IV. ISSUES RELATED TO TRICYCLES

The previous section discussed the factors that could contribute to the further increase of tricycle demand and supply in Quezon City and Puerto Princesa City. It is, however, equally important to understand the issues associated with the subsector in order to come up with an unbiased and prudent policies in this regard.

A. Ambient Air Pollution

Motorcycle and tricycle emissions threaten the city's air quality. The incomplete combustion, caused by poor maintenance and abusive use (i.e., overloading) of vehicle, produces various air pollutants. As previously discussed most tricycles have been in operation for over 5 years. The performance of the motorcycles is not only aggravated by its old age but also by the infrequent maintenance and repairs done by the drivers and operators.

The following discussions provide information on the air pollutants typically emitted by motorcycles and tricycles. Different studies are cited to determine the environmental and health damages caused by a particular pollutant based on the period of exposure and the concentration of such pollutant. The population at risk is also identified.

Particulate Matter

Almost all vehicular particulate emissions are extremely damaging to public health. Concentrations of total suspended particles (TSP) and particulate matters with aerodynamic diameter of less than 10 (PM_{10}) and 2.5 microns ($PM_{2.5}$) remain in suspension in the air for hours or days and can travel significant distances from the source. These particles enter the respiratory tract, reaching deep into the lungs. PM_{10} includes all particles likely to pass through the nose and mouth while $PM_{2.5}$ includes those that are able to reach deeper parts of the respiratory tract especially the alveolar regions of the lung.[24]

Low fuel quality, inefficient combustion processes, and poor vehicle and equipment maintenance in tricycles all contribute to particulate emissions at ground level that can easily enter the human respiratory system. Some of the smallest particles called respirable particulates (particulate matters equal or less than 10 microns) lodge in the lung capillaries and alveoli and can cause the following effects:[25]

- Slowing down the exchange of oxygen and carbon dioxide in the blood, causing shortness of breath; and

[24] Kojima, M. *et al.* 2000. *Improving Air Quality in South Asia by Reducing Emissions from Two-Stroke Engine Vehicles.* World Bank.

[25] Available: http://www.dnr.state.wi.us/org/aw/air/

- Straining the heart, because it must work harder to compensate for oxygen loss.

Those with a known history of asthma or chronic lung disease are especially sensitive to these effects. The elderly or those with preexisting heart conditions may also have severe reactions, since the resulting lack of oxygen may strain the heart. The adverse health effects from particulate matter exposure are often not immediately noticed. Particulates can accumulate in the lungs after repeated, long-term exposure causing respiratory distress and other health problems.

Some particles themselves may be poisonous if inhaled or absorbed, and can damage remote organs like the kidneys or liver. Swallowed mucous laden with poisonous particulate matter may also damage the gastrointestinal system. Irritating odors are also associated with particulates. Examples of sources are gasoline and diesel-engine exhausts, among others.

In addition, particulate matter can: (i) corrode metals and masonry; (ii) soil structures and motor vehicles (cleaning of which, e.g., window washing, sand blasting, and repainting, could costs millions of dollars annually); (iii) dust the leaf surfaces of crops, trees and shrubs, which may injure or inhibit the growth of these valuable plants, and (iv) impair visibility and reduce solar radiation (very small particles remain suspended in the air for long periods of time, and also effectively scatter light. The haze caused by these particles can affect crop productivity by reducing solar radiation, as well as adversely affect property values, aesthetics in urban, countryside and wilderness areas, transportation safety; and potentially the weather.

Isolating the effects of different types of particulate matter is difficult because other pollutants, as well as other factors in the environment like changes in temperature or epidemics or infections also affect health. But a series of extensive studies, has tied changes in particulate concentrations to changes in a wide range of health indicators including deaths, changes in lung function, emergency room visits, exacerbation of asthma, hospital admissions, respiratory symptoms, and time off from school or work.[26]

Carbon Monoxide

Carbon Monoxide (CO) is a colorless, odorless, and tasteless gas. It is emitted when there is incomplete combustion. High levels are possible near large parking lots, traffic jams, or crowded streets, where a large number of slow-moving vehicles accumulate. It may temporarily accumulate at harmful levels, especially during cold weather when fuel combustion reaches a peak and carbon monoxide is chemically most stable because of low temperature.

