7 The Situation for Cyclists in Asmara

7.1 Explanation of the Method of Assessment

An inventory and analysis of the cycling conditions in Asmara has been made based on a Dutch model that is explained below. According to the Dutch design manual ***Sign up for the bike***, cyclists have a number of requirements and wishes regarding bicycle infrastructure. All of these can be placed under one or more of the five main requirements listed and explained in table 7.1 (C.R.O.W., 1994).

Table 7.1 Program of requirements

Requirement	Explanation/Definition
Safety	The cycling infrastructure guarantees the road safety of cyclists and other road users.
Coherence	The cycling infrastructure forms a logical and consistent unit and links with all departure points and destinations of cyclists.
Directness	The cycling infrastructure continually offers the cyclist as direct a route as possible so detours are kept to a minimum.
Comfort	The cycling infrastructure enables a quick and comfortable flow of bicycle traffic.
Attractiveness	The cycling infrastructure is designed and fitted in the surroundings in such a way that cycling is attractive.

The requirements do not follow any particular hierarchy in the Dutch design manual since each requirement forms an integral part of the whole assessment.

It should be noted that these requirements are generally used to analyze planned or existing cycling infrastructure or cycling networks. Since Asmara does not have any formal cycling network and hardly any cycling infrastructure, we have assessed the conditions for cyclists given the current infrastructure of the city.

7.2 Safety

All officials and staff of the city who work with traffic cite the high number of bicycle-related accidents as the main problem regarding cyclists. The Municipality of Asmara has conveyed that the safety requirement is the main reason for seeking help from the Municipality of Lund with planning for cycling. The general public and cyclists also say that safety is the most critical aspect when it comes to cycling in Asmara. Many cyclists feel that the traffic situation is unsafe and the lack of safety is widely considered the main reason why more people do not cycle.

The main requirement of safety can be defined by the following criteria:

- Traffic accidents
- Chance of encounters with motorized vehicles
- Complexity of riding task (C.R.O.W., 1994)

These criteria are studied below.

Traffic accidents

The incidence of traffic accidents is a good way of evaluating the main requirement of safety (C.R.O.W., 1994). Speed of vehicles is closely related to traffic safety and has direct effects on the risk as well as the outcome of traffic accidents. The issue of speed is discussed in chapter 8.

As mentioned in chapter 5, there were only 32.6 light injuries caused by bicycle accidents that were reported per 100,000 inhabitants in Asmara during the year 2001 and the first half of 2002. This number is significantly lower that the corresponding numbers for the cities of Lund and Malmö in Sweden, which were 58 and 118, respectively. See also table 5.1 on page 33.

When it comes to the number of fatalities due to bicycle accidents per 100,000 inhabitants, the number is higher in Asmara than in both of the Swedish cities: 2.4 compared to 0 and 1.2, respectively. Although we only have comparable data for 1.5 years, this piece of information does show that cyclists are vulnerable in Asmara. The fact that this number is higher in Asmara than Lund and Malmö also hints that there are probably many accidents with non-fatal injuries that are not reported to the police. This line of reasoning applies to the number of light injuries in particular.

As to the type of bicycle accidents, the number of accidents involving only one bicycle accounts for 2 % in Asmara for 2001 while the corresponding value is 68 % for Lund and Malmö. It is quite certain that most bicycle-related accidents involve only one bicycle where the cyclist falls off his or her bike. Since there were only three such accidents recorded by the police in Asmara for the year 2001, it is likely that these types of accidents are not as commonly reported in Eritrea as in Sweden. The reasons why hardly anyone reports these accidents probably stem from cultural aspects and have been discussed in chapter 5. The number of this type of accidents is probably many times greater than reported, but without data it is difficult to make any definite conclusions. We can, however, surmise that this is the case.

Unfortunately, we have no statistical data of the previous or current situation regarding location of bicycle accidents. Three bicycle lanes have been built along new roads leading to some of the satellite villages. It will be interesting to see how these newly built bicycle lanes affect the number of accidents there. There are plans to construct more bicycle lanes along the roads to the other villages and this is a good initiative. The speed limit on these roads is 50 km/h. The separation of cyclists from motorized traffic is always recommended where the speed limit exceeds 50 km/h, but should be considered as an alternative already at speeds limits exceeding 30 km/h (C.R.O.W., 1994).

Chance of encounter with motorized vehicles

The chance of encounter or confrontation with motorized vehicles is a criterion used to evaluate the main requirement of safety. In most parts of Asmara where cycling is allowed, cyclists currently share the same space as motorized vehicles. The three bicycle lanes in the outskirts of the city that lead to new areas of development are the exceptions to this situation.

Almost all roads within the city are of a mixed profile. Therefore, it can be said that cyclists are nearly always subjected to encounters or confrontations with motorized traffic in Asmara. This is not necessarily a negative feature. If the speeds are low enough, at most 30 km/h, mixed profiles are often preferred since road users tend to show a greater degree of cooperation and alertness. The traffic situation is adapted to the slowest moving road users and this is positive for everyone's safety. In the case of Asmara, mixed profiles coupled with poor condition of road surfaces may prove a dangerous combination. The behavior of all road users is more unpredictable as they may need to make sharp evasive maneuvers to avoid obstacles in the road.

The standard procedure to decide whether to have a mixed profile or separation on a road depends on ***two*** factors, namely the speed and the Average Annual Daily Traffic. As mentioned in section 6.2, we have not been able to calculate the AADT in Asmara. Therefore, we cannot make any recommendations about the profiles of roads based on the AADT. However, the speed of vehicles can be used to decide where separation is needed.

As mentioned earlier, mixed profiles are the safest solution when motorized vehicles have speed of 30 km/h or less. If the speeds of the motorized vehicles are higher than 30 km/h but lower than 50 km/h, speed-limiting measures can first be considered before the question of a mixed profile is handled. When speeds exceed 50 km/h, cyclists should always be separated from the motorized traffic.

It should be noted that if the number of cyclists increases, their traffic safety situation will most probably improve. The reason for this is that the drivers of motorized vehicles will be more likely to expect cyclists in the traffic environment. The drivers will thus adapt their traffic behavior accordingly and must increase their alertness. In other words, the saying that there is a safety in numbers is true in this case.

Complexity of riding task

The complexity of the task of riding the bicycle is another criteria used to assess the requirement of safety (C.R.O.W., 1994). There are a number of aspects that fall under this criterion. Among these include the following:

- Encounters with motorized traffic
- Condition of the road surface
- Ability to survey obstacles
- Lighting

The different types of road users in Asmara are used to being alert since most of the streets and roads of the city are of a mixed profile. This is especially true for cyclists.

As mentioned earlier in the report, the condition of the road surface is generally not very good in Asmara. There are often potholes and mounds of gravel in the carriageway. These obstacles have adverse effects on safety since all road users can be distracted from the traffic. The poor quality of

the road surface means that cyclists have to make dangerous evasive maneuvers and they can also have difficulties in steering and braking. Flat tires are a common problem for cyclists. Ultimately, the condition of the road surface and the presence of obstacles may cause cyclists to fall off their bicycles. During the rainy season, further problems are caused by masses of water flooding the streets.

The road surface of the newly built bicycle lanes are paved with concrete and are of a high quality. They thus offer smooth riding for cyclists. Hopefully, the new bicycle lanes will prove resistant to the everyday wear and tear of bicycle traffic as well as to weather conditions.

Almost none of the roads in the city have public lighting. This means that safety is compromised for all road users during the night. Cyclists rarely have lights on their bicycles and most cyclists and pedestrians do not use reflectors. A positive feature is that there are plans to have lighting along all newly built bicycle lanes

7.3 Coherence

Since there is no coherent cycling network in Asmara today, we will discuss the main requirement of coherence and explain what needs to be taken into account when making the cycling-structure plan for Asmara. There are a number of criteria that can be used to evaluate the main requirement of coherence. The ones we consider relevant for Asmara are:

- Ease of finding
- Freedom of route choice

These criteria are discussed below.

Ease of finding

Findability is a synonymous term for this criterion. It means the degree of ease that cyclists can find and orientate themselves in the cycling network. Findability can be measured by several parameters such as:

- Completeness/Continuity
- Road signs
- Presence of local area plans
- Readability of street signs

The routes that make up the cycling network should have recognizable and consistent characteristics. If possible, the type and color of the road surface should accentuate the continuity of the routes within the cycling network. In addition, signposting should be clear and strategically located so that cyclists easily can determine which way they should take. Furnishings along the routes should serve as tools of orientation for the cyclists (C.R.O.W., 1994).

Perhaps the most important parameter for Asmara is completeness/continuity. It is desirable that a future cycling-structure plan should consist of routes without breaks. It is therefore vital that all streets and roads are opened to bicycle traffic. Since there is a long tradition of forbidding cycling on the main central streets, this radical change must be carefully studied first.

Today, the only road signs aimed solely at cyclists in Asmara are those which show where cycling is prohibited. We propose the use of positive signs for cycling. Signs showing which way cyclists

can take as well as signs at the start of bicycle lanes are needed. Today, not all road users know the purpose of the bicycle lanes. Figure 7.1 below shows a pedestrian walking on a bicycle lane while talking to a friend.

Figure 7.1 Persons walking on a bicycle lane

We also recommended the use of more road markings. There are already a few cyclist symbols in the three bicycle lanes but it would be good if there could be more. Maps showing the local area plans of the cycling network should be posted at strategic locations. Streets signs should be clear and strategically placed so that cyclists easily can read them.

Freedom of route choice

The criterion of freedom of route choice can be measured by the number of alternative routes with equal lengths. When cycling in the central parts of Asmara today, cyclists are forced to choose alternative routes when they reach roads that are closed to bicycle traffic. This means that the routes that they must take are not the shortest ones. We have seen several cyclists dismount, walk through intersections and mount their bicycles again. They do this to avoid taking longer alternative routes by bicycle. The issue of opening all streets and roads to bicycle traffic becomes critical when discussing the freedom of route choice.

7.4 Directness

The main requirement of directness embraces all factors that influence journey time (C.R.O.W., 1994). The criteria used to define directness which are relevant for this report are:

- Detour distance
- Delay

These two criteria are discussed simultaneously since they are related to each other.

Detour distance and delay

The grid pattern of the street network means that cycling routes cannot be direct. The situation is the same for all road users, but it is more critical for the cyclists since they are also prohibited to cycle on many streets in the central areas of Asmara.

Once again the question of opening all streets to cycling is raised. Having roads where cycling is prohibited means that cyclists must choose alternative routes. These routes are usually detours. Work with the cycling-structure plan should propose the use of signposting and maps. These not only help cyclists to orientate themselves in the cycling network but also aid them in finding a shorter route if there is one. These tools will minimize the detour distance for cyclists.

The condition of the road surface should not force cyclists to slow down. Today the condition of the road surface on many roads is such that cyclists often get flat tires. In addition, cyclists often have to make evasive maneuvers to avoid obstacles in the carriageway. This means that they are delayed in their journeys. Improved road maintenance would minimize such delays.

The delay of cyclists can be minimized by giving them right of way in intersections wherever possible. To reach this goal, a change in the traffic rules and regulations may be needed.

7.5 Comfort

The main requirement of comfort includes all factors dealing with obstructions or delays which forces the cyclist to put in extra physical effort. These obstructions or delays are generally the results of infrastructural problems. The criteria used to define the main requirement of comfort are listed below.

- Smoothness
- Hilliness
- Hindrances of various kinds (C.R.O.W., 1994)

Smoothness

Optimally, the road surface should have a low rolling resistance, and should not cause problems with vibration nor damage to the bicycle (ibid). The three newly built bicycle lanes in the outskirts of Asmara have smooth surfaces and offer cyclists comfortable riding. This is also the case on some of the paved streets and roads in the city. However, as mentioned before, many of the paved roads are in poor shape. See figure 7.2 on the next page. The dirt roads generally do not have a smooth enough surface to give cyclists a comfortable ride. Due to the poor condition of the roads, it is common for cyclists to get a flat tire.

Figure 7.2 Paved road in poor condition

If and when the condition of the roads is improved and more roads are paved, both cyclists and car drivers are likely to increase their speeds. This has an adverse effect on safety and speed-reducing measures may be needed.

Hilliness

Asmara is quite a hilly city with differences in elevation up to 50 meters. The hilliness in combination with a grid pattern means that some streets and roads slope sharply, see figure 7.3 below. This is, of course, adverse to the comfort of cyclists. When making the cycling-structure plan for Asmara, it is important to take hilliness into consideration. The number of inclines for a particular route should be kept at a minimum.

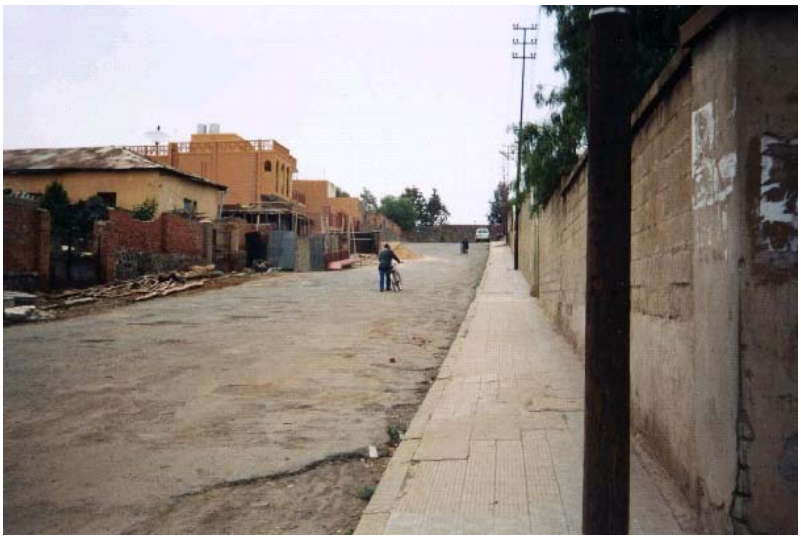

Figure 7.3 Cyclist leading his bicycle up a hill

Hindrances of various kinds

The different types of hindrances include traffic obstacles, forced stops along the journey and weather impediments. As mentioned earlier, there are potholes and heaps of gravel in the carriageways of many roads. Cyclists are forced to make stops in their journeys when they come to roads where cycling is prohibited. Weather impediments due to rain also hinder cyclists. During the rainy season, water floods many roads and forces cyclists to choose alternative routes.

The three bicycle lanes are free from obstacles but there is another problem related with them. In some places, it is difficult to get onto and off some of the cycling lanes since the curb is very high. Of course, there is a valid reason to have curbs 15 cm high. They are needed to keep the rainfall from flooding the sidewalks and bicycle lanes since the drainage system cannot carry off the large amounts of water. However, these high curbs have negative effects on the cyclists' main requirement of comfort. The cyclists are forced to dismount their bicycles in order to use the cycling lanes. This may be one reason why many choose to cycle in the carriageway instead. Biking in the carriageway when there is a bicycle lane has adverse effects on the main requirements of safety, directness and comfort.

This problem is quite easily remedied. One alternative is to make the curbs slope and another is to use low ramps or inclines. Both methods result in that the cyclists experience a continuous slope as they cycle onto or off the bicycle lane.

7.6 Attractiveness

The main requirement of attractiveness is highly subjective and it is therefore very difficult to define. However, this requirement can be evaluated by using the following criteria:

- Visibility
- Social safety
- Experience of surroundings

Visibility

The criterion of visibility includes the extent of the view of the cyclists and the risk that the cyclists are blinded by car headlights. Ideally, the road surface, sidewalk and road markings should always be clearly visible. Public lightning should help cyclists to see the road and other road users in the dark. Partitions on verges such as walls, railing or planting should not decrease the view ahead, especially in curves and at intersections. To prevent cyclists from being blinded by car headlights, cycle routes should be at a correct height and distance from the carriageway for motorized vehicles. Strong public lighting can also help to reduce the risk of being blinded (C.R.O.W., 1994).

Public lighting is not common in Asmara and this has adverse effects on visibility. Cyclists constantly face the risk of being blinded by car headlights. In addition, the cyclists are not easily visible in the dark since they usually do not have lights or reflectors. There are partitions on the verges of some roads but it is difficult to evaluate their effect on the view or the visibility.

It should be noted that lighting is a problem in many areas in Sweden as well. A significant number of bicycle paths do not have lighting. Many cyclists do not have lights on their bicycles although this is obligatory by law. However, car drivers can more easily see the cyclists in Sweden since most bicycles are equipped with reflectors of various kinds.

Social safety

Asmara enjoys a high degree of social safety. The sense of social safety is important to cyclists. This means that cycling facilities should be visible from road sections and that they are not obstructed (C.R.O.W., 1994). Cycle routes should ideally have lighting so that cyclists feel safe. Cycling routes should not be placed in isolated or remote areas of the city where there is little or no social activity.

Experience of surroundings

This criterion embraces the aesthetics of the cycling infrastructure and facilities. It can be summed up with the appreciation of planning (C.R.O.W., 1994). It is very important that the cycling routes are attractive and that they are furnished with lights, plants and so forth. Attractiveness is not viewed uniformly so it is not easy to please everyone. It is essential, however, that the aesthetic aspects are not forgotten when making a cycling-structure plan. Asmara has an array of beautiful qualities that can be incorporated into future cycling routes.

8. Analysis of the Safety Situation for Cyclists in Asmara

8.1 Safety of Cyclists and Speed of Vehicles

There is a strong correlation between vehicle speed and traffic safety. The two points below summarize this correlation:

- The probability of an accident taking place increases with speed.
- The outcome of the accident strongly depends on the collision speed (Scientific Expert Group on the Safety of Vulnerable Road Users, 1998)

The probability of an accident taking place increases with speed

If they drive at very high speeds, car drivers may not have enough time to process information or to react to possible incidents with vulnerable road users (ibid).

Pasanen (1997) has shown the relationship between speed and the distance needed for a vehicle to come to a complete stop after braking. See figure 8.1, in which the reference speed is 40 km/h. If the vehicle speed is 50 km/h, it takes a vehicle ten meters more to come to a stop after braking compared with the reference speed. In addition, the collision speed is much higher.

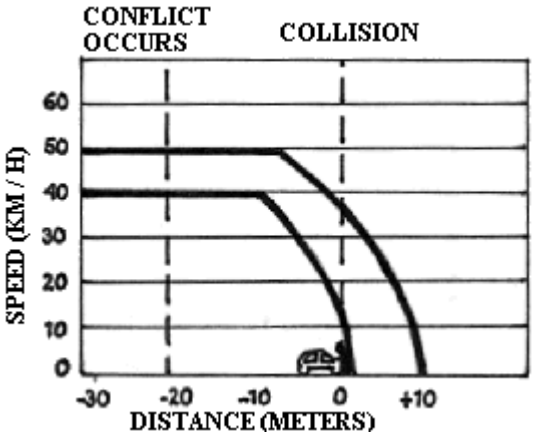

Figure 8.1 The effect of the driving speed on the collision speed (Pasanen, 1997)

Spolander (1999) cites Carlsson (1999) as finding the following: at 30 km/h, a driver can stop his car at half the distance compared to the distance needed when he has a speed of 50 km/h. The collision accidents between cars and pedestrians will be reduced by 50 % if the speeds of the cars are reduced from 50 km/h to 30 km/h.

High speeds or speeds higher than those that can be expected, make the situation particularly difficult for elderly as well as children pedestrians or cyclists. These groups of road users are not skilled at estimating speeds and distances. In addition, they need more time than other road users to decide their next move (Scientific Expert Group on the Safety of Vulnerable Road Users, 1998)

The outcome of the accident strongly depends on the collision speed

With a lower speed, the severity of the accident is lowered. The severity is connected to the kinetic energy that is absorbed by the human body. The kinetic energy is the product of the mass and the speed of the vehicle and will quadruple with the velocity ($E=mv^2/2$). The kinetic energy will quadruple when the speed is doubled. Carlsson (1999), cited by Spolander (1999), found the following: at 30 km/h, the kinetic energy is only one third of the kinetic energy at 50 km/h.

Holmberg, Hydén et al (1996) cite Transportökonomisk institutt in Norway (TÖI, 1989), which has compiled a large number of surveys on the effects of different types of speed-reducing measures. The compilation shows a decrease in both the number and the severity of accidents when the average speed is reduced. See figure 8.2

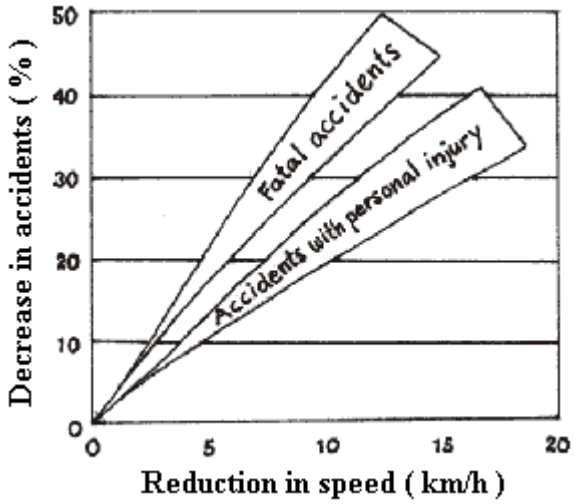

Figure 8.2 The relationship between reduction in speed and decrease in the number of accidents (TÖI, 1989), cited by (Holmberg et al, 1996)

Pasanen (1992) evaluated the correlation of the vehicle speed and the probability of pedestrians being killed in an accident. In Pasanen's study, risk included the probability of pedestrians getting hit by a motor vehicle as well as the probability of being killed. The following factors were of importance: speed of the vehicle, the driver's reaction time in applying the brakes, deceleration and the amount of time that the pedestrian remained on a collision course with the vehicle.

