. Based from the observations, the vehicles passing through the site are mostly from Pasay area. The jeepneys coming from this area had the greatest impact. Also, the traffic flow from the south bound on Sen. Gil Puyat Avenue created some traffic jams due to the vehicles that turn left from Pasay area. The establishments near the project development site are mostly food chains, thus, it affects the traffic flow during the break time which occurs between 11:00A.M.-1:00P.M.

4.1.2 Traffic counts

In conducting this Traffic Impact Assessment, a 12-hour straight traffic count was done. This traffic count occurred from 6:00 in the morning up to 6:00 in the evening. This was conducted to know the behavior of traffic flow in the impacted area, and to determine the effects of the establishment to the traffic flow. The traffic count was conducted last May 15, 2014 (Thursday) and May 24, 2014 (Sunday). There were 4 assigned stations since it is a High Traffic Impact Area. The first two stations are located on North and south bound of Taft Avenue, and the other two are located on Sen. Gil Puyat Avenue, both located before the U-turn slot. In this traffic count, the following classification for the vehicles were considered: Cars, SUV, Jeep, Bus, FX, Taxi, Motorcycle, Trucks (trailer, articulated, and delivery), Motorcycle and Bike.

4.2 Baseline Traffic

4.2.1 Identification of critical movements

It is important to identify the significant roads that affect the traffic system within a High Traffic Impact Assessment area, for the proposed project will have an impact to the vehicles and pedestrians passing by the site.

Figure 1. Location and Direction of Movements

4.2.2 Base traffic

Table 4.2.2.1 Passenger Car Equivalent Factors

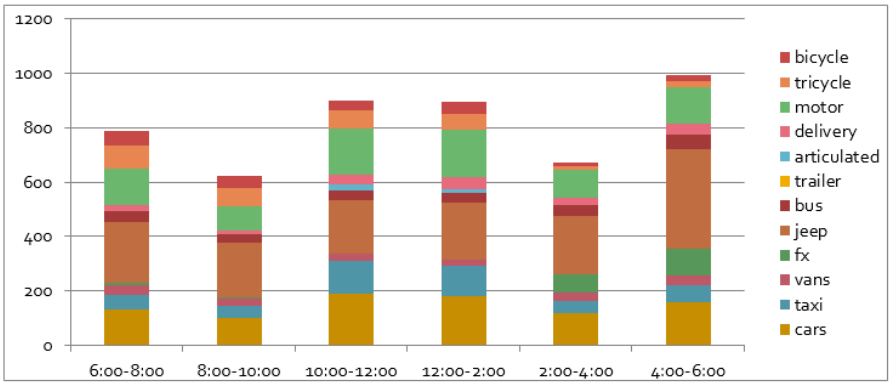
Vehicle Type	Taxi	Bike	FX	Jeep	Bus	Car	Motorcycle	Truck	SUV
PCEF	1	0.5	1.2	1.4	2.2	1	0.5	2.2	1.2

Weekday Traffic Count

Table 2. T1 Weekday Traffic Count

	W/O PCU						PCU					
T1	6:00-8:00	8:00-10:00	10:00-12:00	12:00-2:00	2:00-4:00	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-2:00	2:00-4:00	4:00-6:00
Cars	134	102	189	180	120	159	134	102	189	180	120	159
Taxi	53	43	120	111	44	61	53	43	120	111	44	61
Vans	33	26	27	24	32	39	33	26	27	24	32	39
FX	9	6	2	2	65	98	9	6	2	2	65	98
Jeepneys	224	199	197	208	215	365	313.6	278.6	275.8	291.2	301	511
Buses	40	31	36	33	38	52	88	68.2	79.2	72.6	83.6	114.4
Trailer	0	0	0	0	2	0	0	0	0	0	4.4	0
Articulated	2	1	19	16	0	0	2	1	19	16	0	0
Delivery	20	16	39	43	26	39	20	16	39	43	26	39
Motorcycle	134	86	167	173	103	136	67	43	83.5	86.5	51.5	68
Tricycle	85	67	66	61	15	23	85	67	66	61	15	23
Bicycle	51	44	38	42	12	18	10.2	8.8	7.6	8.4	2.4	3.6
TOTAL	785	621	900	893	672	990	814.8	659.6	908.1	895.7	744.9	1116