Based on a study made in Wisconsin, carbon monoxide enters the blood stream by combining with hemoglobin, the substance that carries oxygen to the cells. The pollutant adversely impacts health in many ways such as:[27]

- It weakens the heart contractions, lowering the volume of blood distributed to various parts of the body;
- It causes people to feel tired and drowsy from short-term exposure to concentrations greater than 30 parts per million (ppm);
- It causes shortness of breath and chest pain in people with heart disease at exposures as low as 10 ppm; and
- It induces irritability, headaches, rapid breathing, blurred vision, lack of coordination, nausea, dizziness,

[26] Holgate, S. *et al.* 1999. *Air Pollution and Health.* London: Academic Press.
[27] Available at: http://www.dnr.state.wi.us/org/aw/air/

confusion and impaired judgment in healthy people at levels greater than 35 ppm.

Even three or four hours after exposure, half the excess carbon monoxide may remain in the blood stream. The study also revealed that people especially susceptible to CO include:

- Children (and the human fetus);
- The elderly;
- Those with respiratory or heart illnesses;
- Those with anemia;
- Those exposed for long periods of time, especially traffic officers; and
- Cigarette smokers. Smoking while driving in heavy traffic may result in increased exposure from cigarette smoke and engine exhaust. Tests of automobile drivers show exposure to high levels of carbon monoxide can impair a driver's judgment and ability to respond rapidly in traffic. It can also impair vision and produce headaches.

On-the-spot emission tests to a number of tricycles in Quezon City and Puerto Princesa City were conducted in April 2004 and the results are shown in Tables 5 and 6. It is interesting to note that the CO concentrations, for both idle and higher speed (2,000 rpm), of 4-stroke engines have higher values on the average compared with those of 2-stroke engines. Technically, 4-stroke emits lower CO compared to 2-stroke. In this case, however, for a 4-stroke to have high CO emission, drivers probably made inappropriate modifications during repair or maintenance.

The tests also show that CO concentration, regardless of the type of tricycle engines, is higher at higher speed. This indicates that acceleration, both gradual and abrupt, produces more CO pollutants. Nevertheless, it is interesting to note that all the tricycles tested passed the 4% standard set by the Clean Air Act.

Table 5: Comparison of CO Concentrations in Tricycles, Quezon City, April 2004

Type of Engine	Condition	CO, %
2-stroke	Idle	1.97
	2,000 rpm	2.24
4-stroke	Idle	2.19
	2,000 rpm	2.87

Table 6: Comparison of CO Concentrations in Tricycles, Puerto Princesa City, April 2004

Type of Engine	Condition	CO, %
2-stroke	Idle	1.77
	2,000 rpm	2.08
4-stroke	Idle	2.32
	2,000 rpm	2.81

Oxides of Nitrogen

Nitrogen oxides (NO_x) are formed during combustion as nitrogen in the air reacts with oxygen at high temperature and under certain other conditions. Nitric Oxide (NO) and nitrogen dioxide (NO_2) are the two most important. Certain members of this group of pollutants, especially NO_2, are known to be highly toxic to various humans and animals. The Wisconsin study reveals that high levels may be fatal, while lower levels affect the delicate structure of lung tissue. In experimental animals this leads to a lung disease that resembles emphysema in humans. As with ozone, long-term exposure to nitrogen oxides makes animals more susceptible to respiratory infections. Nitrogen dioxide exposure lowers the resistance of animals to such diseases as pneumonia and influenza. Humans exposed to high concentrations suffer lung irritation and potentially lung damage. Increased respiratory disease has been associated with lower level exposures.[28]

[28] Available at: http://www.dnr.state.wi.us/org/aw/air/

The human health effects of exposure to nitrogen oxides, such as nitrogen dioxide (NO_2), are similar to those of ozone. These effects may include:

- Short-term exposure at concentrations greater than 3 parts per million (ppm) can measurably decrease lung function;
- Concentrations less than 3 ppm can irritate lungs;
- Concentrations as low as 0.1ppm cause lung irritation and measurable decreases in lung function in asthmatics; and
- Long-term lower level exposures can destroy lung tissue, leading to emphysema.