Pasanen (1992) found that the probability of a pedestrian being killed was nearly eight times higher with a speed of 50 km/h compared to a speed of 30 km/h. With a collision speed under 30 km/h, the injuries sustained by pedestrians were often light to moderate. With collision speeds exceeding 60 km/h, pedestrians would most probably die.

The relationship of the speed and the severity of a pedestrian accident is seen in figure 8.3 on the next page (Pasanen, 1997).

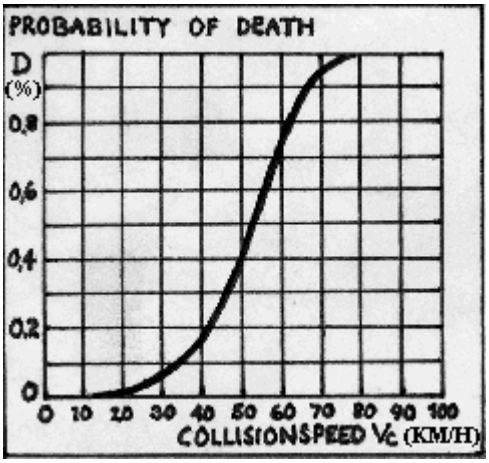

Figure 8.3 The effect of the driving speed on the severity of a pedestrian accident (Pasanen, 1997)

The relationship shown in figure 8.3 can be applied to cyclists as well (Pasanen, 1997). To reduce the number and severity of bicycle accidents, it is very important to keep the speed below 30 km/h where motorized vehicle and cyclists share the same road area. Reducing the speed of motorized vehicles is the most effective way to deal with the accidents involving vulnerable road users.

Speed

The speeds of motorized vehicles affect the safety aspect of cycling. In the central parts of Asmara, the speed limit is 35 km/h. In the semi-central areas, the speed limit is 50 km/h. Outside the city, the speed limit is 60 km/h. Figure 8.4 on page 64 is a map that roughly shows the areas with different speed limits in Asmara.

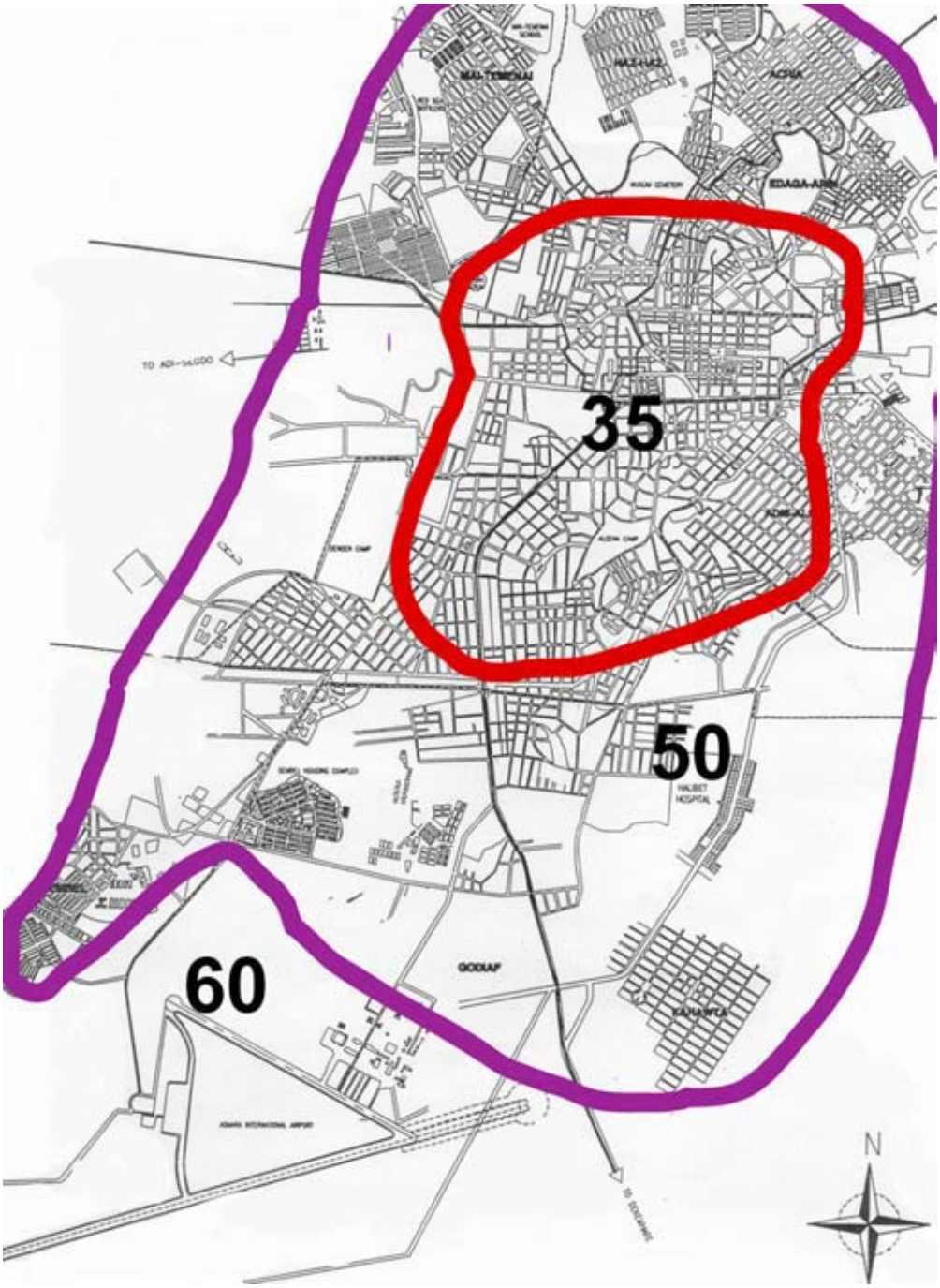

Figure 8.4 A map showing the rough boundaries of the different speed limits (km/h) in Asmara

Figure 8.4 shows that the speed limit of 35 km/h covers a substantial area of Asmara. This is a positive feature. The current speed limits in Asmara are conducive to planning that takes due consideration to the vulnerable road users. Of course, it is the true speeds of the vehicles that are of interest when making an assessment of the traffic safety situation for the road users.

It should be noted that the speed limit in the cities of Lund and Malmö is generally 50 km/h, both in the central and semi-central parts. The speed limit just outside the cities is 70 km/h. The speed limit is 30 km/h on streets in the vicinity of schools as well as on a few selected streets in

the most central parts of the cities. The areas with a speed limit of 30 km/h are currently much smaller in Lund and Malmö than the area with a speed limit of 35 km/h in Asmara.

8.2 Speed measurements in Asmara

The speed measurements were done using a radar gun, see figure 8.5.

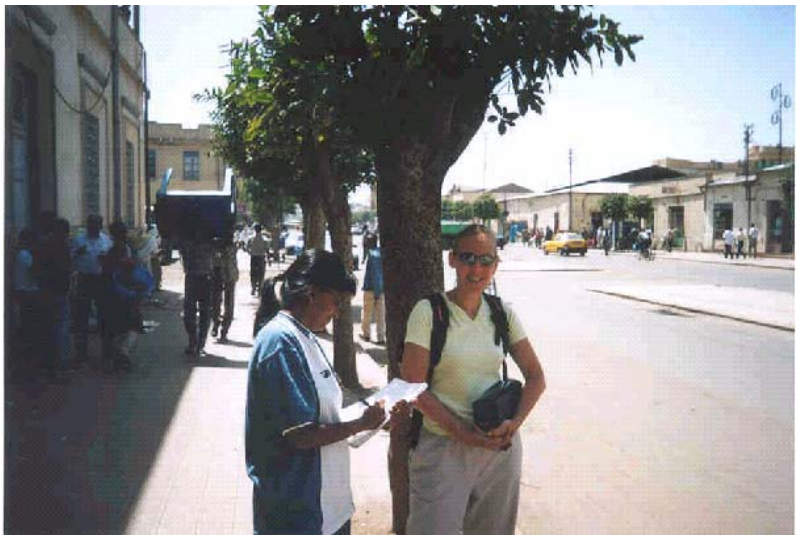

Figure 8.5 Speed measurements in Asmara

Speed measurements should be made for at least fifty vehicles in each direction. It is desirable to make measurements of only free vehicles since accidents seldom take place between vulnerable road users and non-free vehicles (Jonsson, Ekman, 2000). A free vehicle is not in queue behind another vehicle and can thus travel at a speed of its driver's choice. If there is a time interval of at least three seconds between the vehicles in question and the one preceding it, the vehicle is considered to be a free vehicle (ibid).

Speed measurements were made on 13 sections in Asmara, see figure 8.6 on page 66. The form for speed measurements is found in Appendix 3.

On most streets where speed measurements were made, there were many non-free cars. This presented us with a problem since we wanted to measure only free vehicles but weather conditions and safety considerations restricted the length of the time spent on speed measurements for every section to approximately half an hour. We therefore decided to make speed measurements of all vehicles, both free and non-free.

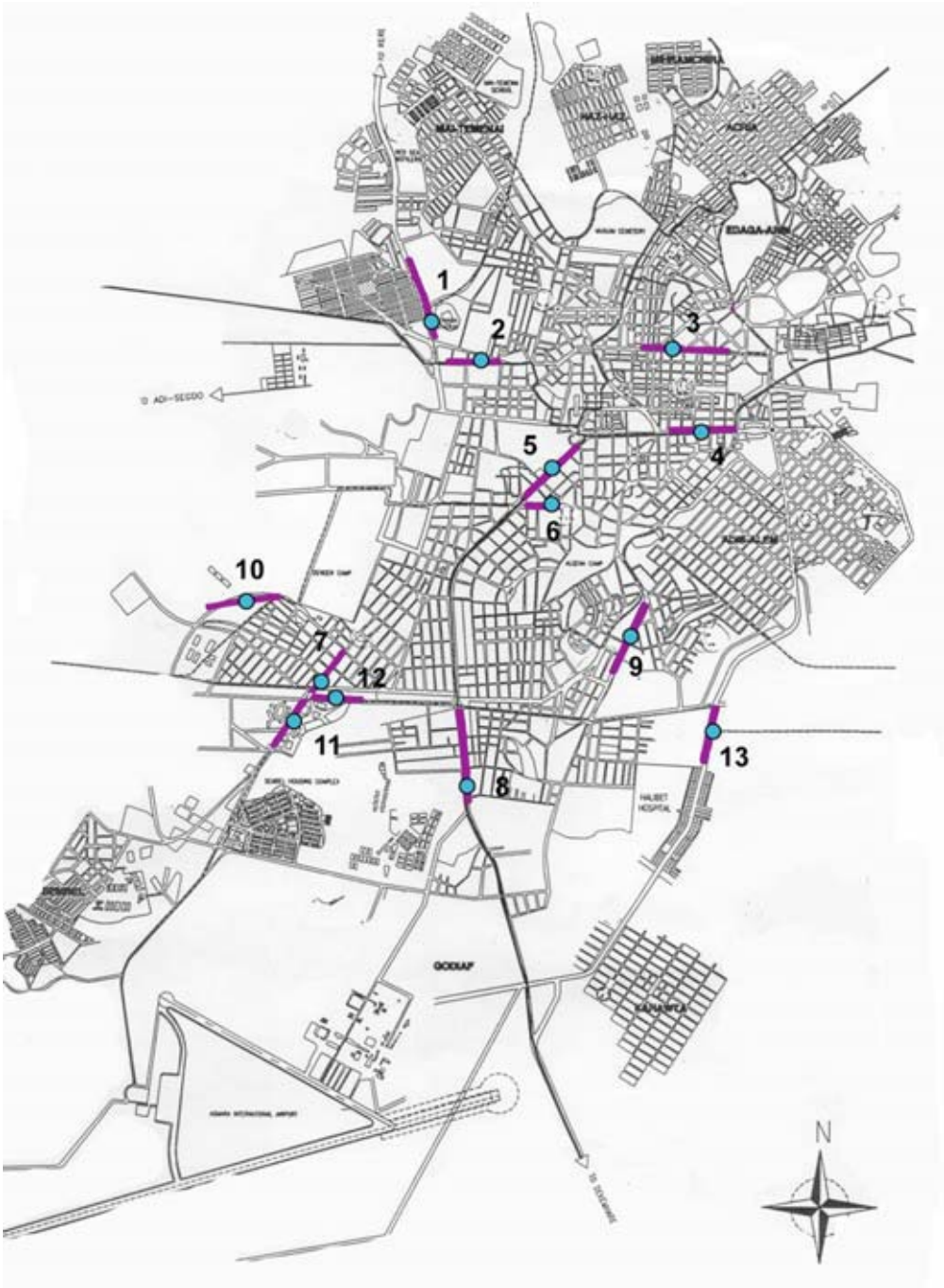

Figure 8.6 Map showing the sections where speed measurements were made

The collected data was then processed in a speed analysis program called Speedboot. This program makes 999 replications from the collected data so that a confidence interval can be estimated. A graph showing the speed distribution is created and the program presents the average speed, the 85-percentile and the percentage of vehicles going faster than the speed limit. The results for both directions of a section were compiled and presented in the program BsGraph. The complete set of these final results can be seen in Appendix 4. The 85-percentile of the speed on the sections is shown in a map in figure 8.7 on the next page.

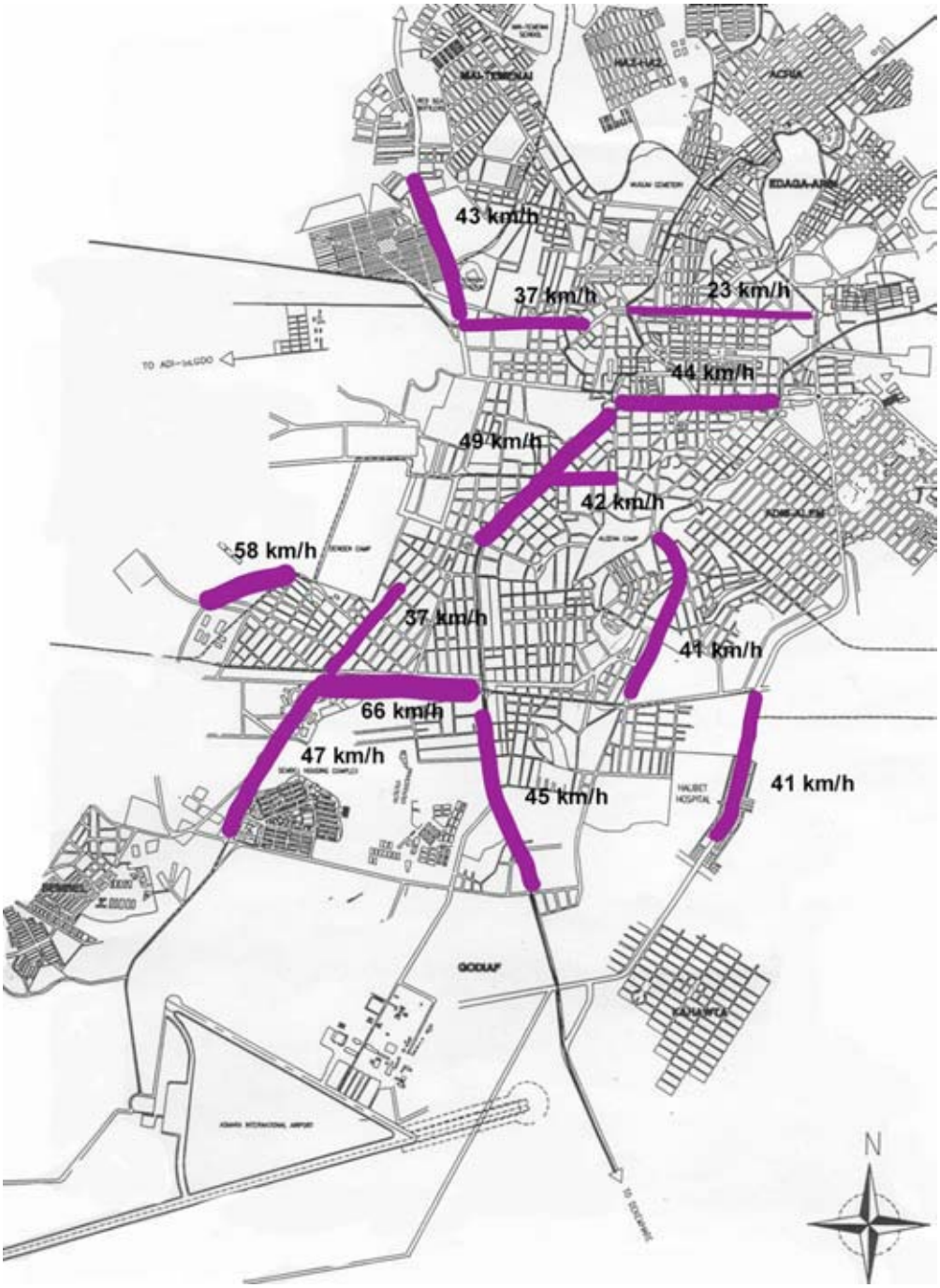

Figure 8.7 85-percentile of speed (average value of the 85-percentiles in both directions)

The measured speeds of the motorized traffic vary depending on the location and type of street or road. Speeding is generally not a big problem in Asmara but speeding does take place on some locations. The high speeds must have adverse effects on the safety for vulnerable road users such as cyclists.

The streets in the center of Asmara have a speed limit of 35 km/h. Nine of thirteen measured sections have this speed limit. See table 8.1 on page 68.

Table 8.1 Speed on sections with a speed limit of 35 km/h

	Average speed (km/h)		85-percentile (km/h)	
1 Road to Keren	n: 33.8	s: 36.9	n: 40.7	s: 45.1
2 Ras Abebe Aregai	e: 32.4	w: 29.4	e: 38.8	w: 35.4
3 Menelik I Street	e: 19.4	w: 18.9	e: 23.7	w: 23.1
4 Independence Avenue	e: 38.5	w: 35.6	e: 46.0	w: 41.2
5 Martyrs Avenue	e: 40.1	w: 43.4	e: 47.2	w: 49.9
6 Emperor Johannes	e: 34.0	w: 34.7	e: 41.4	w: 43.0
7 Andinnet Street	n: 31.2	s: 32.0	n: 37.0	s: 36.6
8 Damtew Avenue	n: 40.5	s: 30.4	n: 51.7	s: 36.5
9 Deg Nesibu Zemanuel	n: 35.9	s: 33.0	n: 42.3	s: 39.3

n=north
s=south
w=west
e=east

On Ras Abebe Aregai Avenue, Independence Avenue, Martyrs Avenue and Damtew Avenue, a majority of the drivers keep speeds over 35 km/h. The worst situations with speeding exist on Martyrs Avenue, where about 80 % drive at a speed over 35 km/h and on Damtew Avenue, where the corresponding percentage is 66% in the northward direction. See figures 8.8 and 8.9 on page 69 showing the results from Speedboot and BsGraph. The fact that there is speeding on these streets can also be seen by the 85-percentile which is 47 and 50 km/ h for Martyrs Avenue and 52 km/h for Damtew Avenue in the northward direction.

On Damtew Avenue, the 85-percentile is 52 km/h in the northward direction while the corresponding value is 37 km/h in the southward direction. This quite large discrepancy may be due to the fact that there was an intersection just south of the location where the speed measurements were made. We were not aware of the fact that there was an intersection so close to where the measurements were made; it was not visible from the location. Unfortunately, there was no time to make new measurements on another location along Damtew Avenue.