Chart1. T1 Weekday Count

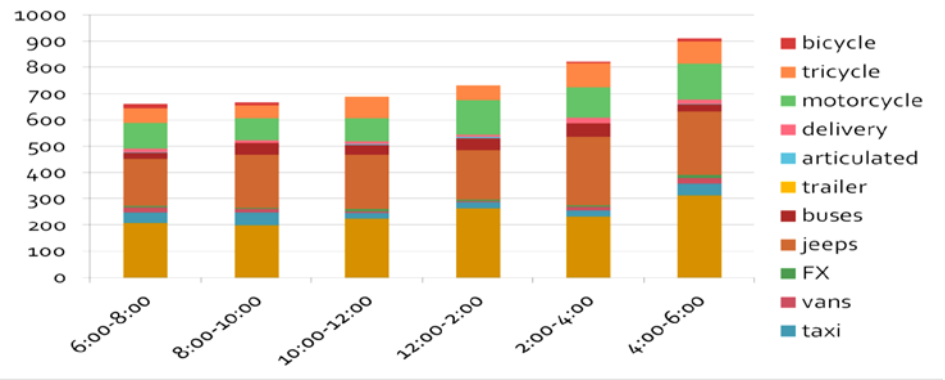


Weekend Traffic Count

Table 3. *T1 Weekend Count*

	W/O PCU						PCU					
T1	6:00-8:00	8:00-10:00	10:00-12:00	12:00-2:00	2:00-4:00	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-2:00	2:00-4:00	4:00-6:00
cars	207	198	223	263	232	311	1	207	198	223	263	232
taxi	40	49	21	23	22	46	1	40	49	21	23	22
vans	21	12	7	4	15	22	1	21	12	7	4	15
FX	5	6	8	6	6	12	1	5	6	8	6	6
jeeps	178	201	207	189	262	240	1.4	249.2	281.4	289.8	264.6	366.8
buses	22	46	38	43	48	29	2.2	48.4	101.2	83.6	94.6	105.6
trailer	0	0	0	0	0	0	2.5	0	0	0	0	0
articulated	3	0	4	8	0	2	1	3	0	4	8	0
delivery	15	9	10	9	24	15	1	15	9	10	9	24
motorcycle	96	85	88	130	116	138	0.5	48	42.5	44	65	58
tricycle	58	50	82	57	92	83	1	58	50	82	57	92
bicycle	17	12	0	0	5	11	0.5	8.5	6	0	0	2.5
TOTAL	662	668	688	732	822	909	14.1	703.1	755.1	772.4	794.2	923.9

Chart 2. T1 Weekend Count



4.3 Baseline Traffic Volume (Peak Hour)

Given the passenger car equivalent factors, volume of vehicles in PCU (passenger car unit) are solved. The traffic volume considered in the traffic count was obtained during the peak hour at morning and afternoon.

Table 4 Baseline Traffic Volume in pcu/hr. (Peak Hour)

	Time	Volume (pcu/hr.)
Weekday	A.M.	3513.7
	P.M.	3617.3
Weekend	A.M.	3397.9
	P.M.	3530

These data will be significant to the estimation of baseline traffic volume in the future for the said area. It will be needed for the development of the Silver star Bus Terminal area.

4.4 Trip Generation

4.4.1 Trips produced and attracted by the development

Silver Star Bus station is a proposed green design bus station which serves transportation to the people travelling from Metro Manila to various provinces such as Cavite, Laguna, Batangas, Rizal, and Quezon. The bus station requires High Impact Traffic Assessment since it is surrounded by existing establishments such as fast food chains, churches, schools, gasoline stations and bus stations. Trips generated affect the flow of traffic within the area.

4.4.2 Traffic assignment

Taft Avenue and the Buendia Avenue are the two main roads within the area which produces high volume of trips. Along the Taft Avenue is the LRT-1 station which greatly contributes to

the large number of vehicles passing to the area. The Buendia Avenue leads to Makati City, a central business district, producing increased of volume of trips.