Children may also be especially sensitive to the effects of nitrogen oxides.

Oxides of nitrogen also can: (i) seriously injure vegetation at certain concentrations with effects ranging from bleaching or killing plant tissue, causing leaves to fall, and reducing growth rate; (ii) deteriorate fabrics and fade dyes; (iii) corrode metals (due to nitrate salts formed from nitrogen oxides); and (iv) reduce visibility.

Oxides of nitrogen (NO_x), in the presence of sunlight, can also react with hydrocarbons, forming photochemical oxidants (see discussions on ozone). Also, NO_x is a precursor to acidic precipitation, which may affect both terrestrial and aquatic ecosystems.

Ozone

Ozone (O_3) is a colorless gas and forms as a secondary pollutant—i.e., it is not directly emitted but is produced by a reaction involving other substances in the air. Hydrocarbons (volatile organic compounds or VOCs) and nitrogen oxides (NO_x), the ozone *precursors*, chemically react in sunlight to form ozone.

According to the Wisconsin study, ozone is a highly reactive gas that affects the respiratory system by severely irritating the mucous membranes of the nose and the throat. Since 90% of the ozone breathed into the lungs is never exhaled, ozone molecules react with sensitive lung tissue to cause several health consequences. Ozone's effects are more severe in individuals with preexisting respiratory disease. The length and frequency of exposure, as well as the concentration, are significant factors in determining the many effects, which may include the following:[29]

- Increased susceptibility to respiratory infection;
- Impaired lung function and reduced ability to perform physical exercise. Recent studies suggest that healthy exercising individuals exposed to 120 parts per billion (ppb) of ozone for an hour experience significant shortness of breath. Similar decreases are also seen upon a 6-hour exposure to 80 ppb;
- Severe lung swelling and death, due to short-term exposures greater than 300 ppb;
- Increased hospital admissions and emergency room visits for respiratory diseases, which may be associated with exposures to one-hour ozone concentrations greater than 120 ppb; and
- Longer-term exposures to moderate levels of ozone present the possibility of irreversible changes in the lungs, which could lead to premature aging of the lungs and/or chronic respiratory illnesses.

Activity levels (e.g., moderate-heavy exercise) and environmental stress (e.g., humidity and high temperatures) also affect susceptibility. Other factors include:

[29] Available at: http://www.dnr.state.wi.us/org/aw/air/

(i) individual sensitivity; (ii) age (children and young adults appear to be more sensitive than older adults); (iii) smoking status (smokers appear to be less sensitive than nonsmokers); (iv) chronic obstructive pulmonary disease or asthma, which may increase susceptibility to ozone-induced decreases in lung function (decreases in lung function are greater in asthmatics concurrently exposed to ozone and pollen than for either pollutant alone); and (v) possibly additive or synergistic effects when ozone combines with sulfur dioxide, nitrogen oxide, carbon monoxide, sulfuric acid, or other particulate aerosols.

Other at-risk groups include adults who are active outdoors (e.g., outdoor workers), and individuals with preexisting respiratory disease such as asthma and chronic obstructive lung disease.

US researchers announced in February 2002 the first evidence suggesting that ground-level ozone is a "causative factor" in development of childhood asthma. Previously scientists suspected it might aggravate asthma cases. To find out whether ozone pollution, also known as smog, can actually cause asthma, researchers followed children in different age groups living in different cities for up to five years. In high-ozone cities, children who played the most outdoor sports were 3 to 4 times more likely to develop asthma than children who played no sports. Meanwhile, in low-ozone cities, children who played outdoor sports were no more likely to develop asthma than sedentary children, which suggests that the ozone pollution, rather than participation in sports, causes higher asthma rates.[30]

The emission tests conducted in April 2004 indicate that the average HC emission of tricycles both in Quezon City and Puerto Princesa City is below the Clean Air Act standard of 7,800 ppm (Tables 7 and 8). Note, however, that 4-stroke engines are emitting substantially low level of the said pollutant, both in idle and higher speed conditions.