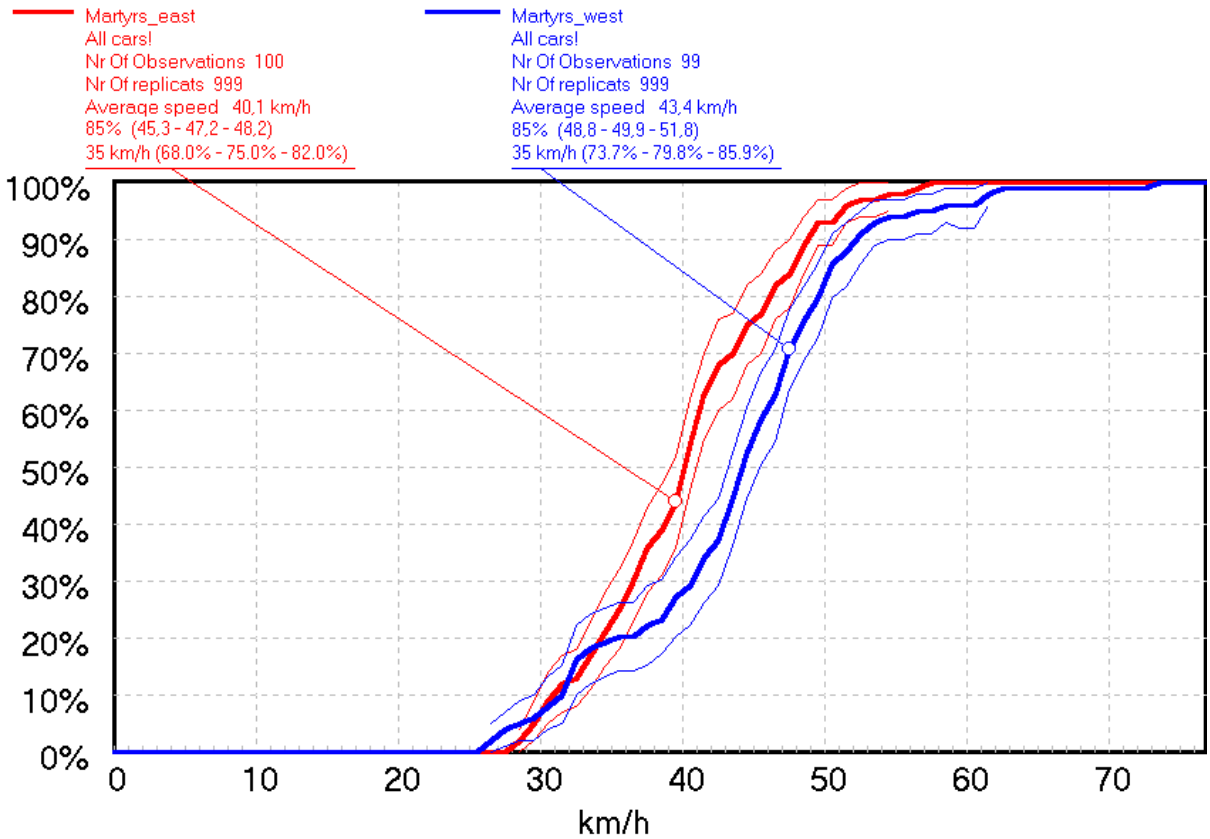

Figure 8.8 Speed distribution at Martyrs Avenue

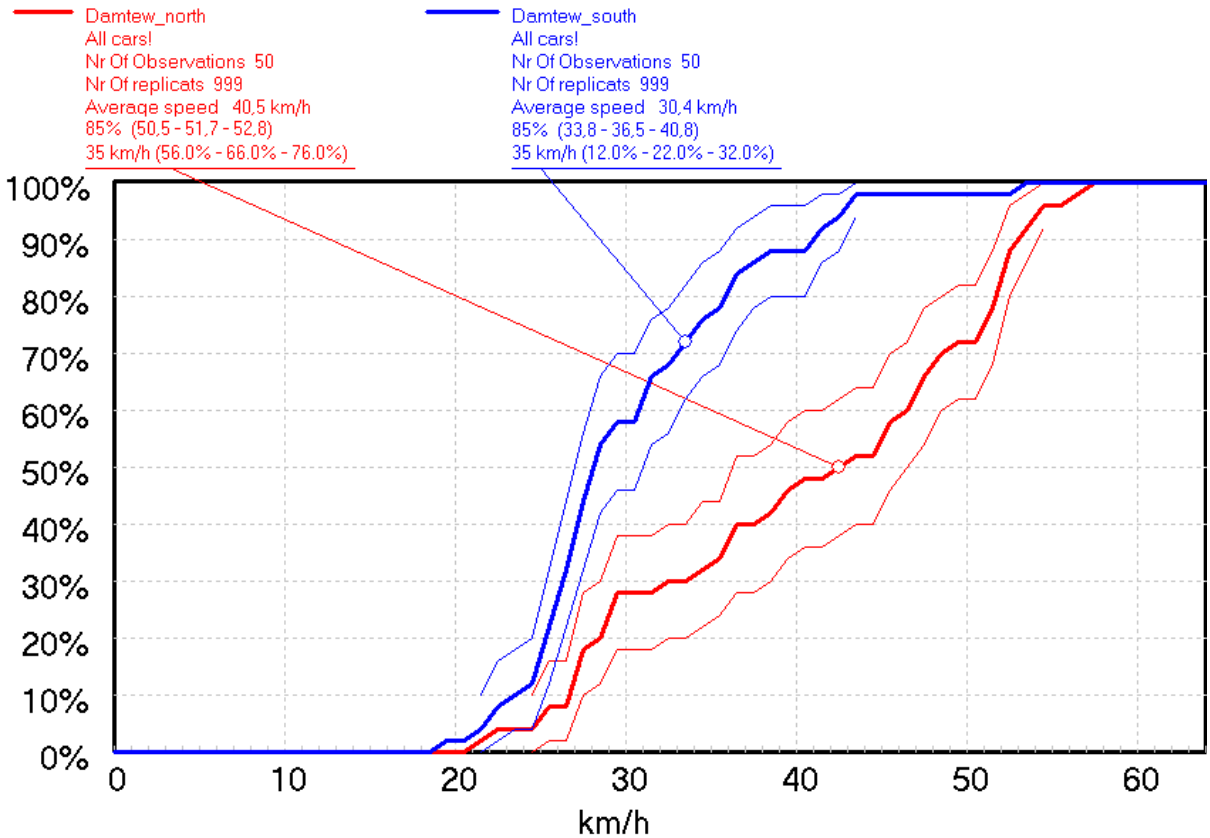

Figure 8.9 Speed distribution at Damtew Avenue

The streets in the semi-central areas have a speed limit of 50 km/h. Four of the sections have this speed limit. See table 8.2 below.

Table 8.2 Speed for sections with a speed limit of 50 km/h

	Average speed (km/h)		85-percentile (km/h)	
10 Road to Kushet	e: 45.8	w: 48.9	e: 56.5	w: 59.5
11 Road to Airport	n: 40.3	s: 40.8	n: 46.0	s: 47.2
12 Edgeth Avenue(east)	e: 49.0	w: 58.4	e: 58.8	w: 72.3
13 Road to Kehauta	n: 30.1	s: 34.3	n: 41.0	s: 40.3

n=north
s=south
w=west
e=east

At the sections Edgeth Avenue (east), Road to Kushet, Road to Kehauta and Road to Airport, the speed limit is 50 km/h. On Edgeth Avenue (east), the 85-percentile is as high as 72 km/h. Figure 8.10 shows that 74% of the drivers in the westward direction are speeding. Speeding is not common on the other three sections.

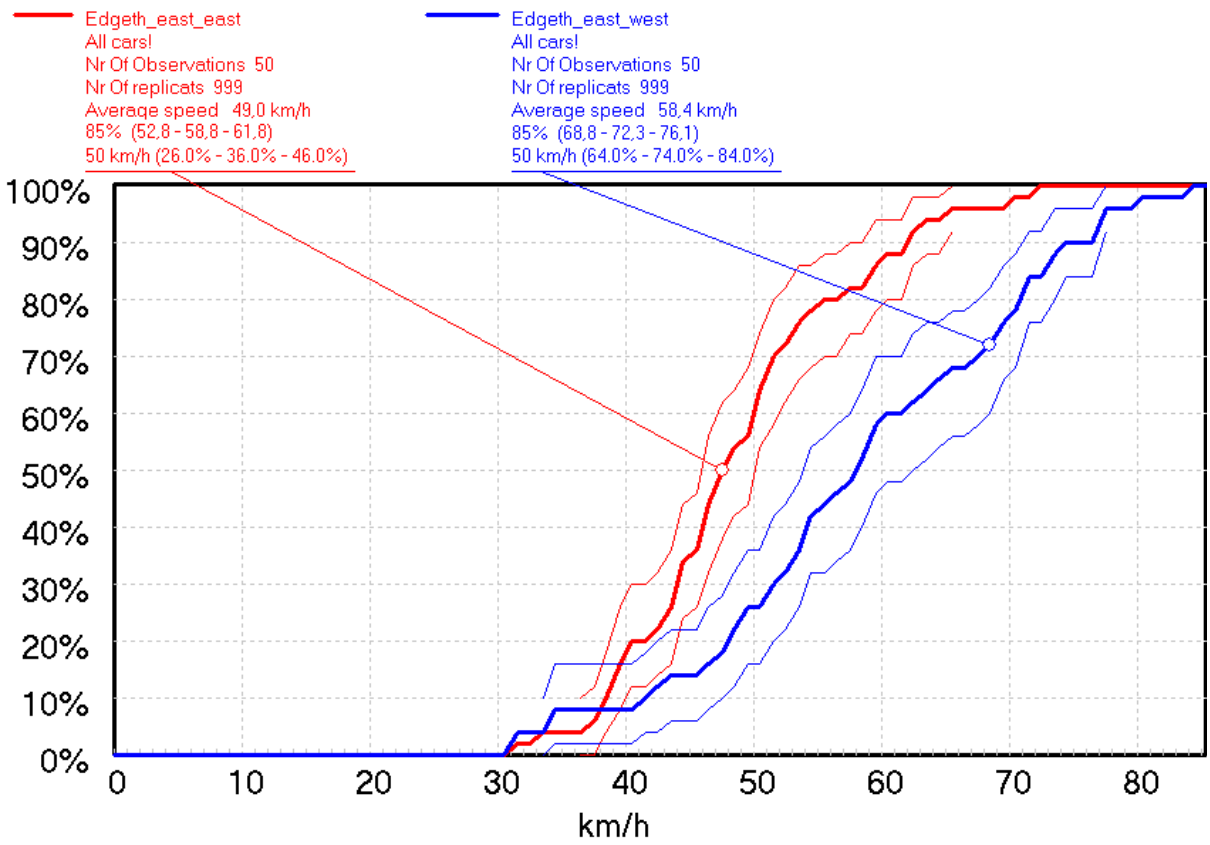

Figure 8.10 Speed distribution at Edgeth Avenue (east of Expo)

The speed measurements on Edgeth Avenue (east) show a discrepancy similar to that found on Damtew Avenue. The 85-percentile in the eastern direction is 59 km/h while it is 72 km/h in the westward direction. In this case, we do not know the possible reasons behind the large difference in the 85-percentiles. Almost all cars on Edgeth Avenue (east) were free vehicles, so the discrepancy cannot be due to the mixing of free and non-free vehicles while making the speed measurements.

Streets in Asmara are generally wide and straight and these features are known to promote high speeds. But in reality, the poor condition of the roads keeps the speed down on many of the roads in the town. Mixed profiles of roads may also be a reason why there is not such a big problem with speeding in Asmara.

Speed measurements have not been made on the roads to the satellite villages located in the outskirts of Asmara. The speed will probably be even higher there.

8.3 Cyclists' Position on the Traffic Scene

Cyclists are generally considered to be a hybrid between pedestrians and motorists. This means that it is not easy for them to know how to act in the traffic environment. They must follow rules for car drivers in certain situations and rules for pedestrians in others (Scientific Expert Group on the Safety of Vulnerable Road Users, 1998). This is the case in many cities and Asmara is no exception.

Some cyclists see themselves as pedestrians with wheels and these types of cyclists increase the risks for accidents. Their behavior may make other road users have less respect for the bicycle as a mode of transport. Many cyclists do not have enough knowledge about traffic rules and behavior; some cyclists even break the traffic rules intentionally. These cyclists prioritize directness and comfort before regulations (ibid). According to traffic police and other authorities in Asmara, the cyclists' general lack of discipline is the main reason why bicycle accidents take place in the city (Negusse, 2002), (Habte, 2002).

One of the main reasons why cyclists do not always follow traffic rules in Asmara may be that traffic planning in the city has, until recently, been geared towards the motorists. In the past, traffic and town planning did not take cyclists into account. Ideally, the needs of cyclists should be considered at the beginning when plans are made for new roads and areas. The local government of Asmara has asked for help in making the town bicycle-friendly and this initiative is certainly promising for the future.

The goal of traffic planning should be that cyclists are given their own place on the traffic scene so that they feel that they are important. They have rights but also obligations to other road users. The bicycle should be treated equally with cars and public transportation in order to work well and develop as a mode of transport (Scientific Expert Group on the Safety of Vulnerable Road Users, 1998).

8.4 Clarity on the Traffic Scene

Clarity on the traffic scene is very important for all road users. Today, none of the road users in Asmara are given a clear signal of how to act. The design of infrastructure is old and very basic. The intersections are large and oftentimes confusing. In addition, the streets are wide and there are very few lane markings and traffic signs.

A street and its environment should be designed to communicate a message to the road users. This message should be clear: there should be no uncertainty when it comes to identifying hazardous situations. Road design should also provide all the necessary information to make decisions easy for all road users. Infrastructure and design of the road environment should promote driver awareness and set expectations of possible presence, movements and behavior of vulnerable road users (Spolander, 1999).

Streets and roads

As mentioned earlier, streets in Asmara are generally wide and straight with a good overview. See figure 8.11 below. Such street design is known to encourage the drivers of motor vehicles to keep a high speed. This in turn has adverse effects on safety, particularly for the vulnerable road users.

Figure 8.11 Wide and straight streets encourages high speed

There are few lane markings and other road markings. There are only a small number of zebra crossings and there are hardly any fields for bicycles that are marked on the streets. The different road users have no specific place marked out in the traffic environment and this makes it more difficult for them to know how to act.

Intersections

The different types of intersections in Asmara are intersections and roundabouts. A striking feature of intersections and roundabouts is that several of them have more than four legs. This does not make the situation for the road users any clearer. The circular islands in the middle of the roundabouts have different sizes; they range from a diameter of one to ten meters.

The intersections are generally large and promote a high speed. There is a high risk of conflicts taking place in intersections. It should therefore be a top priority to keep down the speed of the vehicles in the crossing points.

The clarity in function of some of the intersections is not very high, see figure 8.12. The different kinds of road users have no aid from the physical design on how to act in the intersection. Intersections are a problematic area in traffic and there are many conflicts between the road users. It is therefore very important that the road users are given clear directions on how to act and where their places are. A high clarity in function of the intersection will lead to better interaction between road users.

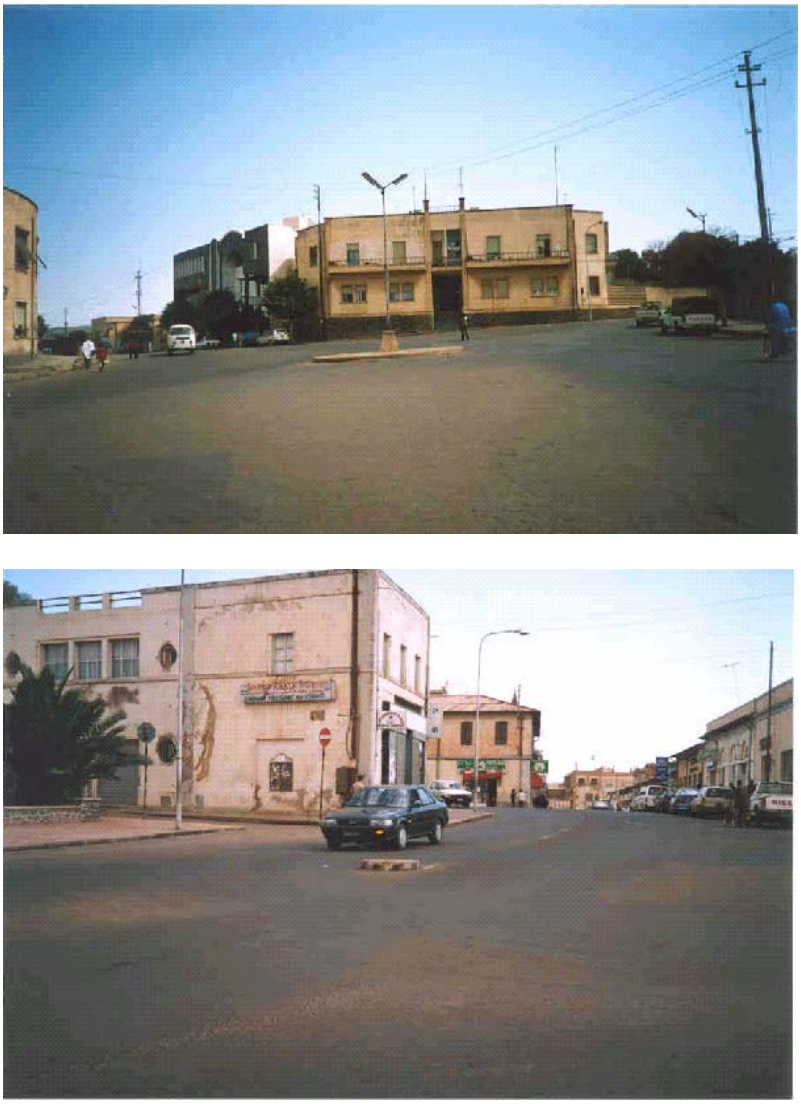

Figure 8.12 Large intersections with lack of clarity

Traffic signs

There is a lack of traffic signs in the traffic environment of Asmara. Especially the cyclists would need more signs to guide them in traffic. Today there are only signs for prohibiting cycling on certain streets. See figure 8.13 below. More signs that encourage instead of prohibit cycling are desirable, positive signs that support the fact that cyclists have a given place on the traffic scene. Generally, there is a need of more signs for all kinds of road users. This will give more clarity and thus road users will get a clearer idea of how they should act in the traffic environment. Of course, traffic signs are only one measure that can be used to increase the clarity in the traffic environment.

In the field of traffic planning, physical design of the road and the environment is the main tool that should be used to guide road users in traffic. If the design of the traffic environment is perfect in its function, a minimum of traffic signs is needed. But since a totally perfect design of the traffic environment is impossible to achieve, a combination of good physical design complemented with the use of traffic signs is a good solution.

Figure 8.13 Sign to the right shows that cycling is prohibited

8.5 Poor Standard of Roads

Statistics from Lund and Gothenburg in Sweden show that 40 - 50% of bicycles accidents involving only one bicycle are related to the condition of the road (Berggren, 1998). As mentioned earlier, there are problems with the condition of the roads in Asmara. This forces the cyclists to have too much attention on the carriageway instead of the traffic.

Since there sometimes are heavy rainfalls in Asmara, especially during summertime, there are problems with rainwater gathering on the streets. The rather large pools of water force the cyclists to dismount their bicycles and to take other routes. A danger is that when maneuvering around a puddle, the cyclist suddenly has to change the direction and other road users may not be prepared for this. Cyclists are also sensitive to breaks in their cycling routes, which makes the cycling less attractive.

Another problem for cyclists as well as pedestrians is caused indirectly by the heavy rainfalls. As mentioned earlier, many of the curbs are as high as 15 cm so that rainwater will not flood the sidewalks and bicycle lanes. According to studies made in Umeå, Sweden, one of the main causes of accidents involving only one bicycle, was high curbs (Berggren, 1998).

Few roads and streets have streetlights and the lack of light makes it dangerous especially for vulnerable road users. To make the situation worse, pedestrians and cyclists are hardly ever equipped with reflectors.

9. Suggestions on How to Improve the Safety Situation for Cyclists in Asmara

9.1 Increase the Status of Cycling

Perhaps the single most important suggestion to improve the safety situation for cyclists in Asmara deals with the idea of the cyclists as road users. There is a need to increase the status of cyclists in order to accentuate that they also have a given place in the traffic environment. They deserve to be considered full-fledged road users with a set of rights and responsibilities. Virtually all of the suggestions that are taken up in this chapter are ultimately geared towards increasing the status of cyclists in Asmara.

As mentioned earlier in the report, we believe that all streets and roads should be opened to cyclists. This factor has positive effects on all the main requirements of cyclists. Allowing cycling in the very heart of Asmara sends the message that cyclists are truly a part of the traffic environment. The status of cycling is thus raised. Prohibiting motorized traffic on some roads would help to improve the main requirements. There is also the possibility of having roads with one way traffic for motorized vehicles while keeping two ways open for other road users. These measures would be a novelty in Asmara, but may very well improve the overall situation for cyclists and other vulnerable road users.

The three newly built cycling lanes show great promise for the future as they cater to the needs of the cyclists. There are some ways to further increase the positive effects of the cycling lanes. They are currently not very clearly marked for cycling. We suggest more frequent use of traffic signs for cycling as well as markings in the cycling lanes to show that this space is reserved for cyclists only. The signs and markings should be used to show the starting point of a cycling lane but should also be used at regular intervals throughout its length. More traffic signs in general are needed to help the different road users to orientate themselves in the traffic and to improve the clarity of the traffic infrastructure.