4.5 Trip Distribution

4.5.1 Trip allocation

Table 5.Shows the distribution of trips in each zone to its destination.

T1	NORTHBOUND	T3	EASTBOUND
T2	SOUTHBOUND	T4	WESTBOUND

Table 6. Trip Distribution of the Development

Trip Distribution					
	Time(Peak Hour)	**Number Person Trips (Trip/hr)**		**Percentage (%)**	
		T1	**T2**	**T1**	**T2**
Weekday	A.M.	445.640	335.716	0.570	0.430
	P.M.	470.239	311.117	0.602	0.398
Weekend	A.M.	427.663	353.693	0.547	0.453
	P.M.	365.544	415.812	0.468	0.532
		T3	**T4**	**T3**	**T4**
Weekday	A.M.	329.801	451.555	0.422	0.578
	P.M.	335.745	445.611	0.430	0.570
Weekend	A.M.	266.834	514.522	0.342	0.658
	P.M.	391.564	389.792	0.501	0.499

4.6 Modal Split

4.6.1 Mode choice

In transport planning, choosing of transport mode is probably one of the most important classic models. A public transport mode provides benefits to more people, like, if they begin to use public transport there will be less congestion and road accidents. Public transport modes are economically more efficient than private transport. Main characteristics of public transport is that they will have some particular schedule, frequency etc. On the other hand, private transport is highly flexible, provides more comfortable and convenient travels. Also, it has better approachability. The issue of mode choice affects the general effectiveness with which we can travel in different places. Developing and using of models which are sensitive is important to those travel attributes that influence individual choices of mode. Therefore, is probably the single most important element in transport planning and policy making.

4.6.2 Factors influencing the choice of mode

The factors considered are: Transit Level of Service, Accessibility, Land Use / Urban Design, Transit Users Characteristics and Characteristics of the trip.

Table 7. Modal Split of Vehicles (Weekday – A.M.) (Weekday – P.M.)

Weekday / **Vehicle Type**	**Number** Person Trips (Trip/hr) (A.M. – Peak Hour)	Percentage (%)	**Number** Person Trips (Trip/hr) (P.M. – Peak Hour)	**Percentage** (%)
Cars	909	29.7448	714	21.8951
Taxi	664	21.7277	496	15.2101
Vans	275	8.9987	88	2.6986
FX	14	0.4581	79	2.4226
Jeeps	534	17.4738	599	18.3686
Busses	302	9.8822	396	12.1435
Trailers	0	0	0	0
Articulated	13	0.4254	8	0.2453
Delivery	63	2.0615	82	2.5146
Motorcycle	219	7.1662	597	18.3073
Tricycle	52	1.7016	127	3.8945
Bicycle	11	0.3599	75	2.3

Table 8. Modal Split of Vehicles (Weekend – A.M.) (Weekend – P.M.)

Weekend / **Vehicle Type**	**Number** Person Trips (Trip/hr) (A.M. – Peak Hour)	**Percentage** (%)	**Number** Person Trips (Trip/hr) (P.M. – Peak Hour)	**Percentage** (%)
Cars	223	32.4128	311	34.2134
Taxi	21	3.0523	46	5.0605
Vans	7	1.0174	22	2.4202
FX	8	1.1628	12	1.3201
Jeeps	207	30.0872	240	26.4026
Busses	38	5.5232	29	3.1903
Trailers	0	0	0	0
Articulated	4	0.5814	2	0.2200
Delivery	10	1.4535	15	1.6502
Motorcycle	88	12.7907	138	15.1815
Tricycle	82	11.9186	83	9.1309
Bicycle	0	0	11	1.2101

5.7 Trip/Route Assignment

Route assignment, route choice, or traffic assignment is the process of allocating the given set of trip interchanges to the specified transportation systems.

The types of traffic assignment models are All or Nothing assignment (AON), incremental assignment, capacity-restraint, user equilibrium assignment (UE), stochastic user equilibrium assignment (SUE), system optimum assignment (SO), etc. The frequently used models are the All or Nothing, user equilibrium and capacity restraint.