[30] Available at: http://www.ems.org/air_pollution/air_pollution.html

Table 7: Comparison of HC Concentrations in Tricycles, Quezon City, April 2004

Type of Engine	Condition	HC, ppm
2-stroke	Idle	4,316.94
	2,000 rpm	4,576.35
4-stroke	Idle	1,145.82
	2,000 rpm	862.52

Table 8: Comparison of HC Concentrations in Tricycles, Puerto Princesa City, April 2004

Type of Engine	Condition	HC, ppm
2-stroke	Idle	6,606.20
	2,000 rpm	5,341.00
4-stroke	Idle	689.67
	2,000 rpm	386.04

B. Noise Pollution

Tailpipe Noise Level Measurement

The impact of traffic noise from tricycles on the community depends on various factors such as road location and design, land use planning measures, building design, vehicle condition and driver behavior. The World Health Organization (WHO) suggests that noise can affect human health and well-being in a number of ways, including annoyance reaction, sleep disturbance, interference with communication, performance effects, effects on social behavior and hearing loss. Noise can cause annoyance and frustration as a result of interference, interruption and distraction.

Research into the effects of noise on human health indicates a variety of health effects. People experiencing high noise levels differ from those with less noise exposure in terms of: increased number of headaches, greater susceptibility to minor accidents, increased reliance on sedatives and sleeping pills, and increased mental hospital admission rates. Exposure to noise is also associated with a range of possible physical effects including: colds, which is the second most frequent ailment of tricycle drivers according to the

survey; changes in blood pressure; other cardiovascular changes; increased doctor/ hospital visits; problems with the digestive system and general fatigue. Further, there is fairly consistent evidence that prolonged exposure to noise levels at or above 80 decibels (dB) can cause deafness. The amount of deafness depends upon the degree of exposure.[31]

Based on the tailpipe noise level measurement of April 2004, all tricycles tested under running condition are way above the maximum permissible environment noise level for motorcycles of 77 dB set under ECE Regulation 41. Tricycles with 2-stroke engines produce noise levels ranging between 83-87 dB and 90-97 dB (Figures 9 and 10), while that of 4-stroke ranges between 78-86 dB and 82-91 dB (Figures 11 and 12) in Quezon City and Puerto Princesa City, respectively. In terms of engine age, tricycles aging beyond 15 years contribute most to noise pollution.

It is important to note that while the reading of the noise level exceeds the standard, 83% of driver respondents in Quezon City and 79% in Puerto Princesa City signified

Figure 9: Noise Level of 2-Stroke Engines vs. Motorcycle Age, Quezon City, April 2004

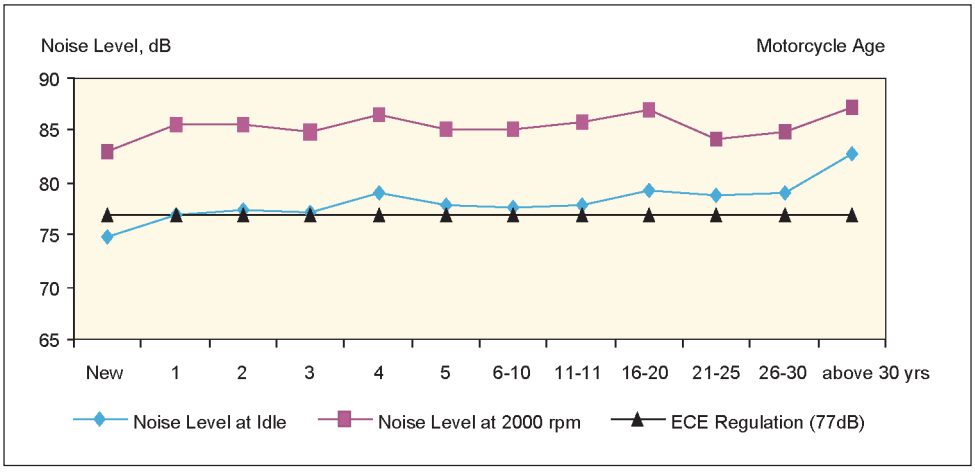
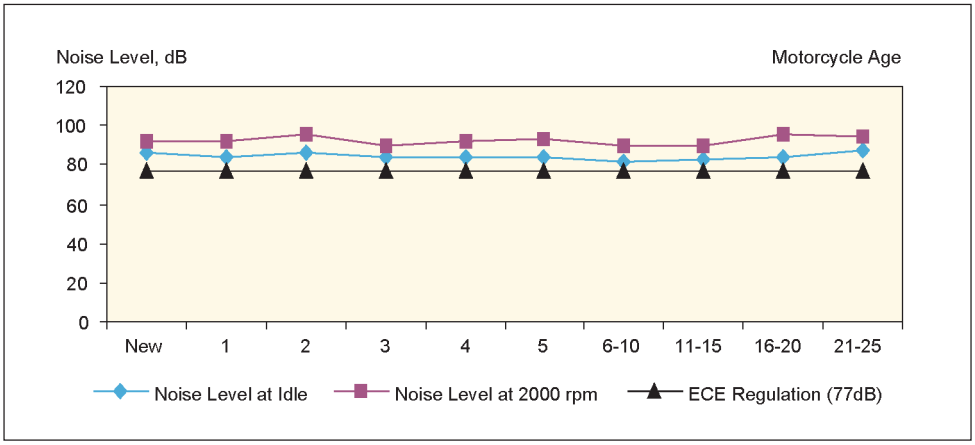