There are hardly any parking facilities for bicycles in Asmara. Cyclists therefore tend to leave their bicycles wherever they need to stop, such as next to shops, on the sidewalks and so forth. If there were bicycle parking facilities in various places in the city, cyclists would have a given place where they can keep their bicycles while working, studying, running errands or socializing. The flexibility that cyclists are used to must not be compromised. It is therefore important that parking areas or stands for bicycles are placed at key locations in the city. There should also be an adequate amount of parking facilities.

There are several bicycle repair shacks and shops in and around the city. This is good since cyclists are able to service their bicycles easily. In 1997, there were 42 bike repair shops in Asmara and 20 in other parts of the country. From what we have seen, there are certainly many more today. This is a positive trend. Perhaps these repair shacks and shops can be organized in such a fashion that they can become centers for promoting the pedalizing of Eritrea (Gebremehdin, 2002).

9.2 Improve the Situation in the Intersections

Complicated situations arise when different types of road users meet in intersections.
Many of the intersections in Asmara are large and confusing. Traffic rules do not seem to apply. It is difficult for all road users, including cyclists, to know how they should act in the intersections. The situation in the intersections needs to be improved. An important aspect is that there are several intersections and roundabouts in Asmara with more than four legs. The safety situation for road users is compromised in such intersections and roundabouts. A first recommendation is therefore that intersections and roundabouts should have four legs at the most.

Three- and four-legged intersections

As mentioned above, many of the three- and four-legged intersections in Asmara are large and lack clarity. Motorists generally have high speeds when they pass the intersections. We will discuss two important principles that should be considered in intersections in general (Spolander, 1997). These principles can be applied to intersections in Asmara. It is important that ***both*** of these principles are followed in order to achieve the desired effects in safety.

1. Low speeds in intersections

   If an intersection is to be safe, all road users must slow down before they reach it. They should maintain low speeds while passing the intersection as well. This helps motorists and cyclists to detect the presence of one another. This, in turn, means that they can make good decisions on how to act in the intersection.

2. Good visibility in intersections

   All types of road users should have an overview of the traffic situation at hand. This is ultimately a question of good visibility, which is two-fold. Good visibility means that the road users ***should readily be able to see*** each other and it also means that they ***should easily be seen*** by others.

It deserves to be repeated that these two principles must work together. If there is only good visibility in intersections, the speeds may increase. This may aggravate the problem instead of solving it. It is vital to simultaneously bring about low speeds ***and*** good visibility. If this is an impossible task, the only solution is total separation of cyclists from motorists at the point of intersection (Spolander, 1997).

Roundabouts

A comparison was made in the document ***Safety of Vulnerable Road Users*** (Scientific Expert Group on the Safety of Vulnerable Road Users, 1998) between two studies on safety in roundabouts. The document cites one study made in Växjö, Sweden (Hydén, Odelid, Várhelyi, 1995) and another one made in Denmark (Danish Road Administration, 1994).

The study in Växjö concluded that safety was noticeably improved with the use of small roundabouts, especially for the vulnerable road users. The 21 roundabouts in the study had only one circling lane and central islands ranging from four to 18 meters, but only two had diameters of more than ten meters. The improvement was realized through lower speeds as well as better

interaction between road users on the traffic scene. The lower speed enabled vulnerable road users to participate in the traffic environment on more equal terms (Hydén, Odelid, Várhelyi, 1995).

The Danish study on cyclist safety in roundabouts concluded that cyclists do not obtain the same safety effect as motorists in roundabouts (Danish Road Administration, 1994). The information regarding the size of the roundabouts in this study was not clearly stated in the document, but they seemed to be rather large (Scientific Expert Group on the Safety of Vulnerable Road Users, 1998).
The results of the Swedish study in Växjö showed that traffic safety was better for cyclists in smaller roundabouts (Hydén, Odelid, Várhelyi, 1995). This is probably due to the fact that in these roundabouts, there is only one lane; car drivers cannot overtake cyclists. If there is a cyclist in a roundabout, he or she thus determines the speed for everyone in the roundabout. All road users share the circling area; positive interaction and safety are promoted (ibid).

In Asmara, the roundabouts are currently of two main types. The first type has a small central island with a diameter of about one meter with large circling areas. The other type has a large central island with a diameter of 12-15 meters and a large circling area as well. The roads leading into the roundabouts are generally straight. This means that road users are not forced to slow down as they enter the intersection. This design is not conducive to safety for any type of road user, least of all for cyclists. The two studies mentioned above show that the safety situation for cyclists is better in small roundabouts.

9.3 Speed-reducing measures in Asmara

It is recommended that some of the wider streets in Asmara should be redesigned and made narrower to reduce the speed. The straight lines of the streets should be cut up both by physical and visual means. Creating different “traffic rooms” for the car drivers to travel through, will make them more observant of the traffic environment. A combination of reduced width and sight as well as forcing the drivers to make maneuvers sideways are preferable to reduce the temptation for speeding (Spolander, 1999).

Roundabouts are another engineering measure that will reduce the speed. The roundabout forces the driver to make movements sideways, which reduces the speed. Roundabouts are suitable on different kinds of streets and roads. There are several roundabouts in Asmara today but the design is not optimal. It is important that the circular island in the middle of the roundabout has the right proportion so there will be a significant movement sideways. Roundabouts also have the effect of cutting of the streets straight lines and in that way reducing the speed.

Speed humps are another speed-reducing measure. Studies show that speed humps can reduce the speed down to 20 - 25 km/h regardless of what the speed was before (Linderholm, Svedberg, 1992). However, buses and trucks have some difficulties when crossing speed humps. The buses in Asmara are rather old and the suspension may not be of the best quality. The buses are almost always crowded with several passengers standing and the use of speed humps may thus be uncomfortable. Speed humps should therefore be used with care, especially on bus routes. Other vehicles in Asmara that may have problems with speed humps are the animal-drawn carts.

Whether the road engineering measures, such as roundabouts or speed humps will have the same effect in developing countries as in countries where the research is done, is unknown. But they are likely to do so, because they influence physical forces or road user behavior directly (Assum, 1997).

9.4 Separation of cyclists from motorized vehicles

The number of bicycle accidents is almost the same in the intersections whether there are bicycle lanes or not. The number of accidents on the links is much lower where there are bicycle-lanes. (Statens planverk, 1981)

Separated bicycle lanes that are well designed make the cyclists feel safer and thereby they are more likely to cycle faster. This does not lead to any big problems as long as the cyclists are on the links. But in the intersections, the cooperation between cyclists and drivers of motor vehicles is reduced. This can be explained by the following: for natural reasons, the car drivers and the cyclists do not observe one another as well in separated traffic as they do in non-separated traffic.

It is recommended that the cyclists should be led out in the car lane before the intersection, in order to avoid the problems in the intersection. This distance should be 30 meters according to Linderholm (1991), as cited by Rystam (1995). See figure 9.1 below that shows a rough sketch of this solution.

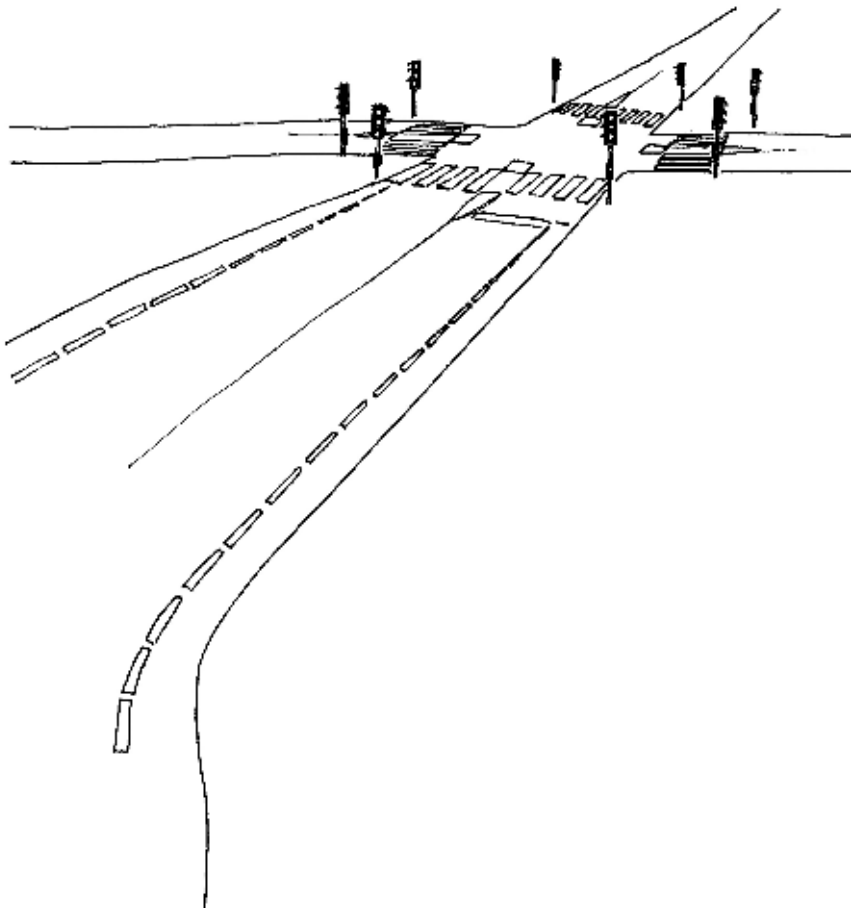

Figure 9.1 Cyclists can be led out in the car lane 30 meters before an intersection

If the speeds are lower than 30 km/h, mixed profiles are often preferred since road users tend to show a greater degree of cooperation. The traffic situation is adapted to the slowest moving road users and this is positive for everyone's safety. If the speeds of the motorized vehicles are higher than 30 km/h, it is generally recommended to separate the bicycle traffic.

Roads that are in need of separation in Asmara are especially the roads with a speed limit of 50 km/h. Edgeth Avenue (west), road to Kushet and road to Kehauta already have separated bicycle

traffic. Road to Airport and Edgeth Avenue (east) on the other hand, have no separation, which is necessary for these roads. Plans for bicycle lanes along Edgeth Avenue (east) already exist.

Also the Road to Keren, Ras Abebe Aregai Avenue by the university and Damtew Avenue are in need of separated bicycle lanes. Whether or not separation is needed on Independence and Martyrs Avenue if they are opened for cycling, is a complicated question. Further studies are needed to make the correct decision.

9.5 Maintenance of Streets and Roads

It is important that the maintenance of streets and roads is given high priority. The poor condition of the pavement of many roads has adverse effects on several aspects of the traffic situation. All road users are affected, but the vulnerable road users such as cyclists and pedestrians are particularly exposed. The cyclists' main requirements of safety, coherence, directness, comfort and attractiveness are all influenced by the condition of the road surface.

Eritrea is a young nation in the process of building and growing. Areas of development include health care, education, housing and infrastructure. There is an incredible growth in all of these areas. We realize that the maintenance of the existing road network may currently not be considered as important as the construction of new roads. We do believe, however, that increased efforts on repairs and maintenance of the older roads would help to improve the situation for all road users.

9.6 Traffic Education and Public Awareness Campaigns

Many of the persons working with traffic feel that the cyclists, above all, lack discipline on the streets. In reality, most of the road users have problems with discipline. To improve the discipline of all the road users, we recommend that traffic rules and safety aspects should be a part of the school curriculum. This subject should be introduced at an early stage in the schooling system. The Municipality of Asmara and the Ministry of Education could join efforts to set up the program for this subject. It is vital to provide basic facts to the youngsters so that they grow up to become responsible road users.

All citizens need to become conscious of how to act in the traffic environment. Traffic awareness campaigns targeted at the general public can help to improve the behavior of all road users. The planning and execution of these campaigns should be worked out by the Department of Infrastructural Services of the Municipality of Asmara, the Traffic Police Department and perhaps also the Ministry of Education.

It is not easy to reach out to all the of road users since they are so diverse in nature. There are different types of road users such as pedestrians, cyclists and motorists. To make matters more difficult, these groups are not homogenous. It is an intricate task to make the campaigns as effective as possible. There must be a few well-defined messages and the language should be clear and simple. It is important to remember that the tone of the campaigns should be instructional but not admonishing. People should be able to relate to what is said.

9.7 Define Goals Regarding Traffic Accidents

As mentioned in section 5.1, statistical data about the traffic accidents is a vital tool when it comes to assessing the traffic safety situation. Ideally, traffic accident data should be collected by both the traffic police and the hospitals so that data from the two sources can be compiled. This

will help to give a more complete picture of the circumstances of the accidents. Based on the accident data, suggestions can be made regarding measures to improve the traffic safety for the road users. Statistical data of traffic accidents also makes it possible to see trends and to make analyses as to the effects of measures taken. If this is to be done, data must be collected annually and compared over a long time period such as 5 or 10 years.

Goals regarding traffic accidents should be defined and these goals can be assessed on the basis of the traffic accident data. The goals can be defined annually in terms of a certain reduction in the number of traffic accidents or injuries.

9.8 Model Routes

The purpose with a model route or a demonstration-bicycle-route is to show how different designs of bicycle facilities affect the safety, trafficability and convenience of the cyclists. Another important goal is to create a bicycle route that is continuous and well planned for the cyclists. It should be noticed that the route is designed with the cyclists' priorities and needs in mind. Preferably, the chosen area or route should include different types of town structures and traffic structures to give the opportunity to show solutions for different environments (Rystam, 1995).

Results from a demonstration-bicycle-route in Gothenburg show that the bicycle accidents were more or less reduced with 50 % after safety measures had been implemented. The reduced number is significant of the 95%-level (ibid).

Discussions with staff at the Municipality of Asmara showed that their view regarding the purpose of a model route included the same factors as mentioned above. Their expectation of a model route is that it will prioritize the cyclists. A model route is a good way to see the different ways of solving specific problems as well as to test new solutions with for instance narrower streets and smaller intersections. The effects of new solutions can be studied and assessed. Another expectation is that a model route will help to develop cycling as a safe means of transportation. In time, all good experiences of this model route will be used in other parts of Asmara to improve the cyclists' situation in traffic.

One must be open to the possibility of unexpected effects. For instance, a wide bicycle lane may lead to such effects such as the parking of cars on the bicycle lane or that people start using the bicycle lanes as a place to sell their products.

To establish a model route, information about the main bicycle flows are important. As seen in figure 9.2 and table 9.1 on pages 83 and 84 respectively, the main bicycle flows occur at Damtew Avenue, Ras Abebe Aregai Avenue, Menelik I Street, Road to Keren, Deg Nesibu Zemanuel Avenue and Road to Adi Segdo.

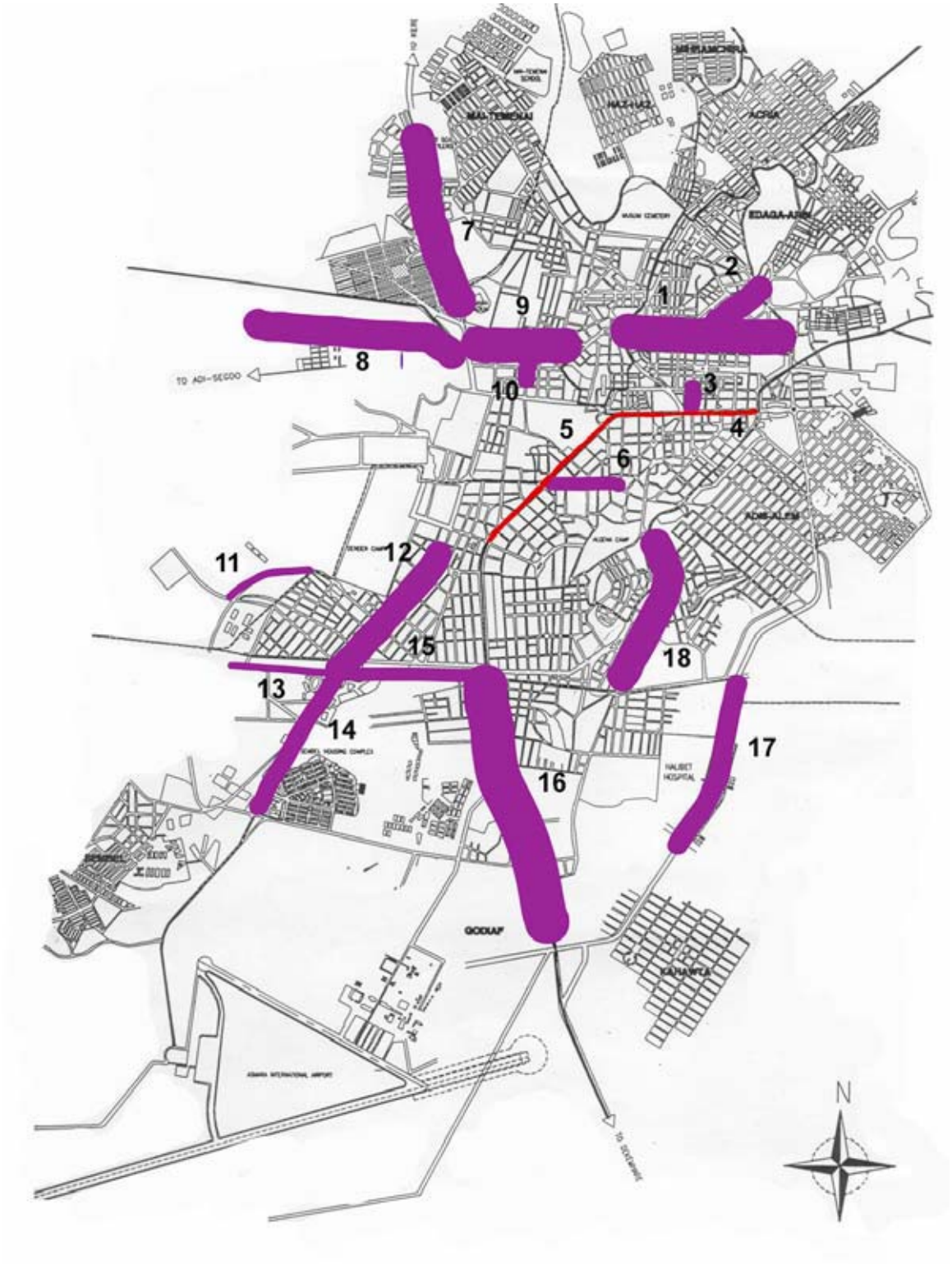

Figure 9.2 Bicycle flows 7:30 - 8:00

Cycling is prohibited on Independence and Martyrs Avenues (sections 4 and 5). The thickest line along section 16 corresponds to 486 bicycles while the thinnest line along section 11 corresponds to 82 bicycles.

Table 9.1 Bicycle flows

	Number of bicycles
	07:30-08:00
1 Menelik I Street	389
2 Dancalia Street	269
3 Kalu Street	165
4 Independence Avenue	0
5 Martyrs Avenue	0
6 Emperor Johannes Avenue	138
7 Road to Keren	368
8 Road to Adi Segdo	320
9 Ras Abebe Aregai Avenue	395
10 Nejo Street	205
11Old Road to Kushet	82
12 Andinnet Street	293
13 Edgeth Avenue (west)	90
14 Road to Airport	202
15 Edgeth Avenue (east)	140
16 Damtew Avenue	486
17 Road to Kehauta	229
18 Deg Nesibu Zemanuel Avenue	338

It should be noted that the zeroes in the table reflect the fact that cycling is prohibited on Independence Avenue and Martyrs Avenue.