Table 9. Trip Assignment of Vehicles (Weekday – A.M.)

WEEKDAY (A.M. - PEAK HOUR)	**Number** Person Trips (Trips/hr)				**Percentage** (%)			
Vehicle Type	Trip 1	Trip 2	Trip 3	Trip 4	Trip 1	Trip 2	Trip 3	Trip 4
Cars	189	70	669	909	21.00000	10.32448	29.97312	29.74476
Taxi	120	128	513	664	13.33333	18.87906	22.98387	21.72775
Vans	27	18	98	275	3.00000	2.65487	4.39068	8.99869
FX	2	3	12	14	0.22222	0.44248	0.53763	0.45812
Jeeps	197	276	351	534	21.88889	40.70796	15.72581	17.47382
Buses	36	29	180	302	4.00000	4.27729	8.06452	9.88220
Trailer Trucks	0	0	0	0	0.00000	0.00000	0.00000	0.00000
Articulated Trucks	19	3	1	13	2.11111	0.44248	0.04480	0.42539
Delivery Trucks	39	11	77	63	4.33333	1.62242	3.44982	2.06152
Motorcycle	167	84	278	219	18.55556	12.38938	12.45520	7.16623
Tricycle	66	26	30	52	7.33333	3.83481	1.34409	1.70157
Bicycle	38	30	23	11	4.22222	4.42478	1.03047	0.35995

Table 10.Trip Assignment of Vehicles (Weekend – A.M.)

WEEKEND M. - PEAK HOUR)	**Number** Person Trips (Trips/hr)				**Percentage** (%)			
Vehicle Type	Trip 1	Trip 2	Trip 3	Trip 4	Trip 1	Trip 2	Trip 3	Trip 4
Cars	223	84	365	1180	32.41279	13.83855	23.80952	39.91881
Taxi	21	95	480	609	3.05233	15.65074	31.31115	20.60217
Vans	7	22	58	18	1.01744	3.62438	3.78343	0.60893
FX	8	0	0	30	1.16279	0.00000	0.00000	1.01488
Jeeps	207	235	237	495	30.08721	38.71499	15.45988	16.74560
Buses	38	48	108	320	5.52326	7.90774	7.04501	10.82544
Trailer Trucks	0	0	0	0	0.00000	0.00000	0.00000	0.00000
rticulated Trucks	4	2	3	4	0.58140	0.32949	0.19569	0.13532
Delivery Trucks	10	6	40	11	1.45349	0.98847	2.60926	0.37212
Motorcycle	88	55	185	269	12.79070	9.06096	12.06784	9.10014
Tricycle	82	45	54	13	11.91860	7.41351	3.52250	0.43978
Bicycle	0	15	3	7	0.00000	2.47117	0.19569	0.23681

4.8 Estimation of Future Traffic

The computations for the forecasted volume of vehicles in pcu/hr are based on the peak volume held during a weekday and a weekend, separating the morning and afternoon trip for each. Taking into consideration the traffic growth rates (TGR) in the National Capital Region (NCR).

Table 11. Traffic Growth Rates in NCR

Vehicle Type	**Growth Rates**	
	2015-2020	2021-2026+
Car/SUV/Fx/Taxi	5.6%	4.8%
Jeepney/Bus	6.5%	6.1%
Truck(trailer, articulated, delivery)	4.9%	3.8%
Motorcycle/Tricycle/ Bicycle	5.6%	4.8%

4.8.1 Future traffic without development

The estimated traffic along the roads without development having direct impact to the site is shown in Table 12 and Table 13 considering the weekday and weekend trip, respectively.