Figure 10: Noise Level of 2-Stroke Tricycle Engines vs. Motorcycle Age, Puerto Princesa City, April 2004



[31] http://www.epa.nsw.gov.au/soe/97/ch1/ch1.htm.Job%201996

Figure 11: Noise Level of 4-Stroke Engines vs. Motorcycle Age, Quezon City, April 2004

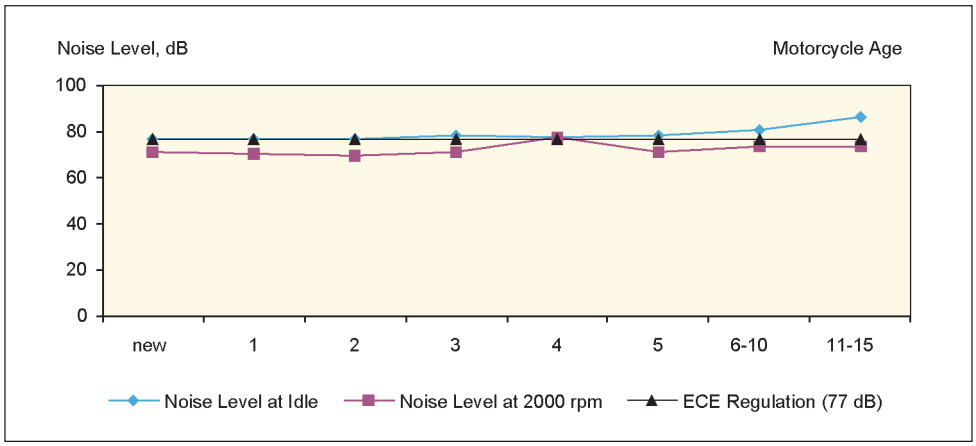
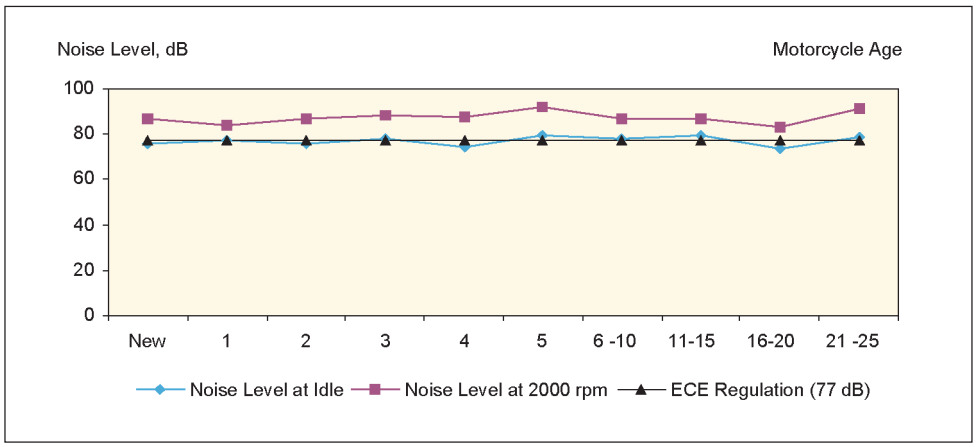


Figure 12: Noise Level of 4-Stroke Engines vs. Motorcycle Age, Puerto Princesa City, April 2004



that they have functional silencers. It is conclusive therefore that even though the silencers are attached in their motorcycles, they are not functional.