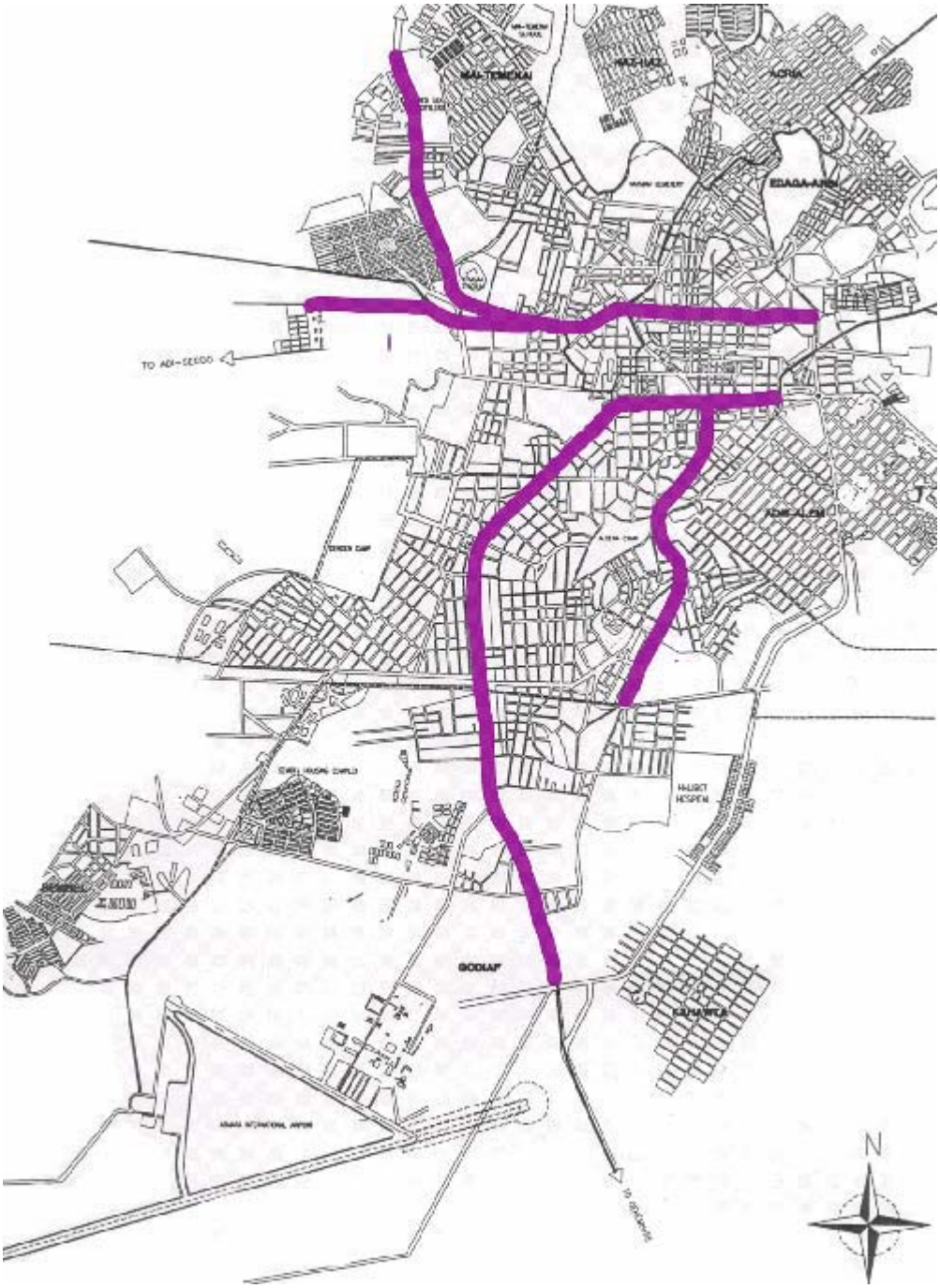

Figure 9.3 Suggestions of model routes for cycling

The suggested model routes in figure 9.3 correspond to the largest flows of bicycle traffic. They stretch over different types of streets and roads and will take cyclists from the outskirts of Asmara into the very center of the city. If these model routes are constructed, they will be able to show different types of bicycle infrastructural designs and solutions. After assessing these, the model routes can lay the groundwork for a safe, coherent, direct, comfortable and attractive cycling network in Asmara.

10 Conclusions and Final Discussion

The two main objectives of this Master's thesis were to make an analysis of the situation for cyclists in Asmara and to make suggestions on how to improve the safety situation for them. Although cycling is a widespread means of transportation in Asmara, the lack of safety is the most common reason why more people do not use the bicycle. To assess the traffic situation in Asmara we needed the following information: structure of the road network, traffic accident data, traffic flows and the speed of vehicles.

Road network

The road network in Asmara follows a grid pattern. About 50 % of the roads in the city are paved. Both paved and unpaved roads are generally in poor condition. Aside from three bicycle lanes there is no specific cycling infrastructure in Asmara. Cycling is not allowed on the two main streets and on some of the streets leading up to them.

Accident data

The accident data has been difficult to analyze since we did not have access to data from more than the past 1.5 years. In addition, the data is compiled in a different manner than traffic accident data in Sweden, so it is also intricate to make comparisons between the two countries. We can, however, make some conclusions:

- The number of fatalities from bicycle accidents per 100,000 inhabitants for 2001 and the first half of 2002 was higher in Asmara than in Lund and Malmö.

- The number of light and severe injuries in Asmara is probably higher than the data shows. Accidents leading up to these injuries are most likely not reported to the police to the same extent as fatal accidents.

- The number of reported accidents involving only one bicycle is remarkably low in Asmara. This is probably due to the same reason as mentioned in the point above.

- The number of reported accidents involving persons under the age of 18 years accounts for 46 % of the bicycle-related accidents. This high value is expected.

Traffic flows

The traffic counts have revealed a number of interesting features:

- The traffic in Asmara does not follow a characteristic pattern with well-defined peak times. It is interesting to see that the traffic is quite evenly distributed during the day and therefore it is not so easy to ascertain peak times.

- The traffic counts have shown that cycling is widespread means of transportation in Asmara. On a few sites, there are more bicycles than motorized vehicles, and it is common that at least 50 % of the total number of vehicles is made up of bicycles.

- At most, counts of 300 - 500 bicycles during half an hour were noted. This is considered a very high figure.

Speed of vehicles

The speed limits of the city are conducive of traffic planning that prioritizes the needs of the vulnerable road users. The areas with a speed limit of 35 km/h in Asmara cover a substantial part of the city. In both Lund and Malmö in Sweden, the limit of 50 km/h is the norm in central and semi-central areas of the cities. The speed limit of 30 km/h is held only in the vicinity of schools and in a few other selected areas in the very centers of the cities.

Of course, it is the true speed of vehicles that is of interest when assessing the traffic situation. The speed is closely related to the traffic safety. Higher speeds mean an increased risk that an accident will occur as well as an increase in the severity of the injuries sustained.

We have made some conclusions about our speed measurements:

- In general, speeding is not a big problem in Asmara.
- There are problems with speeding on the following sections with a speed limit of 35 km/h: Martyrs Avenue, where the 85-percentile is 50 km/ h in the westward direction; Damtew Avenue, with an 85-percentile of 52 km/h in the northward direction.
- On Edgeth Avenue (east), the 85-percentile is as high as 72 km/h in the westward direction. The speed limit here is 50 km/h.
- The speed of vehicles is likely to increase with an improvement in the condition of the streets and roads.

Suggestions on how to improve the safety situation for cyclists

The culmination of our project has been to make suggestions on how to improve the safety situation for cyclists in Asmara. These can be summarized in the following manner:

- Increase the status of cyclists
- Improve the situation in the intersections
- Speed-reducing measures in Asmara
- Separation of cyclists from motorized vehicles
- Maintenance of streets and roads
- Traffic education and public awareness campaigns
- Define goals regarding traffic accidents
- Model Routes

Further work and plans

We chose this particular project for our Master's thesis because the subject matter was interesting and challenging. The challenge lay in the fact that some of the fieldwork we made had never been done in Asmara before. It was rewarding to show that traffic counts and speed measurements can be made with a minimum of equipment and that they are not difficult to plan or carry out.

The Municipality of Asmara can carry out comprehensive traffic counts on more sections over a longer period of time. Another area for further work is to continue to make speed measurements and to include measurements at several types of sections as well as intersections. Assessment of the

traffic counts and the speed measurements should be a natural part of the strategy in making Asmara a bicycle-friendly town.

From the very beginning of the project, we hoped that our findings would be of use for the cyclists in Asmara. We were pleased to find that our fieldwork formed the basis for continued work in making Asmara a bicycle-friendly city. This past autumn, staff of the Municipality of Lund held a workshop about bicycle planning in Asmara. We were very privileged to be asked to participate in this workshop, which took place during two weeks in November 2002. The goal of the workshop was to make suggestions and recommendations regarding three main points:

- Standards and guidelines for cycling infrastructure
- A comprehensive cycling-structure plan for Asmara
- Two model routes and detailed plans on the sections and intersections of these routes.

The results of the workshop are very promising. Final documents dealing with the points mentioned above are being completed by the staff of the Municipality of Lund and will soon be sent to the Department of Infrastructural Services in Asmara (Grip, 2003).

There are now plans to construct a model route in Asmara. This alone will probably not increase the number of cyclists, nor will it change the cycling conditions overnight. However, the creation of a model route is an excellent start and results from this work can be applied elsewhere in the city. Ultimately, a model route can lead to the development of a comprehensive and safe cycling network in Asmara.

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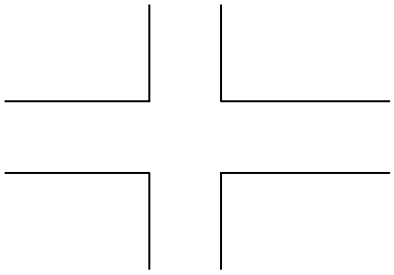
APPENDIX 1

TRAFFIC COUNT FORM

Road name:
Direction of vehicles:
Date:
Time:
Weather conditions:



Simple sketch of road section

Number of cars, motorcycles and mopeds

Number of trucks and buses (Heavy traffic)

Number of bicycles

Number of animal-drawn carts

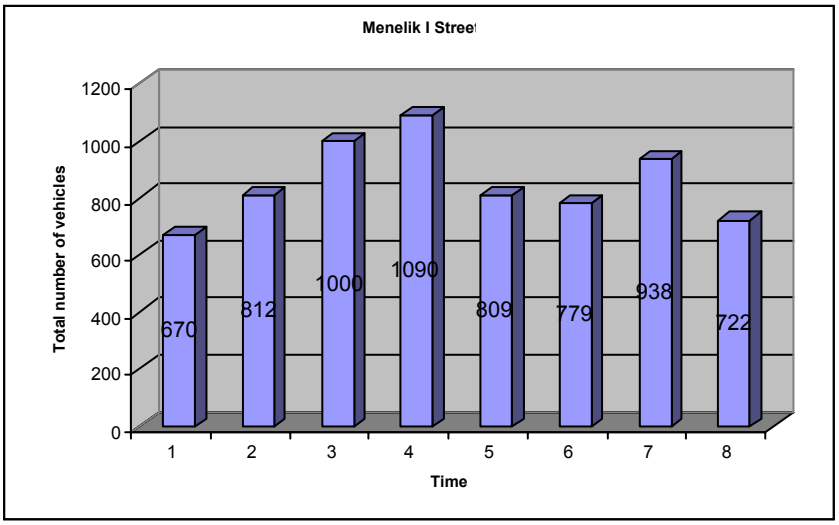
APPENDIX 2

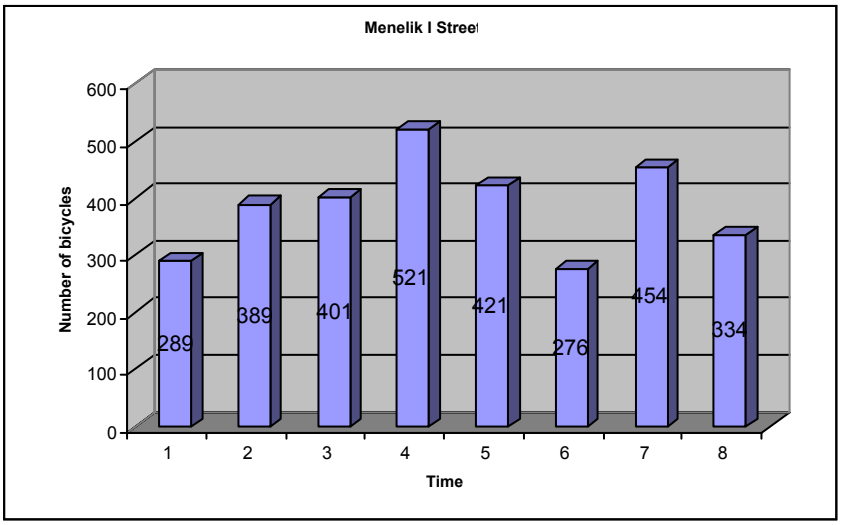
MENELIK I STREET 17/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
6:30-7:00								
eastward	93	64	23	141	35,55556	43,92523	180	321
westward	110	83	8	148	41,29353	42,40688	201	349
total	203	147	31	**289**	38,58268	43,13433	381	**670**
7:30-8:00								
eastward	123	80	17	185	36,36364	45,67901	220	405
westward	123	65	15	204	32,0197	50,12285	203	407
total	246	145	32	**389**	34,27896	47,9064	423	**812**
9:30-10:00								
eastward	229	84	8	205	26,16822	38,97338	321	526
westward	185	82	11	196	29,4964	41,35021	278	474
total	414	166	19	**401**	27,71285	40,1	599	**1000**
12:00-12:30								
eastward	212	65	8	286	22,80702	50,08757	285	571
westward	177	97	10	235	34,15493	45,27938	284	519
total	389	162	18	**521**	28,471	47,79817	569	**1090**
13:30-14:00								
eastward	118	57	9	191	30,97826	50,93333	184	375
westward	124	79	1	230	38,72549	52,99539	204	434
total	242	136	10	**421**	35,05155	52,03956	388	**809**
15:30-16:00								
eastward	186	62	8	148	24,21875	36,63366	256	404
westward	146	88	13	128	35,62753	34,13333	247	375
total	332	150	21	**276**	29,82107	35,43004	503	**779**

APPENDIX 2

MENELIK I STREET 17/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
17:15-17:45								
eastward	156	63	7	219	27,87611	49,21348	226	445
westward	163	87	8	235	33,72093	47,66734	258	493
total	319	150	15	**454**	30,99174	48,40085	484	**938**
18:00-18:30								
eastward	110	35	3	131	23,64865	46,95341	148	279
westward	145	88	7	203	36,66667	45,82393	240	443
total	255	123	10	**334**	31,70103	46,26039	388	**722**

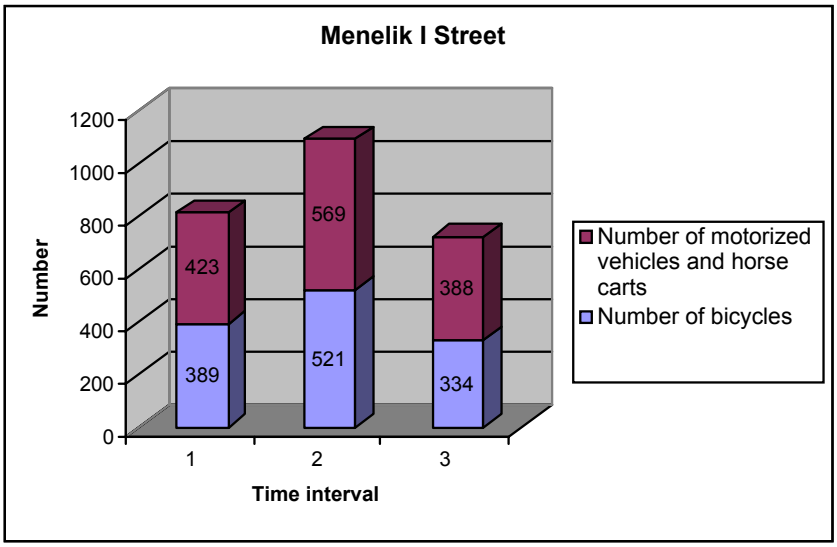
APPENDIX 2





Legend

1	06:30 - 07:00
2	07:30 - 08:00
3	09:30 - 10:00
4	12:00 - 12:30
5	13:30 - 14:00
6	15:30 - 16:00
7	17:15 - 17:45
8	18:00 - 18:30



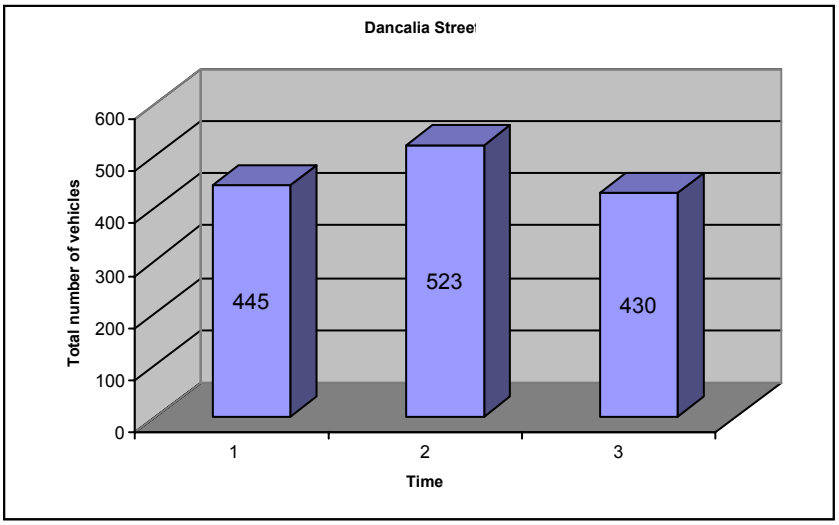
Legend

1	7:30 - 8:00
2	12:00 - 12:30
3	18:00 - 18:30

APPENDIX 2

DANCALIA STREET	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
northward	54	15	1	49	21,42857	41,17647	70	119
southward	88	13	5	220	12,26415	67,48466	106	326
total	142	28	6	**269**	15,90909	60,44944	176	**445**
12:00-12:30								
northward	114	9	2	180	7,2	59,01639	125	305
southward	88	16	3	111	14,95327	50,91743	107	218
total	202	25	5	**291**	10,77586	55,64054	232	**523**
18:00-18:30								
northward	79	15	3	137	15,46392	58,54701	97	234
southward	76	14	2	104	15,21739	53,06122	92	196
total	155	29	5	**241**	15,34392	56,04651	189	**430**

APPENDIX 2



Legend

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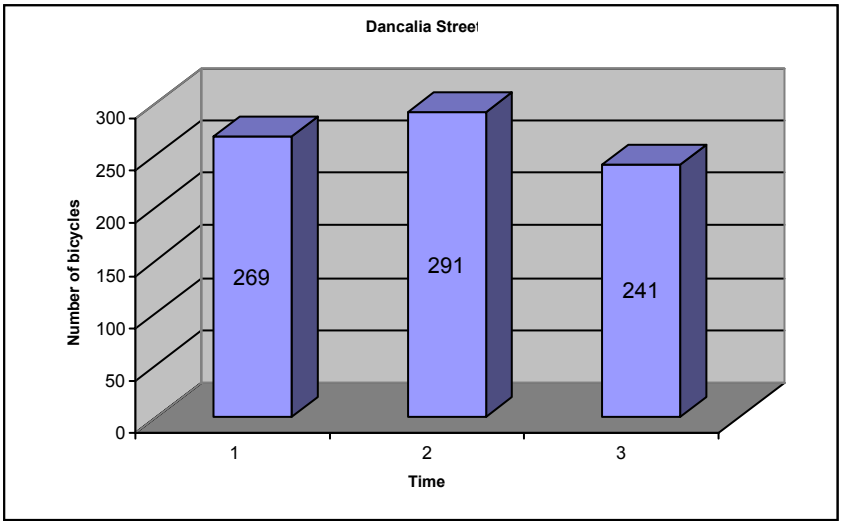
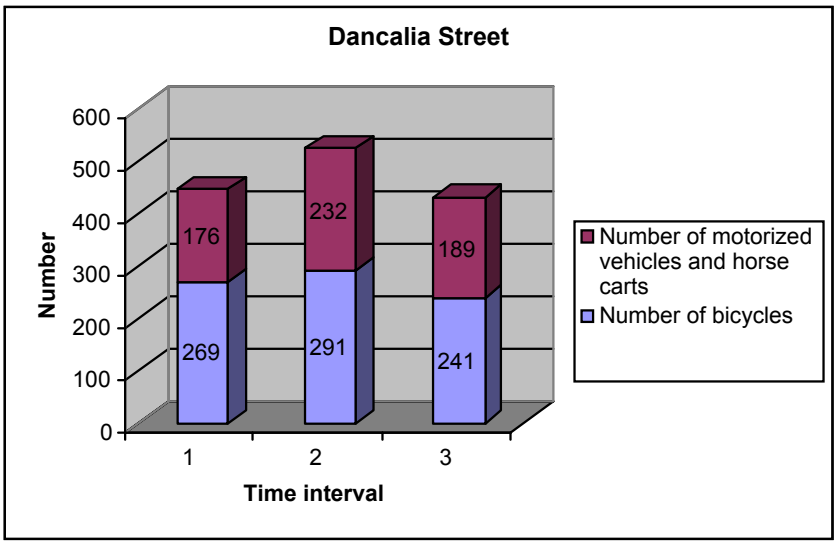
2 12:00 - 12:30
3 18:00 - 18:30





APPENDIX 2

INDEPENDENCE AVENUE 18/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:00-7:30								
eastward	95	34			26,35659		129	129
westward	121	7			5,46875		128	128
total	216	41		0	15,95331		257	**257**
7:30-8:00								
eastward	156	34			17,89474		190	190
westward	141	11			7,236842		152	152
total	297	45		0	13,15789		342	**342**
9:30-10:00								
eastward	215	29			11,88525		244	244
westward	217	8			3,555556		225	225
total	432	37		0	7,889126		469	**469**
12:00-12:30								
eastward	189	35			15,625		224	224
westward	269	11			3,928571		280	280
total	458	46		0	9,126984		504	**504**
13:30-14:00								
eastward	111	25			18,38235		136	136
westward	124	11			8,148148		135	135
total	235	36		0	13,28413		271	**271**
15:30-16:00								
eastward	251	36			12,54355		287	287
westward	221	9			3,913043		230	230
total	472	45		0	8,704062		517	**517**