Table 12. Estimated A.M. and P.M. Peak Traffic Volume in Weekday Trip for 'Without Development' Scenario

Direction	**Time**	**Traffic Volume** (pcu/hr)	**WEEKDAY - Estimated Traffic Volume (pcu/hr)**									
			2017	**2020**	**2023**	**2026**	**2029**	**2032**	**2035**	**2038**	**2041**	**2044**
T1	A.M.	**908.10**	1078.79	1281.83	1495.36	1745.21	2037.66	2380.15	2781.37	3251.61	3802.96	4449.67
	P.M.	**1116.00**	1332.27	1590.75	1868.87	2196.48	2582.53	3037.61	3574.24	4207.26	4954.23	5835.94
T2	A.M.	**757.20**	905.01	1081.86	1273.13	1498.75	1764.97	2079.21	2450.24	2888.46	3406.20	4018.07
	P.M.	**707.50**	845.46	1010.50	1188.86	1399.20	1647.36	1940.22	2285.94	2694.20	3176.45	3746.29
T3	A.M.	**2431.00**	2887.84	3431.13	4002.07	4669.75	5450.85	6364.98	7435.21	8688.65	10157.23	11878.49
	P.M.	**2733.40**	3248.22	3860.76	4505.82	5260.83	6144.86	7180.41	8393.89	9816.48	11484.83	13442.20
T4	A.M.	**3513.70**	4178.78	4970.62	5807.34	6787.40	7935.79	9281.89	10860.33	12711.88	14884.60	17435.10
	P.M.	**3617.30**	4309.50	5135.10	6014.89	7048.13	8262.00	9688.63	11365.90	13338.54	15659.42	18390.95

Table 13. Estimated A.M. and P.M. Peak Traffic Volume in Weekend Trip for 'Without Development' Scenario

Direction	**Time**	**Traffic Volume** (pcu/hr)	**WEEKEND - Estimated Traffic Volume (pcu/hr)**									
			2017	**2020**	**2023**	**2026**	**2029**	**2032**	**2035**	**2038**	**2041**	**2044**
T1	A.M.	**772.40**	920.58	1097.38	1286.13	1507.90	1768.58	2075.08	2435.60	2859.80	3359.10	3947.00
	P.M.	**962.00**	1144.58	1362.05	1592.31	1862.17	2178.57	2549.65	2985.04	3496.05	4096.03	4800.73
T2	A.M.	**665.30**	795.29	950.84	1119.15	1317.71	1552.03	1828.63	2155.23	2541.01	2996.80	3535.48
	P.M.	**1122.30**	1336.05	1590.79	1861.20	2178.34	2550.44	2987.14	3499.87	4102.05	4809.54	5641.05
T3	A.M.	**1662.50**	1974.02	2344.31	2732.51	3186.13	3716.37	4336.40	5061.70	5910.44	6903.99	8067.50
	P.M.	**3384.20**	4009.85	4752.26	5523.46	6422.89	7472.37	8697.51	10128.39	11800.31	13754.79	16040.64
T4	A.M.	**3397.90**	4043.38	4812.26	5626.77	6581.40	7700.63	9013.31	10553.41	12360.95	14483.10	16975.48
	P.M.	**3530.00**	4198.08	4993.39	5833.45	6817.15	7969.42	9319.63	10902.34	12758.20	14935.13	17489.55

Based on the comparison of traffic volumes for weekday and weekend trip between T1 and T2 corresponding to its A.M. and P.M. peak periods, the P.M. peak period was determined to be the more critical peak period for both weekday and weekend. Based on the comparison of traffic volumes for weekday and weekend trip between T3 and T4 corresponding to its A.M. and P.M. peak periods, the P.M. peak period was determined to be the more critical peak period for both weekday and weekend. Thus, the critical period for the four trips is the P.M. peak period for both weekday and weekend. From these results, the focus can now be shifted towards the critical period. Therefore, formulation of traffic management system to address potential problems will be evaluated as well as for the recommendations.

4.8.2 Future traffic with development

The estimated traffic attracted and generated by the site was added to the computed values shown in Table 12 and Table 13 to come up with the values for 'with development'. Table 14 shows the additional attracted traffic volume of the proposed project.

Table 14. Attracted Traffic Volume of the Development

	Weekday		**Weekend.**	
Time	**A.M.**	**P.M**	**A.M.**	**P.M**
Traffic Volume (pcu/hr)	131.1	131.1	131.1	131.1

The computed values for the 'with development' are shown in Table 15 and Table 16 for weekday and weekend trip, respectively, taking into consideration the traffic volume for both A.M. and P.M. peak periods.