Ambient Noise Level Sampling

For roadside conditions, noise levels are measured in areas where majority of transportation is tricycle. In Quezon City, the average noise level is registered at 88 dB while in Puerto Princesa City, it is at 74 dB. The measured levels in both cities are above the local permissible standard of 70 dB (for commercial area[32]).

In Quezon City, District II has the most number of areas registering substantially high noise levels of more than 110 dB due to its gradient terrain. The district also has the most number of tricycles operating in the City. Observations were also made in a residential area (Novaliches) of the said district served by

[32] In general, the *poblacion* is a commercial district. The highest noise limit except light industrial area (75 dB) and heavy industrial area (80 dB) based on standards set by the National Pollution Control Commission (PD 1152 Sect. 5).

more than 5 TODAs and adjacent to several factories, schools, religious establishments and to the central business district. About 70% of the vehicles in the area are tricycles serving students, factory and office workers, of which operation is at peak between 5 PM to 8 PM. It has been measured that noise levels averaged at 80 dB in the morning until early evening (6 AM to 7 PM) and 65 dB in the late evening until dawn (10 PM to 4 AM). Note, however, that the figures are way above the national standards for residential area of 60 dB during daytime and 50 dB during nighttime. It has also been observed that during late evenings, tricycles have tendencies to speed up thus creating loud irritating noise. As for the rest of the City, high noise levels are also observed along commercial areas, factories and schools where there is significant demand for tricycle services.

In Puerto Princesa City, the area with the highest noise level in the city is the Malvar-National Highway Junction (82 dB) wherein 45% of the vehicles are tricycles. Other areas with significant noise levels were along the Rizal Avenue between Malvar and Valencia streets and at Valencia-Rizal Avenue intersection registering 78 dB. The rest of the City is naturally quiet that even local noise level standards of 60 dB can be attained. These places are Manalo-Fernandez intersection (63 dB) and along Abueg Street near the radio station DZRH (60 dB). The lowest noise level in the City is measured at daytime along Abueg Road with 42 dB.[33] The other areas measured were between 77 dB to 67 dB, these areas have corresponding prominence of tricycles as public transportation.

The noise level sampling and measurement results obtained from the two cities are detailed in Appendix 1.

C. Traffic Congestion

Tricycles are the major contributors to traffic congestion. The frequency of tricycles plying the major streets is obviously higher than that of passenger jeeps/ buses and private vehicles combined. Because of their numbers and constraint in speed, they contribute most to road congestion.

In Quezon City, it has been noted that many secondary and tertiary roads leading to residential areas across the city experience traffic congestion during 6:30 AM to 9:00 AM. A slight build-up reoccurs by 11:00 AM lasting until 12:30 PM and then again by 4:30 PM until 8:00 PM. The road condition is not really the problem but the volume of the vehicles, which far exceeds the carrying capacity of the road.

In Puerto Princesa City, daily traffic congestions occur between 7:30 AM to 8:30 AM and 10:00 AM to 12:00 noon. Heavy traffic occurs in four major roads namely: Rizal Avenue (Roxas Street-Junction 1); Malvar Street (Public Market-Caltex Station); Manalo Street (Fernando-Roxas Streets); and National Highway (Junction I-Junction II). Similarly, traffic congestions are experienced in four minor streets of Lancao, H. Mendoza, E. Valencia and Burgos. Note that a significant number of tricycles is operating in these areas than the rest of the City.

D. Accidents

Tricycles are perceived to be more accident prone than four-wheeled vehicles. Among the reasons for this are the instability of the sidecar attached to the motorcycles, which serves as passengers' seat, and the obstruction it brings as its height usually exceeds the driver's line of sight.