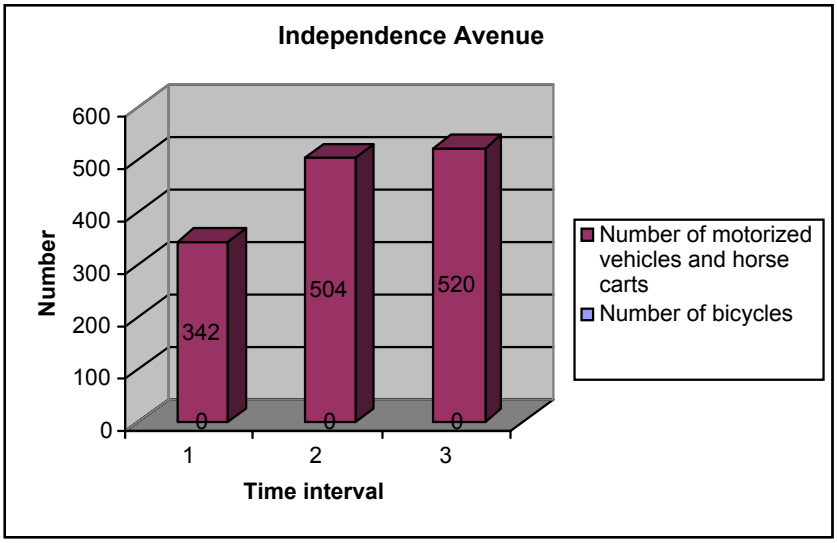
APPENDIX 2

INDEPENDENCE AVENUE 18/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
17:15-17:45								
eastward	237	26			9,885932		263	263
westward	234	6			2,5		240	240
total	471	32		0	6,361829		503	**503**
18:00-18:30								
eastward	242	34			12,31884		276	276
westward	237	7			2,868852		244	244
total	479	41		0	7,884615		520	**520**
19:30-20:00								
eastward	175	34			16,26794		209	209
westward	211	7			3,211009		218	218
total	386	41		0	9,601874		427	**427**
22:00-22:30								
eastward	112	8			6,666667		120	120
westward	131	1			0,757576		132	132
total	243	9		0	3,571429		252	**252**

APPENDIX 2

Legend

1	7:00 - 7:30
2	7:30 - 8:00
3	9:30 - 10:00
4	12:00 - 12:30
5	13:30 - 14:00
6	15:30 - 16:00
7	17:15 - 17:45
8	18:00 - 18:30
9	19:30 - 20:00
10	22:00 - 22:30



Legend

1	7:30 - 8:00
2	12:00 - 12:30
3	18:00 - 18:30

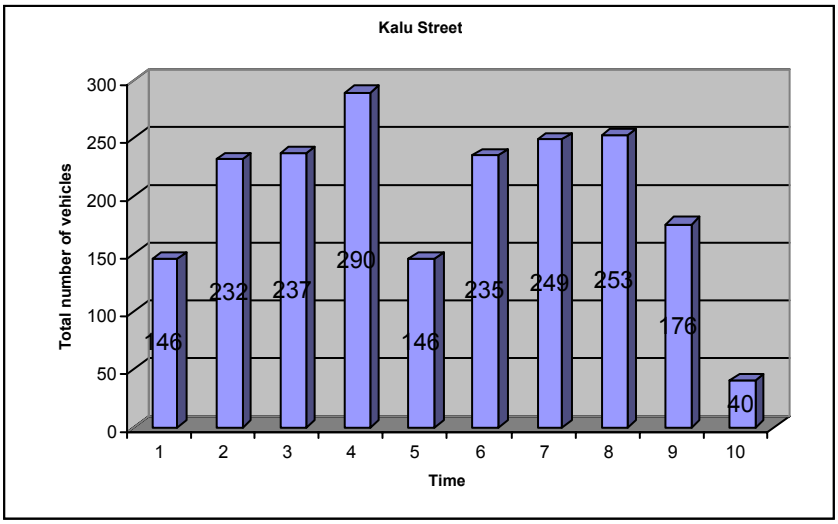
APPENDIX 2

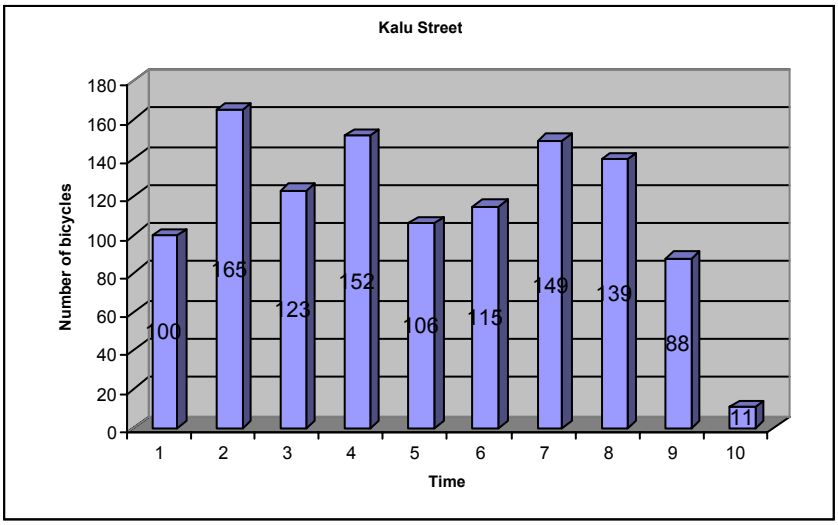
KALU STREET 17/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:00-7:30								
northward	31	1	0	42	3,125	56,75676	32	74
southward	14	0	0	58	0	80,55556	14	72
total	45	1	0	**100**	2,173913	68,49315	46	**146**
7:30-8:00								
northward	47	2	0	64	4,081633	56,63717	49	113
southward	18	0	0	101	0	84,87395	18	119
total	65	2	0	**165**	2,985075	71,12069	67	**232**
9:30-10:00								
northward	57	3	0	65	5	52	60	125
southward	52	2	0	58	3,703704	51,78571	54	112
total	109	5	0	**123**	4,385965	51,89873	114	**237**
12:00-12:30								
northward	75	2	0	93	2,597403	54,70588	77	170
southward	61	0	0	59	0	49,16667	61	120
total	136	2	0	**152**	1,449275	52,41379	138	**290**
13:30-14:00								
northward	20	1	0	38	4,761905	64,40678	21	59
southward	19	0	0	68	0	78,16092	19	87
total	39	1	0	**106**	2,5	72,60274	40	**146**
15:30-16:00								
northward	79	0	0	65	0	45,13889	79	144
southward	40	1	0	50	2,439024	54,94505	41	91
total	119	1	0	**115**	0,833333	48,93617	120	**235**

APPENDIX 2

KALU STREET 17/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
17:15-17:45								
northward	70	0	0	102	0	59,30233	70	172
southward	29	1	0	47	3,333333	61,03896	30	77
total	99	1	0	**149**	1	59,83936	100	**249**
18:00-18:30								
northward	60	2	0	73	3,225806	54,07407	62	135
southward	51	1	0	66	1,923077	55,9322	52	118
total	111	3	0	**139**	2,631579	54,94071	114	**253**
19:30-20:00								
northward	43	0	0	33	0	43,42105	43	76
southward	45	0	0	55	0	55	45	100
total	88	0	0	**88**	0	50	88	**176**
22:00-22:30								
eastward	10	0	0	5	0	33,33333	10	15
westward	19	0	0	6	0	24	19	25
total	29	0	0	**11**	0	27,5	29	**40**

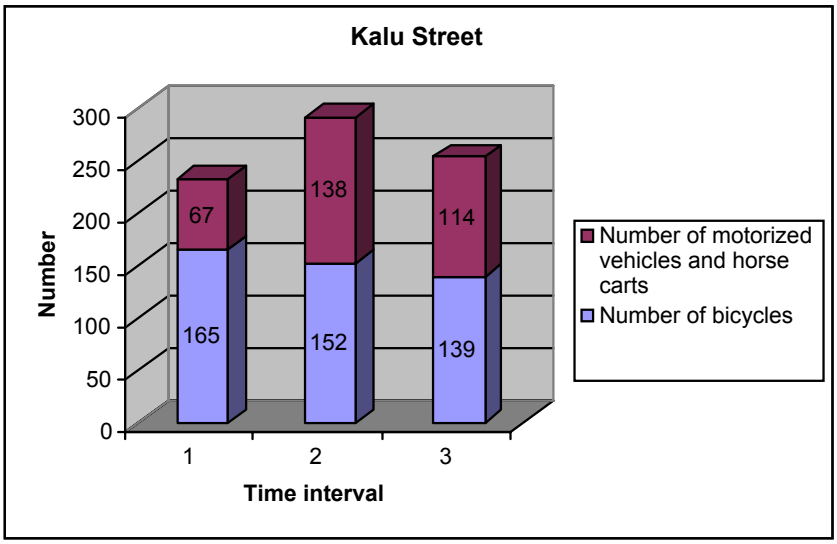
APPENDIX 2





Legend

1	7:00 - 7:30
2	7:30 - 8:00
3	9:30 - 10:00
4	12:00 - 12:30
5	13:30 - 14:00
6	15:30 - 16:00
7	17:15 - 17:45
8	18:00 - 18:30
9	19:30 - 20:00
10	22:00 - 22:30



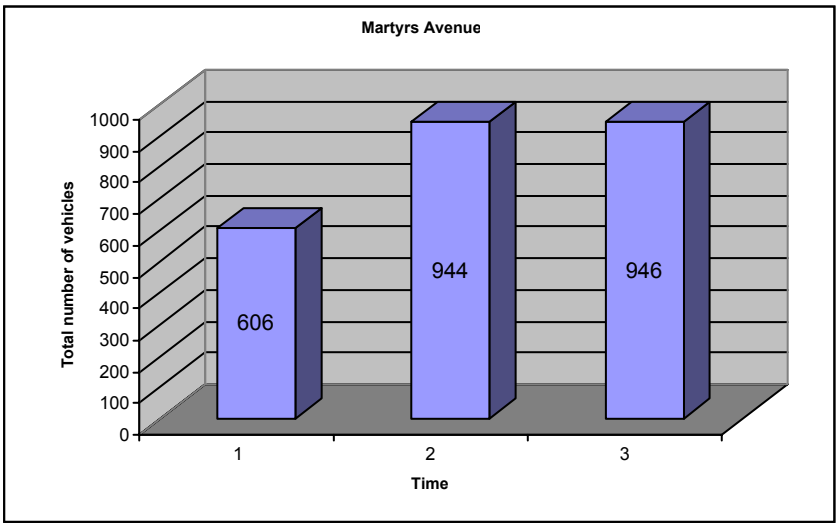
Legend

1	7:30 - 8:00
2	12:00 - 12:30
3	18:00 - 18:30

APPENDIX 2

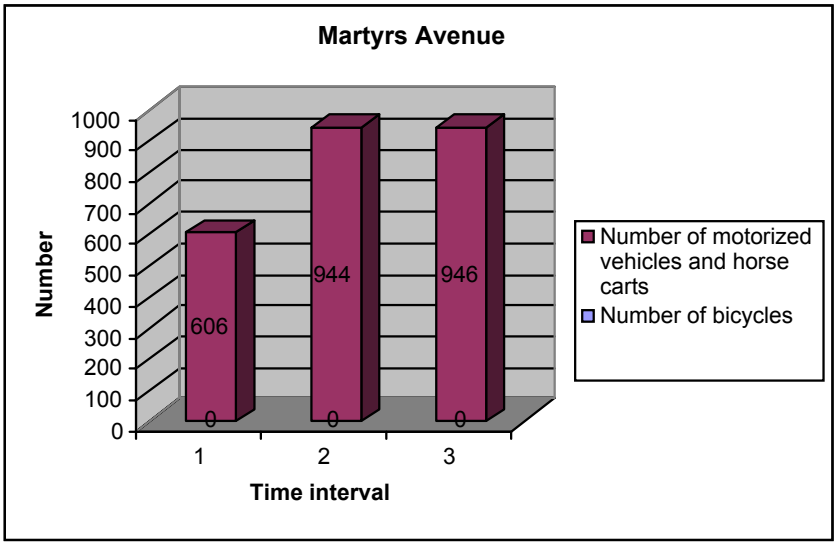
MARTYRS AVENUE 22/7	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
eastward	327	32	0	0	8,913649	0	359	359
westward	223	24	0	0	9,716599	0	247	247
total	550	56	0	**0**	9,240924	0	606	**606**
12:00-12:30								
eastward	370	51	0	0	12,11401	0	421	421
westward	495	28	0	0	5,353728	0	523	523
total	865	79	0	**0**	8,368644	0	944	**944**
18:00-18:30								
eastward	458	48	0	0	9,486166	0	506	506
westward	416	24	0	0	5,454545	0	440	440
total	874	72	0	**0**	7,610994	0	946	**946**

APPENDIX 2



Legend

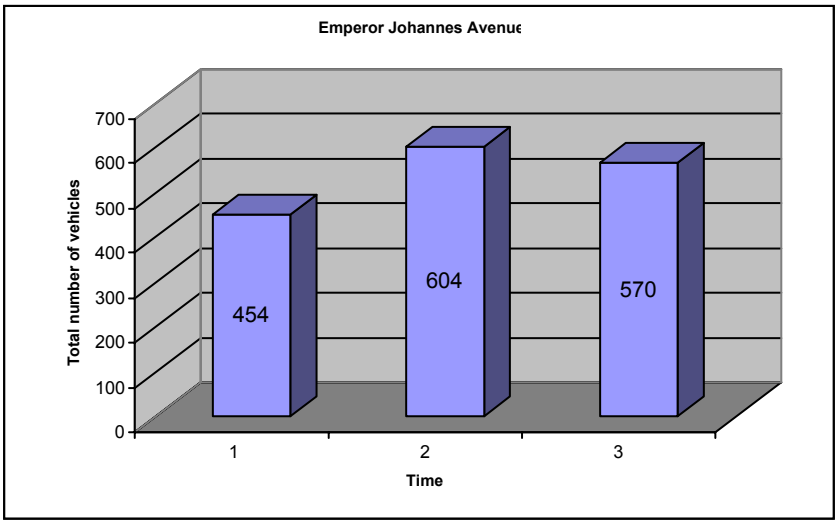
1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30



APPENDIX 2

EMPEROR JOHANNES AVENUE 22/7	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
eastward	155	9	0	68	5,487805	29,31034	164	232
westward	141	9	2	70	5,921053	31,53153	152	222
total	296	18	2	**138**	5,696203	30,39648	316	**454**
12:00-12:30								
eastward	173	17	0	46	8,947368	19,49153	190	236
westward	289	5	0	74	1,70068	20,1087	294	368
total	462	22	0	**120**	4,545455	19,86755	484	**604**
18:00-18:30								
eastward	173	6	0	58	3,351955	24,47257	179	237
westward	274	4	0	55	1,438849	16,51652	278	333
total	447	10	0	**113**	2,188184	19,82456	457	**570**

APPENDIX 2



Legend

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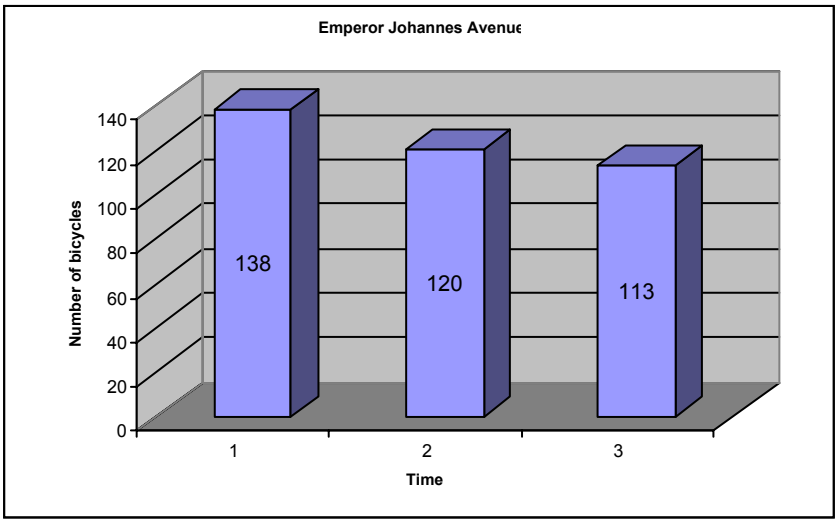
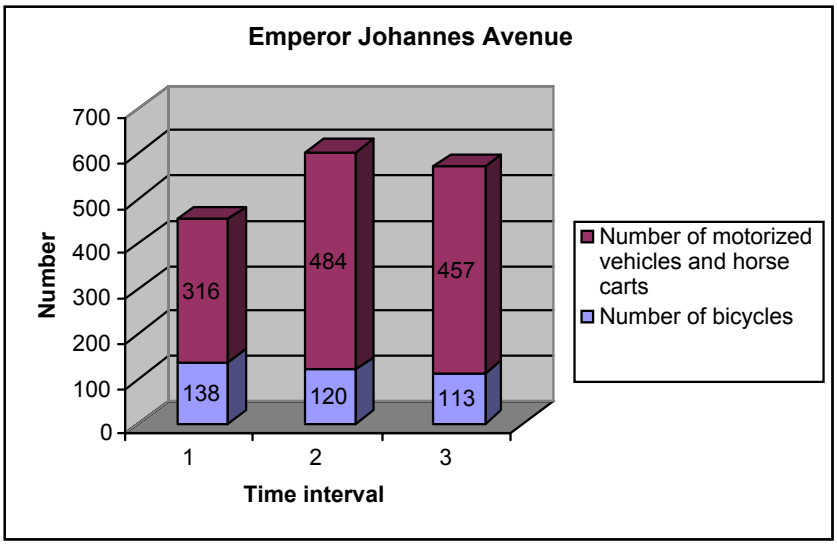
2 12:00 - 12:30
3 18:00 - 18:30





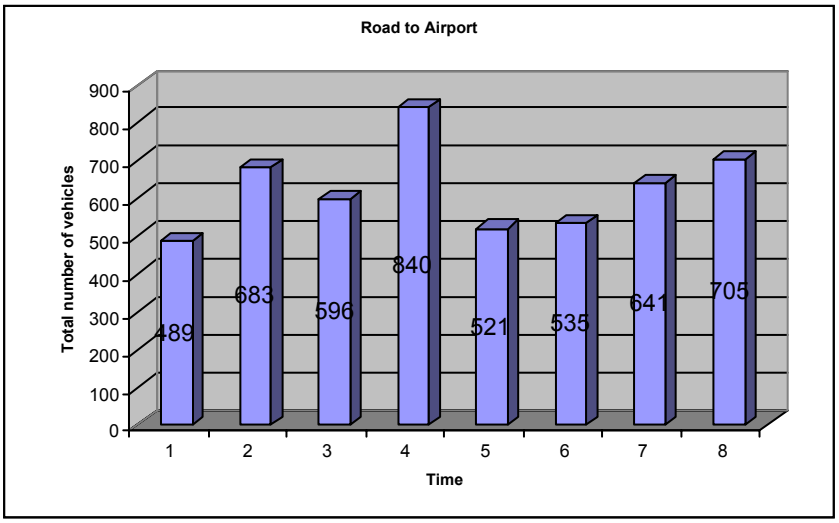
APPENDIX 2

AIRPORT ROAD	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:00-7:30								
northward	146	32	3	114	17,67956	38,64407	181	295
southward	96	30	0	68	23,80952	35,05155	126	194
total	242	62	3	**182**	20,19544	37,21881	307	**489**
7:30-8:00								
northward	205	36	2	121	14,81481	33,24176	243	364
southward	200	38	0	81	15,96639	25,39185	238	319
total	405	74	2	**202**	15,38462	29,5754	481	**683**
9:30-10:00								
northward	220	29	0	47	11,64659	15,87838	249	296
southward	227	25	1	47	9,881423	15,66667	253	300
total	447	54	1	**94**	10,75697	15,77181	502	**596**
12:00-12:30								
northward	293	29	2	101	8,950617	23,76471	324	425
southward	326	41	0	48	11,17166	11,56627	367	415
total	619	70	2	**149**	10,13025	17,7381	691	**840**
13:30-14:00								
northward	185	31	0	48	14,35185	18,18182	216	264
southward	182	33	0	42	15,34884	16,34241	215	257
total	367	64	0	**90**	14,84919	17,27447	431	**521**
15:30-16:00								
northward	192	35	0	38	15,4185	14,33962	227	265
southward	201	28	2	39	12,12121	14,44444	231	270
total	393	63	2	**77**	13,75546	14,39252	458	**535**