Table 15. Estimated A.M. and P.M. Peak Traffic Volume in Weekday Trip for 'With Development' Scenario

Direction	**Time**	**Traffic Volume** (pcu/hr)	**WEEKDAY - Estimated Traffic Volume (pcu/hr)**									
			2017	**2020**	**2023**	**2026**	**2029**	**2032**	**2035**	**2038**	**2041**	**2044**
T1	A.M.	**1039.20**	1222.88	1439.02	1693.36	1992.66	2344.85	2759.30	3247.00	3820.90	4496.23	5290.93
	P.M.	**1247.10**	1467.52	1726.90	2032.13	2391.30	2813.96	3311.32	3896.59	4585.30	5395.74	6349.42
T2	A.M.	**888.30**	1045.30	1230.06	1447.47	1703.31	2004.36	2358.63	2775.51	3266.07	3843.34	4522.64
	P.M.	**838.60**	986.82	1161.24	1366.48	1608.01	1892.22	2226.66	2620.22	3083.34	3628.31	4269.60
T3	A.M.	**2562.10**	3014.94	3547.83	4174.90	4912.80	5781.13	6802.93	8005.33	9420.25	11085.25	13044.54
	P.M.	**2864.50**	3370.79	3966.57	4667.65	5492.65	6463.46	7605.86	8950.18	10532.10	12393.62	14584.16
T4	A.M.	**3644.80**	4289.01	5047.08	5939.14	6988.87	8224.13	9677.73	11388.24	13401.08	15769.69	18556.94
	P.M.	**3748.40**	4410.92	5190.54	6107.95	7187.52	8457.89	9952.81	11711.94	13782.00	16217.93	19084.41

Table 16. Estimated A.M. and P.M. Peak Traffic Volume in Weekend Trip for 'With Development' Scenario

Direction	Time	Traffic Volume (pcu/hr)	WEEKEND - Estimated Traffic Volume (pcu/hr)									
			2017	2020	2023	2026	2029	2032	2035	2038.	2041	2044
T1	A.M.	**903.50**	1063.19	1251.11	1472.24	1732.45	2038.66	2398.99	2823.00	3321.96	3909.11	4600.03
	P.M.	**1093.10**	1286.30	1513.65	1781.19	2096.01	2466.47	2902.42	3415.41	4019.07	4729.44	5565.35
T2	A.M.	**796.40**	937.16	1102.80	1297.72	1527.09	1797.00	2114.61	2488.37	2928.18	3445.73	4054.75
	P.M.	**1253.40**	1474.94	1735.63	2042.39	2403.38	2828.17	3328.05	3916.27	4608.46	5422.99	6381.49
T3	A.M.	**1793.60**	2110.61	2483.66	2922.64	3439.21	4047.08	4762.39	5604.13	6594.65	7760.24	9131.84
	P.M.	**3515.30**	4136.62	4867.76	5728.12	6740.55	7931.93	9333.88	10983.61	12924.94	15209.39	17897.61
T4	A.M.	**3529.00**	4152.74	4886.73	5750.45	6766.82	7962.84	9370.25	11026.42	12975.31	15268.67	17967.36
	P.M.	3661.10	4308.19	5069.65	5965.70	7020.12	8260.91	9721.01	11439.17	13461.01	15840.21	18639.93

4.9 Traffic Analysis

4.9.1 Road capacity analysis

Based on the projected traffic flows and the estimated road capacities, the level of service (LOS) are evaluated for the links that were influenced by the proposed development. The level of service (LOS) is a measure for assessing the traffic conditions along transportation facilities. The six level of service (LOS) designation are: A, B, C, D, E, and F, with 'A' pertaining to free flow conditions and 'F' congested or traffic jam conditions. The measure of effectiveness corresponding to each LOS value is the volume to capacity ratio or VCR. The level of service criteria for roads are provided in table below.