The ADB tricycle passenger survey in April 2004 shows that in Quezon City, about 37% of the respondents claim that tricycles are not safe, in which 11% had accidents with a tricycle while in Puerto Princesa City, the

[33] 40 dB is equivalent to bedroom noise without any noise from radio or television.

figures are at 25% and 14%, respectively. Among the types of accidents encountered are colliding either with a fixed structure (wall), a person or another vehicle; tipping over on a ground or drainage; and flat tires. Those who suffered from accidents needed medical attentions with effects ranging from bruises, back pains and broken bones. Some, however, admitted that the accidents were traumatic for them.

Among the major causes of tricycle accidents are: (i) drivers' attitude, (ii) sidecar fabrication, and (iii) tricycle stability. Majority of the respondents said that tricycle drivers are often reckless and negligent of traffic rules, as they are in the habit of competing against each other in transporting as many passengers as possible. Also, the relatively small size of the tricycle, compared with other public transport, makes it easier for the driver to take turns anywhere, where miscalculations result in collisions.

Sidecar fabrication is another concern. The height, length (legroom) and width of the tricycle's body seem insufficient for an average tricycle passenger. Any abrupt movements in the tricycle caused either by the driver's recklessness or potholes along the road could cause physical pains to the passenger. Appendix 2 details the physical specifications of the sidecars in Quezon City and Puerto Princesa City.

Tricycle sidecars in Quezon City are small for the average Filipino as illustrated in Figure 13. The basic dimensions are 1.3 meters in height, 1.0 meter in width and almost 1.6 meters in length. The most distinctive features of the tricycles are:

- Low-rise overall seating;
- Ornamented in and out including a pajero-type[34] bumper;
- Inadequate room for two adult Filipinos;
- Suspension system—bumpy since coil springs are made of scraps or, sometimes no suspension at all; and
- Body number and sidecar body color—to identify service area TODA membership.

Sidecar fabrication in Quezon City is flexible, in which reconfiguration of the total outlook of the tricycles disregards the fact that motorcycles are intended for single riders. Most tricycles carry two passengers inside the cab and another at the seat behind the driver. The designs in Quezon City are beyond ordinary by making the tricycle a sporty transport or a heavy workhorse with such a small engine that is not even close to 500cc.

Shown in Figures 14, 15 and 16 are units with engines not greater than 125cc but are used for public transportation. Designs of tricycles vary due to material (and thus, cost) minimization (Figure 7), capacity optimization (Figure 8), and image or style (Figure 9).[35] Except for the 11-seater tricycle configuration, all other design formats almost have the same suspension system that is basically a scrapped-coil spring welded to a 1-inch reinforcement bar. In the interviews conducted among tricycle drivers, about 40% do not even install used-coil spring to cushion the ride. The bumps therefore are absorbed by the tires and

Figure 13: Proportion of a Filipino to a Quezon City Tricycle

[34] Pajero is a type of 4-wheeler sport utility vehicle (SUV) with customized protruding bumper.

[35] Photos courtesy of UP-NCTS Tricycle Study Team, 2003.

Figure 14
Lean materials—lowered body, cheaper fabrication, gaining popularity.

Figure 15
Heavy tricycle workhorse: 11-seater, modified rear-wheel configuration.

Figure 16
Extreme and sporty—lowered, leathered, folded, stainless and galvanized.

improvised contraption of reinforcement bar. As a result, this gives an unpleasant ride to passengers that could further cause injuries.