APPENDIX 2

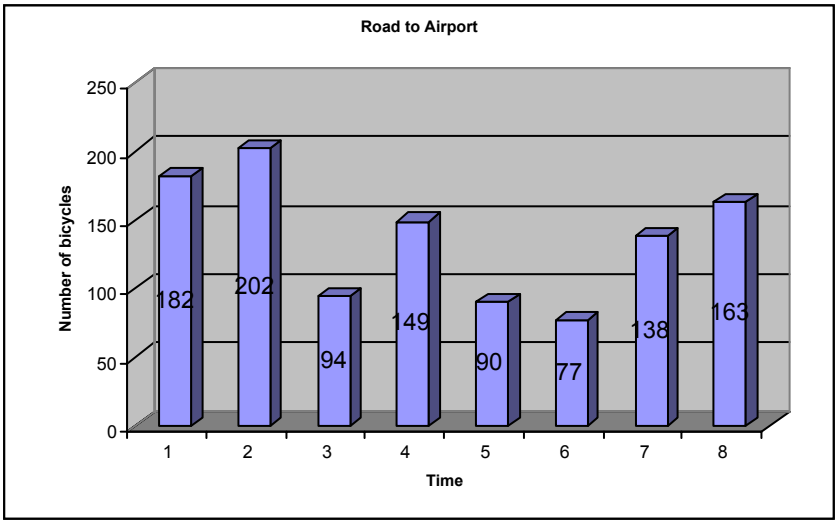
AIRPORT ROAD	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
17:15-17:45								
northward	250	26	0	64	9,42029	18,82353	276	340
southward	204	20	3	74	8,810573	24,58472	227	301
total	454	46	3	**138**	9,145129	21,52886	503	**641**
18:00-18:30								
northward	270	27	0	97	9,090909	24,61929	297	394
southward	224	20	1	66	8,163265	21,22186	245	311
total	494	47	1	**163**	8,671587	23,12057	542	**705**

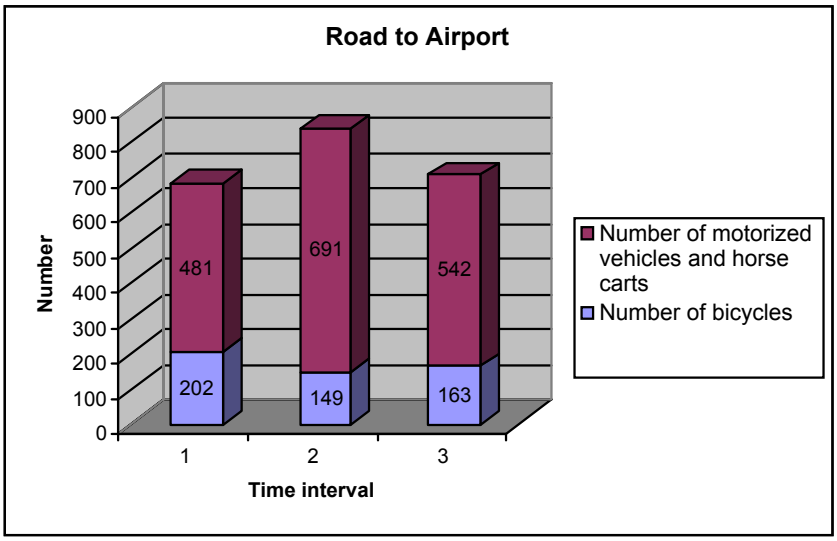
APPENDIX 2



Legend

1	7:00 - 7:30
2	7:30 - 8:00
3	9:30 - 10:00
4	12:00 - 12:30
5	13:30 - 14:00
6	15:30 - 16:00
7	17:15 - 17:45
8	18:00 - 18:30





Legend

1	7:30 - 8:00
2	12:00 - 12:30
3	18:00 - 18:30

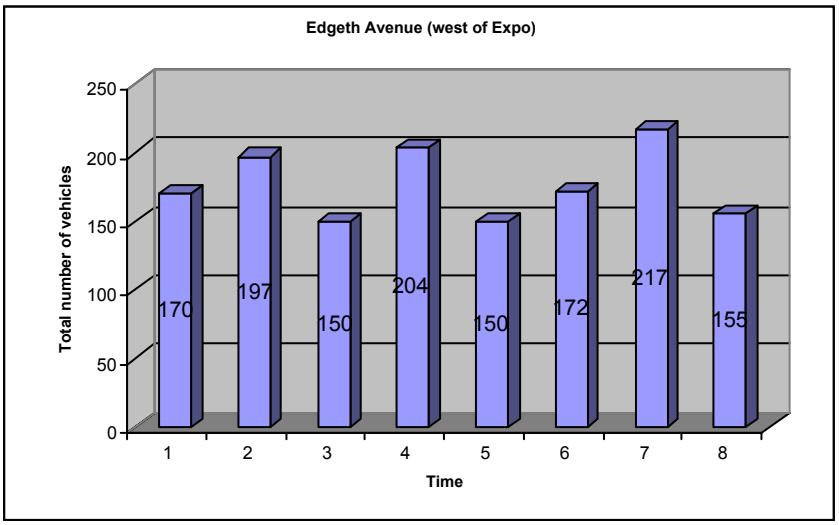
APPENDIX 2

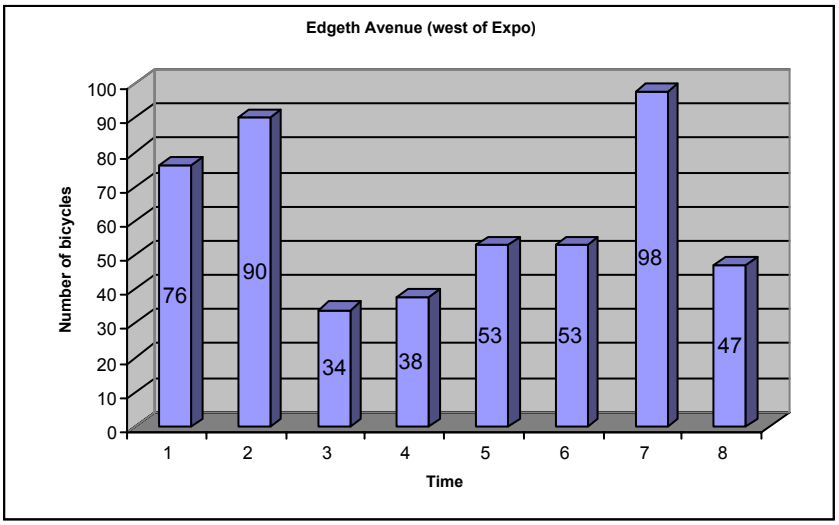
EDGETH (WEST OF EXPO)	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:00-7:30								
westward	22	12	1	36	16,90141	50,70423	35	71
eastward	49	7	3	40	7,070707	40,40404	59	99
total	71	19	4	**76**	11,17647	44,70588	94	**170**
7:30-8:00								
westward	25	11	0	48	13,09524	57,14286	36	84
eastward	62	8	1	42	7,079646	37,16814	71	113
total	87	19	1	**90**	9,64467	45,68528	107	**197**
9:30-10:00								
westward	31	20	4	22	25,97403	28,57143	55	77
eastward	39	22	0	12	30,13699	16,43836	61	73
total	70	42	4	**34**	28	22,66667	116	**150**
12:00-12:30								
westward	94	14	1	10	11,76471	8,403361	109	119
eastward	39	17	1	28	20	32,94118	57	85
total	133	31	2	**38**	15,19608	18,62745	166	**204**
13:30-14:00								
westward	28	15	0	19	24,19355	30,64516	43	62
eastward	45	8	1	34	9,090909	38,63636	54	88
total	73	23	1	**53**	15,33333	35,33333	97	**150**
15:30-16:00								
westward	47	19	1	25	20,65217	27,17391	67	92
eastward	41	11	0	28	13,75	35	52	80
total	88	30	1	**53**	17,44186	30,81395	119	**172**

APPENDIX 2

EDGETH (WEST OF EXPO)	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
17:15-17:45								
westward	44	11	1	39	11,57895	41,05263	56	95
eastward	50	13	0	59	10,65574	48,36066	63	122
total	94	24	1	**98**	11,05991	45,16129	119	**217**
18:00-18:30								
westward	43	3	2	27	4	36	48	75
eastward	50	10	0	20	12,5	25	60	80
total	93	13	2	**47**	8,387097	30,32258	108	**155**

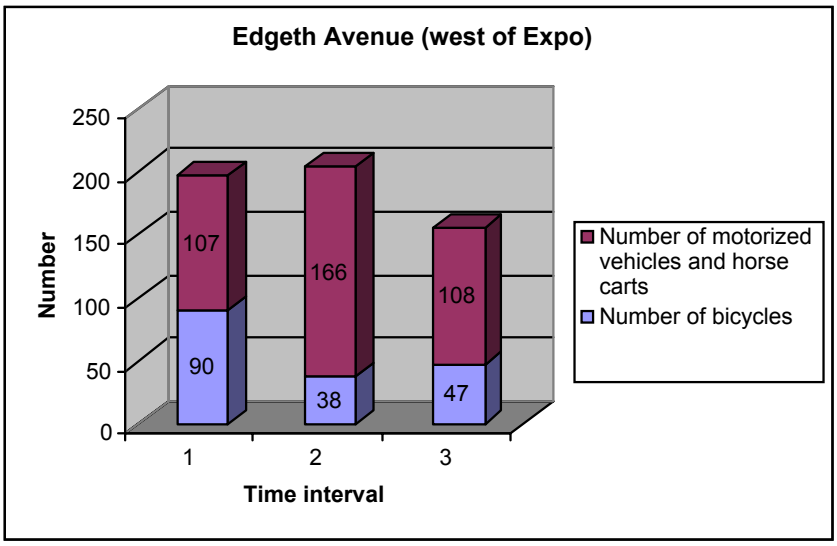
APPENDIX 2





Legend

1	7:00 - 7:30
2	7:30 - 8:00
3	9:30 - 10:00
4	12:00 - 12:30
5	13:30 - 14:00
6	15:30 - 16:00
7	17:15 - 17:45
8	18:00 - 18:30



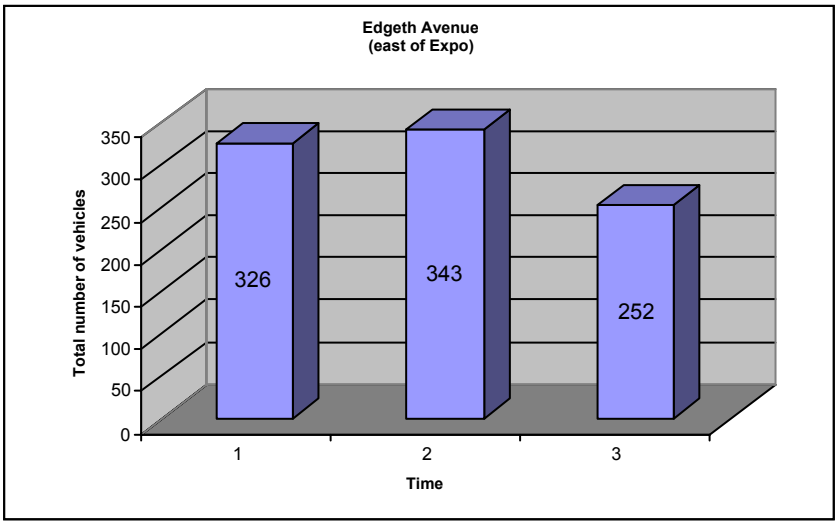
Legend

1	7:30 - 8:00
2	12:00 - 12:30
3	18:00 - 18:30

APPENDIX 2

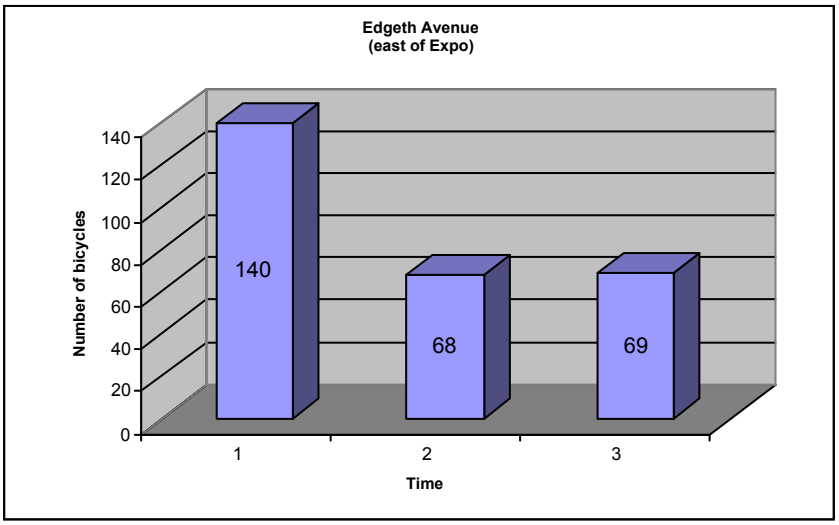
EDGETH AVENUE (EAST OF EXPO) 26/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
westward	69	26	0	65	27,36842	40,625	95	160
eastward	78	13	0	75	14,28571	45,18072	91	166
total	147	39	0	**140**	20,96774	42,94479	186	**326**
12:00-12:30								
westward	126	13	1	31	9,285714	18,12865	140	171
eastward	109	26	0	37	19,25926	21,51163	135	172
total	235	39	1	**68**	14,18182	19,82507	275	**343**
18:00-18:30								
westward	77	11	0	23	12,5	20,72072	88	111
eastward	81	14	0	46	14,73684	32,62411	95	141
total	158	25	0	**69**	13,6612	27,38095	183	**252**

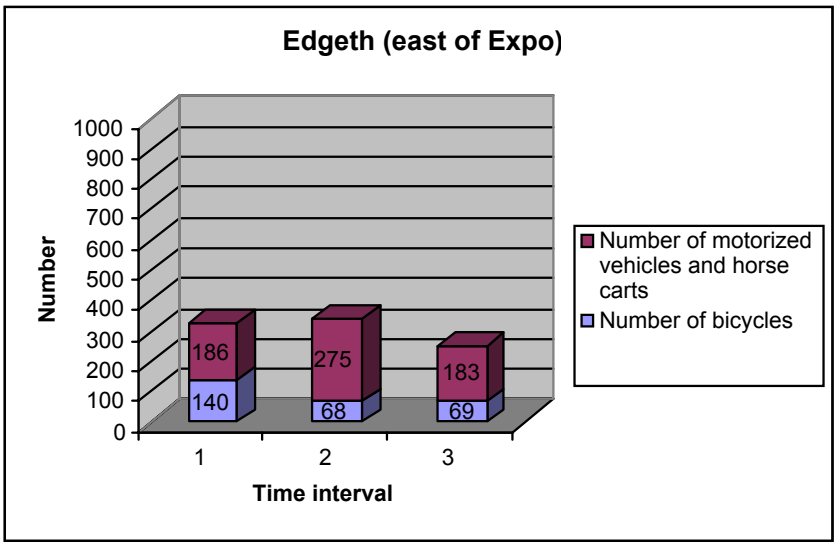
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30

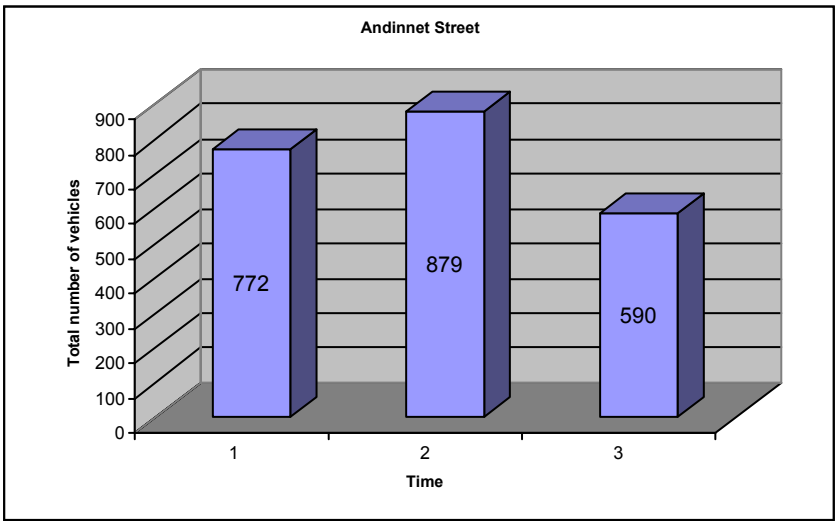




APPENDIX 2

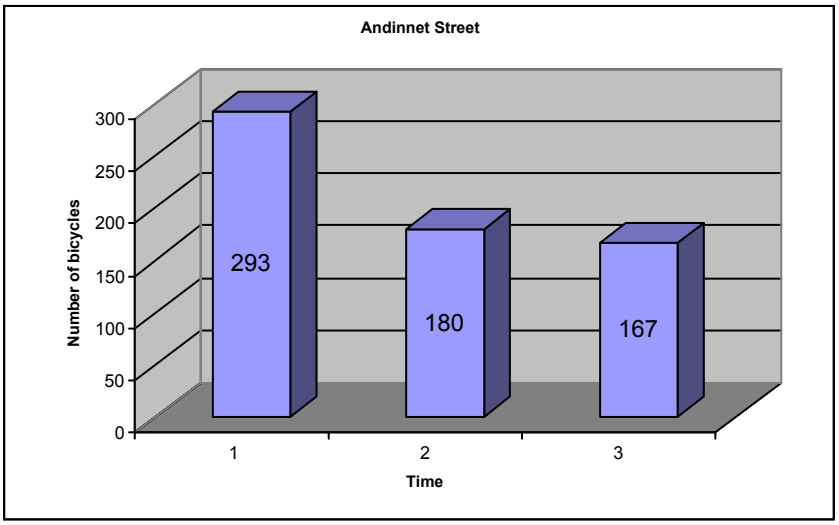
ANDINNET 26/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
northward	227	25	7	134	9,65251	34,09669	259	393
southward	183	32	5	159	14,54545	41,95251	220	379
total	410	57	12	**293**	11,89979	37,95337	479	**772**
12:00-12:30								
northward	320	40	1	80	11,08033	18,14059	361	441
southward	300	33	5	100	9,763314	22,83105	338	438
total	620	73	6	**180**	10,44349	20,47782	699	**879**
18:00-18:30								
northward	171	15	1	80	8,02139	29,96255	187	267
southward	213	21	2	87	8,898305	26,93498	236	323
total	384	36	3	**167**	8,510638	28,30508	423	**590**

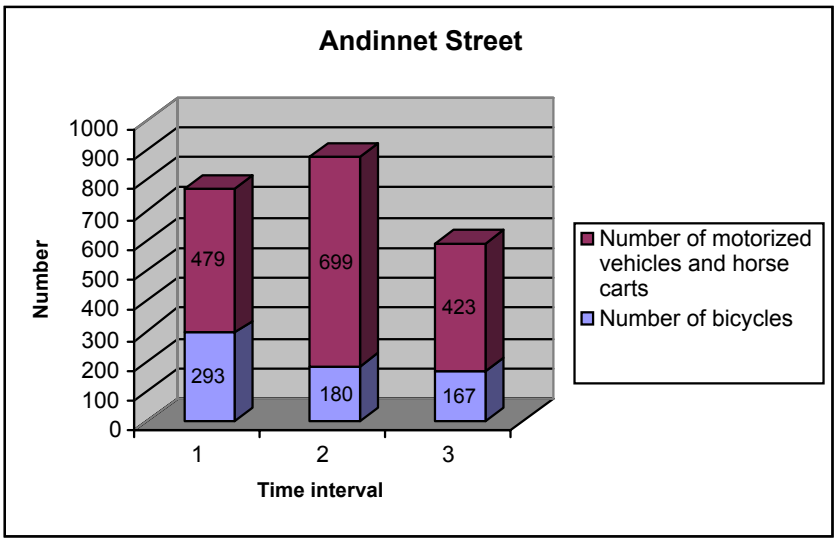
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30