Table 17. The Level of Service Criteria

Level of Service	VCR Value/Range	Description
A	Less than 0.20	Free flow traffic
B	0.21 - 0.50	Free flow traffic
C	0.51 – 0.70	Moderate traffic
D	0.71 – 0.85	Moderate to Heavy traffic
E	0.86 – 1.00	Heavy traffic
F	Greater than 1.00	Forced flow, stop and go

The lane capacity (pcu/hr/lane) is determined taking into consideration road friction that include public transport operations (e.g., loading and unloading area), lane widths, pedestrian movements, roadside land use, and other elements. The table below shows the estimation of road capacity as a product of the number of lanes and the capacity per lane.

Table 18. Basic Capacity

Number of lanes per direction	2	3	4
Hourly capacity, pcu/lane	1800	1750	1700

Source: Ministry of Public Works and Highways 1982

Solve the hourly capacity of 6 lanes per direction by extrapolation:

$$\frac{5-3}{4-3} = \frac{X-1750}{1700-1750} \quad (1)$$

$$X = 1650\ pcu/lane$$

Table 19 Road Capacity for each Direction

Direction (T3&T5)	Number of Lanes	Lane Capacity (pcu/hr/lane)	Capacity (pcu/hr)
Southbound	5	1650	8250
Nothbound	5	1650	8250
Eastbound	2	1800	3600
Westbound	2	1800	3600

Table 20. Directional Factor for each Direction

T3&T4	Direction	Directional Factor
Weekday	Eastbound	0.195947
	Westbound	0.167120
Weekend	Eastbound	0.272983
	Westbound	0.175730
Weekday	Southbound	0.189021
	Northbound	0.183238
Weekend	Southbound	0.196079
	Northbound	0.232629

VCR = PCU*0.08/BHCC

Legend:
AADT = annual average daily traffic
BHCC = basic hourly car capacity (in PCU)
Hourly design volume = 8% of AADT in PCU
PCU = passenger car units
PCEF = passenger car equivalent factors, and
VCR = traffic volume capacity (0.00-1.00)

Figure 2. DPWH Department Order No. 22 Series of 201

Sample Computation of Level of Service for Weekday:

$$\frac{v}{c} = \frac{D \times K \times AADT}{c} \qquad (2)$$

where,

D :proportion of peak hour traffic travelling in the peak direction expressed as decimal 0.588639 K

K :proportion of daily traffic occurring during peak hour expressed in decimal 0.08

AADT : average annual daily traffic $(24\ x\ 4087.10)$

c : hourly capacity $(6\ x\ 1600)$

$\frac{v}{c}$: level of service

$$\frac{v}{c} = \frac{0.588639 \times 0.08 \times 24 \times 4087.1}{6 \times 1600}$$

$\frac{v}{c}$=0.481 **Therefore, Level of Service B (0.21-0.50)**

Table 21 Level of Service 'Without Development' – Weekday

Direction	**Time**	**Weekday - Level of Service**										
		2014	2017	2020	2023	2026	2029	2032	2035	2038	2041	2044
T1	A.M.	B	B	B	B	B	C	C	D	E	F	F
	P.M.	B	B	B	C	C	D	D	E	E	F	F
T2	A.M.	B	B	B	B	B	B	C	C	D	E	F
	P.M.	B	B	B	B	B	B	C	C	D	E	F
T3	A.M.	B	B	B	B	C	C	D	E	F	F	F
	P.M.	B	B	B	B	C	C	D	E	F	F	F
T4	A.M.	C	C	C	D	E	F	F	F	F	F	F
	P.M.	B	C	C	D	D	F	F	F	F	F	F

Table 23 Level of Service 'With Development' – Weekday

Direction	Time	Weekday - Level of Service										
		2014	2017	2020	2023	2026	2029	2032	2035	2038	2041	2044
T1	A.M.	B	B	B	B	C	C	D	E	F	F	F
	P.M.	B	B	C	C	D	E	F	F	F	F	F
T2	A.M.	B	B	B	B	B	C	C	D	E	F	F
	P.M.	B	B	B	B	C	C	D	E	F	F	F
T3	A.M.	B	B	B	C	C	C	D	E	F	F	F
	P.M.	B	B	B	C	C	D	E	F	F	F	F
T4	A.M.	B	C	C	D	E	F	F	F	F	F	F
	P.M.	B	C	C	D	E	F	F	F	F	F	F

5. CONCLUSION AND SUMMARY

This study presents how aspiring the Civil Engineers of Mapua Institute of Technology address the need of a green design and TIA in their plan of having a modern Bus Terminal. In a way, we can help the said bus terminal to improve their operation and the level of service.