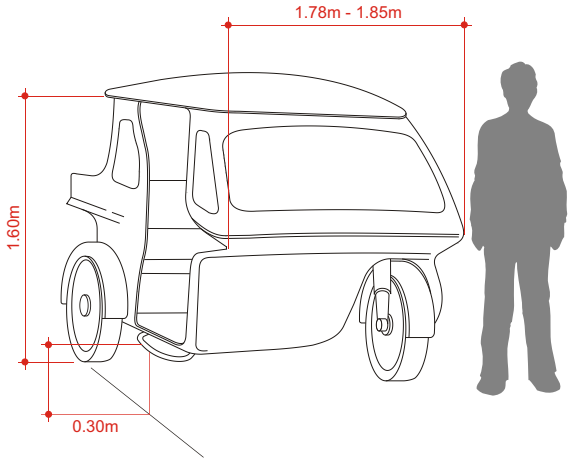
Recognizing the accidents caused by tricycle sidecars, the UP-NCTS conducted a study on the recommended design, height, width and capacity of a sidecar. The study recommends that the sidecar should be based on cost, safety and comfort, aesthetics, durability and environment-friendly. The said study, however, recognizes that resistance in tricycle sidecar modifications can be anticipated because the tricycle users are so accustomed with the present appearance.[36] As shown in Appendix 2, the basic specifications of a tricycle sidecar in Quezon City are compared to the ideal model.

Puerto Princesa City, on the other hand, is basically an agricultural and tourism area, which explains the emphasis of design incorporating the rear cargo compartment. Profile of the design is still reminiscent of the 1950s vintage cars with long trunks. This trunk-like design however, has no purpose but mere ornament. Tricycle sidecars are generally larger than the Metro Manila model. Shown in Figure 17 is an illustration of the proportion of an average Filipino beside a unit. The basic dimensions are 1.6 meters in height, 1.8 meters in width and almost 2 meters in length. The most distinctive features of the tricycles are:

- Windshield—wide and integrated with the driver;
- Integrated roof—resulting in a simpler structure;
- Roomy sidecar—the absence of a dividing panel between the driver and passenger provides sufficient space for passengers;
- Suspension system—parallel link with active moving parts but appears to be scrap material yet functional; and
- No color code—body panels are not colored to denote the line or route or to indicate their membership.

The fabrication of sidecars of the tricycles in Puerto Princesa City is designed to carry more people than the capacity of the engine.

Figure 17: Proportion of Passenger to Tricycle

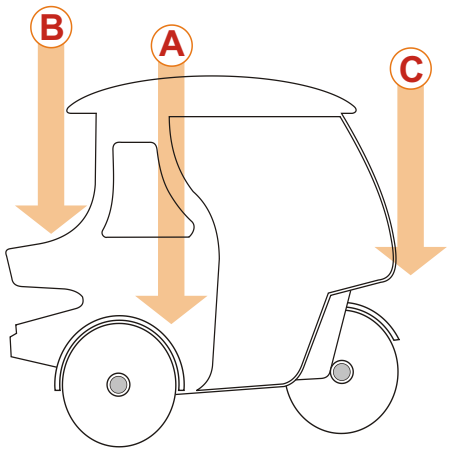


[36] University of the Philippines National Center for Transportation Studies Foundation, Inc. (UPNCTSFI). 2004. *Standards Development for Local Motorcycle/Tricycle Sector: Final Report.* Quezon City.

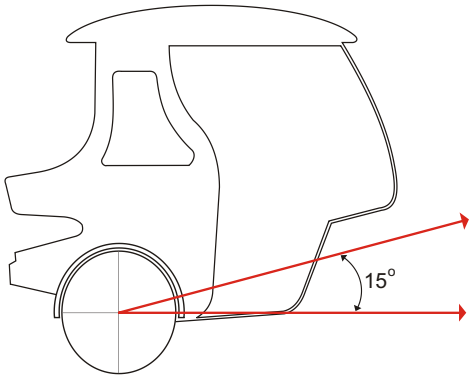
Most tricycles carry people inside the cab or behind the driver. The design in Palawan considered loading even at the front making it flexible for cargo or passenger (Figure 18).

The suspension is working fairly but loading at the front causes tilting, applying pressure and reducing the speed. In order to counter this, the inventor or pioneer mounted the sidecar on an angle to give a rear tilt. This would mean that if a load is applied at the front, the sidecar runs on a flat angle and balance is achieved. However, in the long run the tilt will affect the total ride and comfort while a sudden jerk at high speed may result in overturning.

Figure 18: Loading Design for Sidecars of Tricycles in Puerto Princesa City



Pressure points for the Puerto Princesa tricycle design format



Required angle to provide comfort tilt for passengers should be approx. 15°