The Silver Star Bus Terminal is a planned bus terminal located along Taft Avenue at Buendia, near Gil Puyat LRT Station. The series of roads around the terminal caters various kinds of transportation, may it be private or public. Since the location of the bus terminal (Taft Avenue) has an increased traffic volume due to its development and construction, mitigation measures are required in order to decrease the negative impact of such project in the traffic within its vicinity. The group conducted Traffic Impact Assessment (TIA) that will give sustainable mitigating solutions for the traffic congestion that the bus terminal caused in the area. In addition, in order to say that the design is a green and sustainable plan, the proposed project had gone through Traffic Impact Assessment. Knowing the impact of the proposed project is the main objective of this research.

As observed, the sum of the vehicle in the area can lead to an occupation of a significant portion of traffic. However, the group's observation leads to the determination that there were certain hours in which the vehicle count on a specific road increases (peak) or decreases (off peak). Different vehicles such as cars, jeeps, taxis, bus motorcycle, bicycle, tricycle, trucks, vans and FX taxis can be found within the area. The different commercial establishments and educational institutions within and near the vicinity are its trip generators.

According to the computation of the future traffic estimated thirty years from now (2014-2044) it has been identified that both in the "without development" and "with development" situation the level of service in year 2044 will be Level F, which is identified as forced flow. The vehicles are expected to have a very inconvenient time since heavy traffic congestion, a "stop and go" scenario is expected. For the reason, measures indicated in the Traffic Impact Assessment must be implemented at the right place and the right time during the duration of the project. The proposed measures are parking control techniques, employer-based TDM strategies, ride-sharing techniques, designation of lanes/public transportation improvement techniques, improvement of existing facilities (intersection channelization regular maintenance of pavement marking, road widening), non-motorized transport improvements/development of a bikeway system, improvement of traffic signalization system, public transport facilities, and transit improvements.

6. RECOMMENDATIONS

Due to constraint in time, further improvement of the innovation is recommended by finding alternative materials for the green roof, not limiting in sourcing materials in Manila, but also in finding potential native materials in provinces of the Philippines. Hence, in discovering new various economical alternatives, its maintenance, use, and quality should be better or as the same as the materials available in the market today.

The researchers also recommend the students or group of individuals and professionals to pursue in applying green roof having the same goal or greater than the objective of the group to encourage transportation groups which are known as main contributors of pollution and other individuals to adopt green roof in their green design for a reason that the researchers observed that the benefit of having a green roof in any type of structure gives a lot of advantages than disadvantages not only to man but also to the environment. Since green

roof is also a trending green design in other countries, the respond in this calling is also reasonable and highly recommended.

As for the governing agencies, the researchers recommend support in the campaign of further research regarding this matter. The agencies of the country, just like other countries must give advantages to those individuals who will adopt green roof such as decrease in tax and other favors that will highly encourage them for the promotion of a better environment and health conditions.

As for the Traffic Impact Assessment, though the study have revealed that the flow of traffic in the roads near the site of the project considering this year's data is of high level of service, the data gathered may be subjected to changes over a period of time, considering different factors such as, establishments may rise within the vicinity that will affect the flow traffic and number of pedestrians, another is the traffic regulations and laws that may be implemented within the nearby roads and highways. As well as thinking about the result of the computed future traffic in the conducted TIA it is firmly recommended to put into operation the mitigating measures expresses by the researchers. A follow up Traffic Impact Assessment is also recommended to be perform to determine the new level of service the terminal could offer, and for them to come up with new mitigating measures.

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