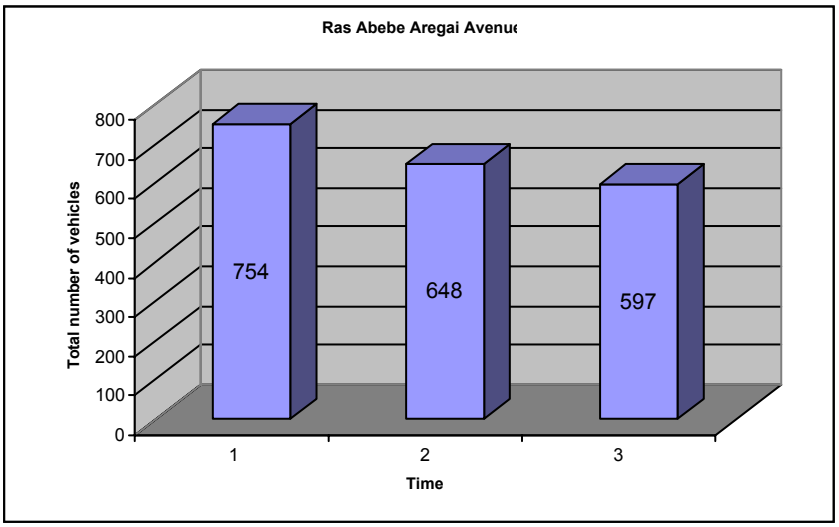


RAS	Cars	Trucks	Horse-	Bicycles	% heavy	%	Total	Total

APPENDIX 2

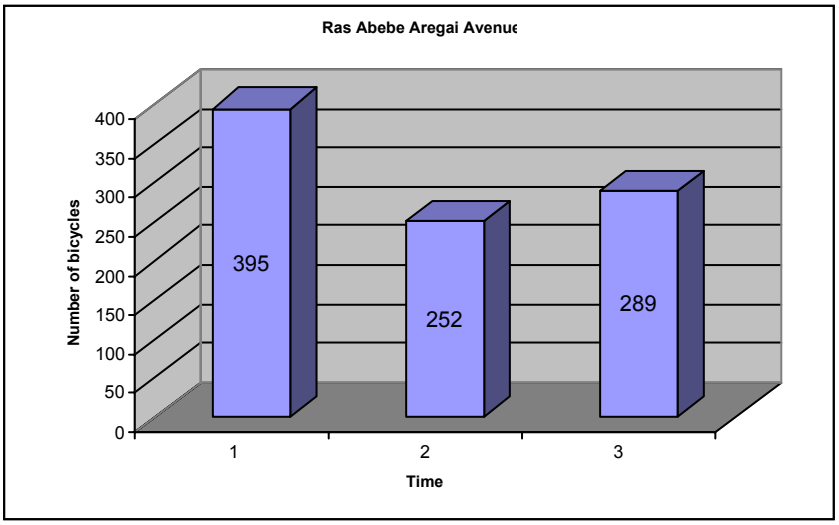
ABEBE AREGAI AVENUE		and buses	carts		traffic	bicycles	number of motorized vehicles + horses	number of vehicles
7:30-8:00								
eastward	129	76	13	189	34,86239	46,43735	218	407
westward	101	35	5	206	24,8227	59,36599	141	347
total	230	111	18	**395**	30,91922	52,38727	359	**754**
12:00-12:30								
eastward	159	61	3	148	27,35426	39,89218	223	371
westward	132	40	1	104	23,12139	37,54513	173	277
total	291	101	4	**252**	25,50505	38,88889	396	**648**
18:00-18:30								
eastward	121	32	1	142	20,77922	47,97297	154	296
westward	119	32	3	147	20,77922	48,83721	154	301
total	240	64	4	**289**	20,77922	48,40871	308	**597**

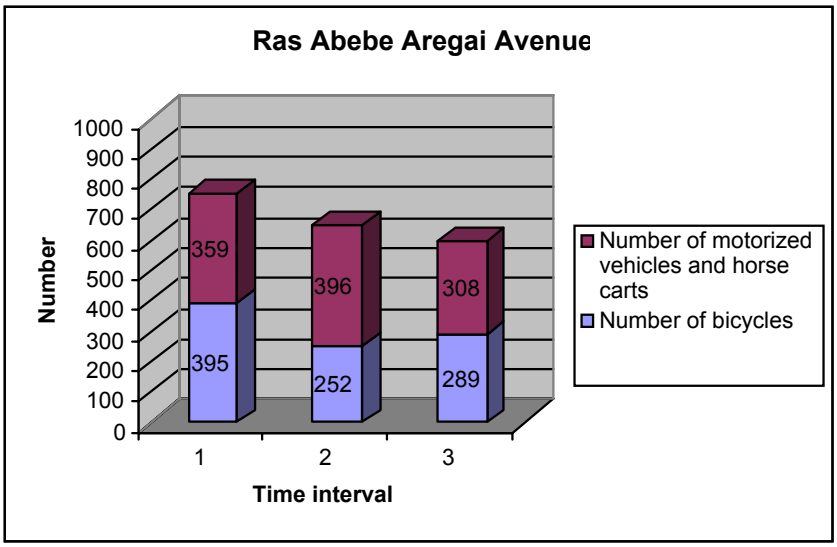
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30

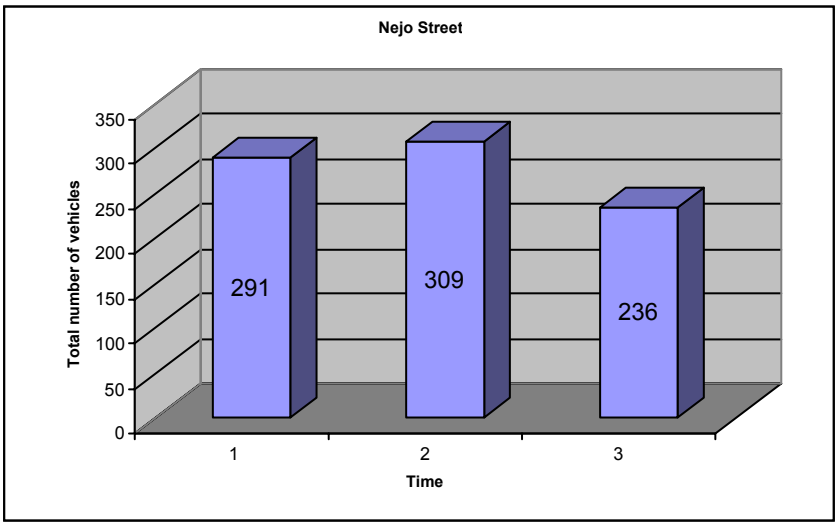




APPENDIX 2

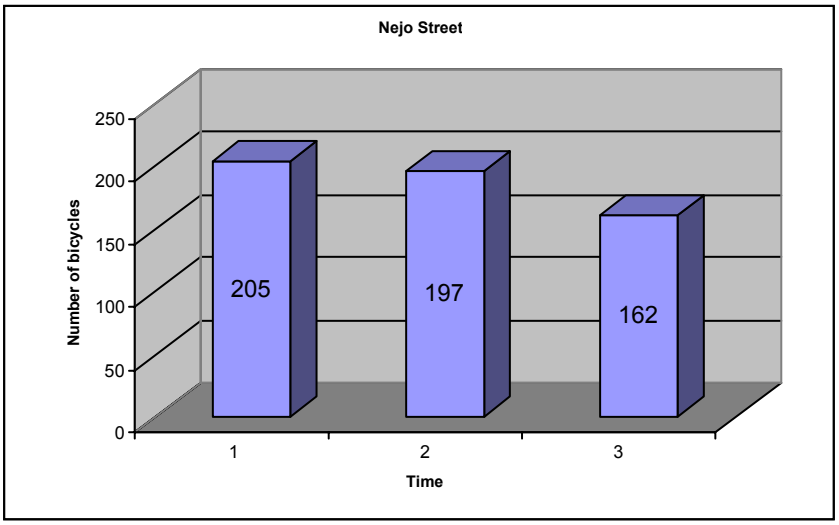
NEJO STREET	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
northward	51	3	1	88	5,454545	61,53846	55	143
southward	30	1	0	117	3,225806	79,05405	31	148
total	81	4	1	**205**	4,651163	70,44674	86	**291**
12:00-12:30								
northward	50	2	4	119	3,571429	68	56	175
southward	51	5	0	78	8,928571	58,20896	56	134
total	101	7	4	**197**	6,25	63,75405	112	**309**
18:00-18:30								
northward	42	4	1	93	8,510638	66,42857	47	140
southward	23	1	3	69	3,703704	71,875	27	96
total	65	5	4	**162**	6,756757	68,64407	74	**236**

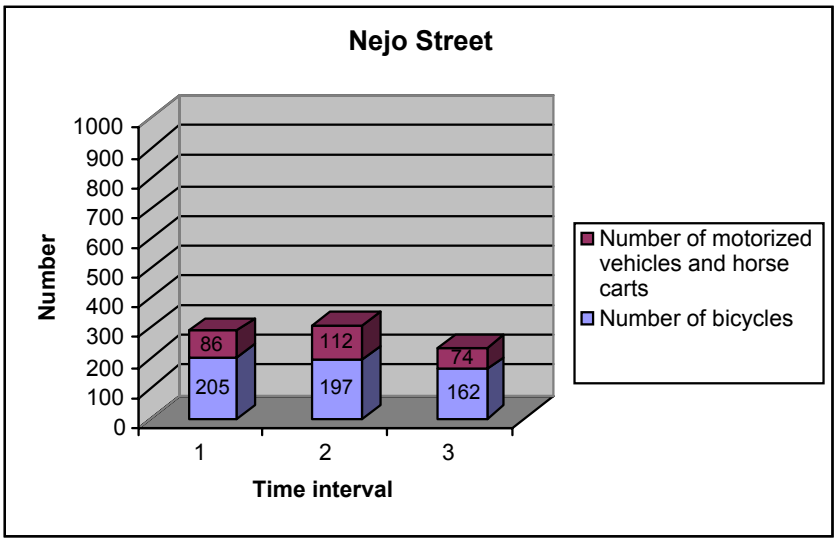
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30



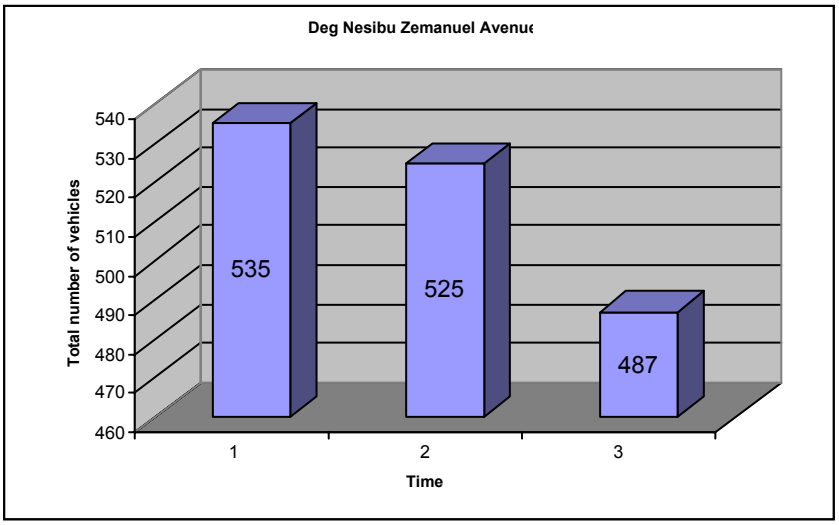


Deg Nesibu Cars Trucks Horse- Bicycles % heavy % Total Total

APPENDIX 2

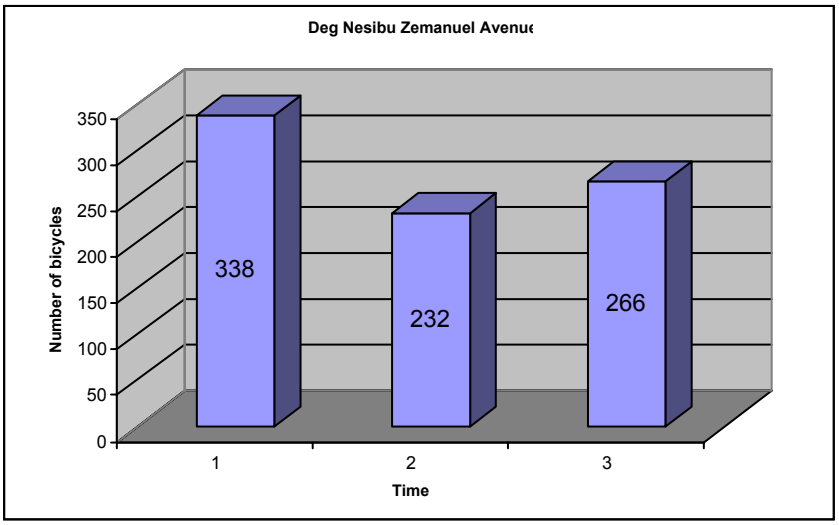
Zemanuel Avenue 25/6		and buses	carts		traffic	bicycles	number of motorized vehicles + horses	number of vehicles
7:30-8:00								
northward	78	13	3	188	13,82979	66,66667	94	282
southward	86	13	4	150	12,62136	59,28854	103	253
total	164	26	7	**338**	13,19797	63,17757	197	**535**
12:00-12:30								
northward	131	26	1	95	16,4557	37,54941	158	253
southward	119	16	0	137	11,85185	50,36765	135	272
total	250	42	1	**232**	14,33447	44,19048	293	**525**
18:00-18:30								
northward	121	15	0	139	11,02941	50,54545	136	275
southward	71	14	0	127	16,47059	59,90566	85	212
total	192	29	0	**266**	13,12217	54,62012	221	**487**

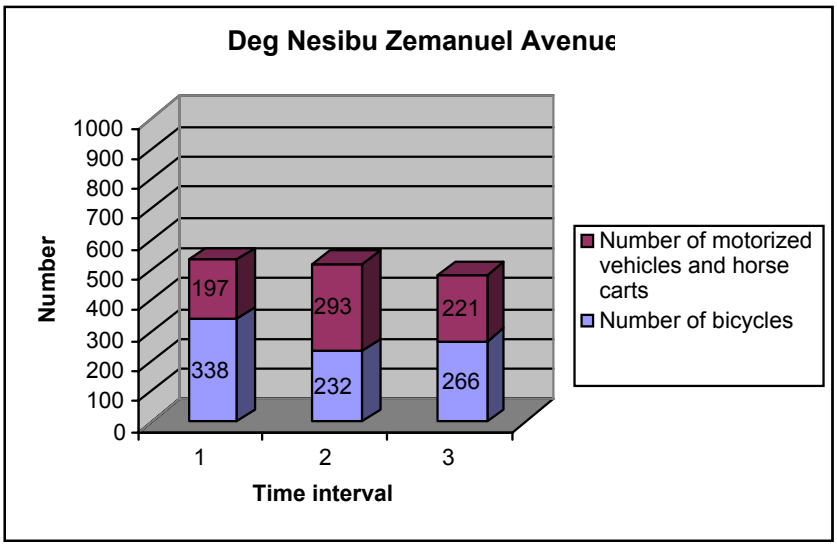
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30

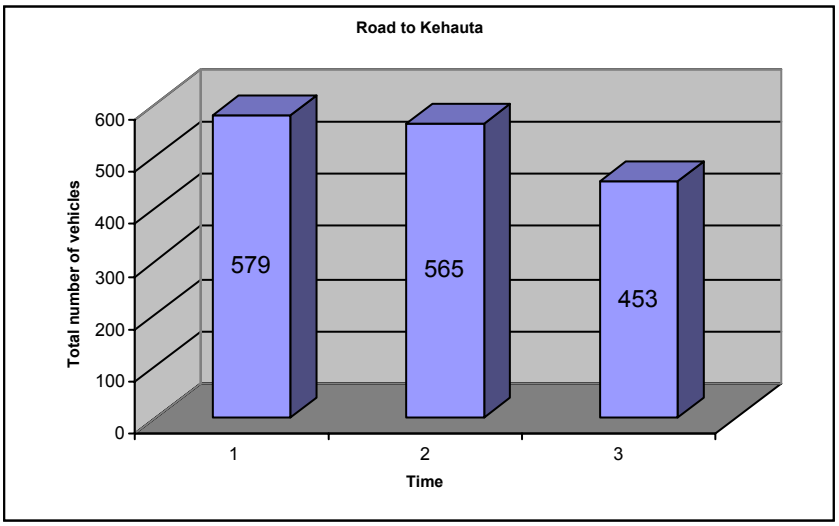




APPENDIX 2

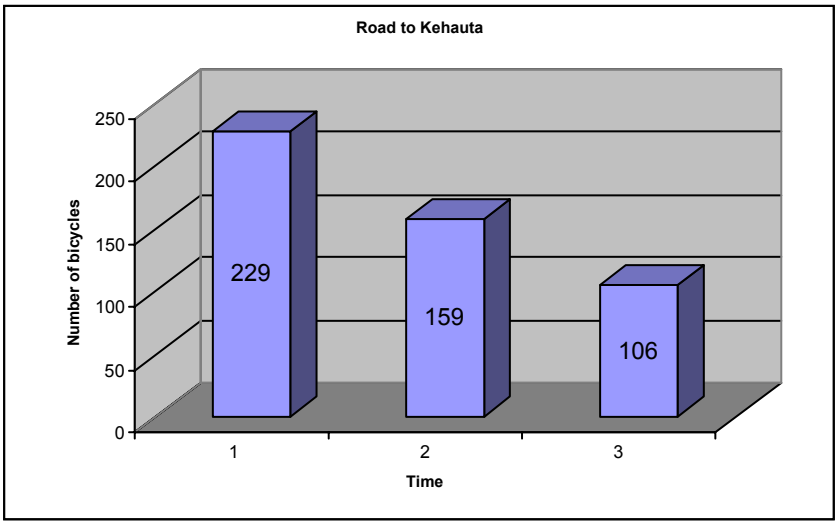
KEHAUTA 27/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
northward	117	60	2	135	33,51955	42,99363	179	314
southward	107	64	0	94	37,4269	35,4717	171	265
total	224	124	2	**229**	35,42857	39,55095	350	**579**
12:00-12:30								
northward	120	70	0	56	36,84211	22,76423	190	246
southward	152	62	2	103	28,7037	32,2884	216	319
total	272	132	2	**159**	32,51232	28,14159	406	**565**
18:00-18:30								
northward	114	43	0	46	27,38854	22,6601	157	203
southward	134	56	0	60	29,47368	24	190	250
total	248	99	0	**106**	28,53026	23,39956	347	**453**

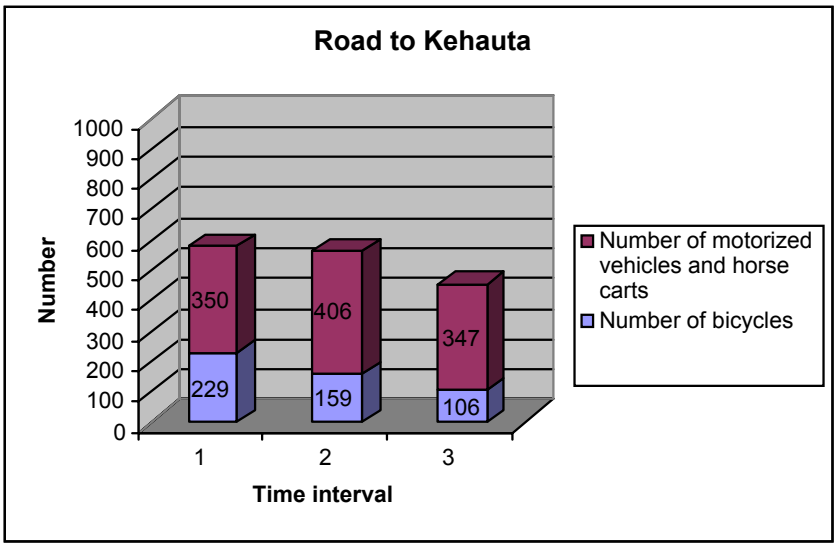
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30

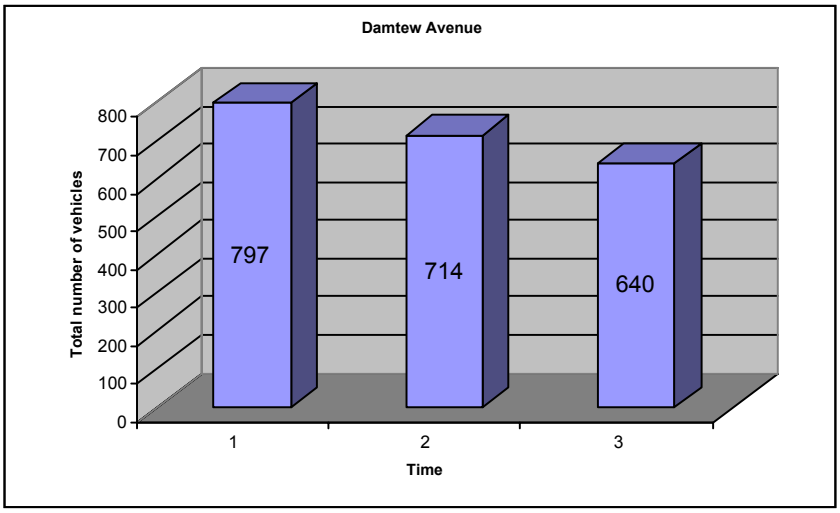




APPENDIX 2

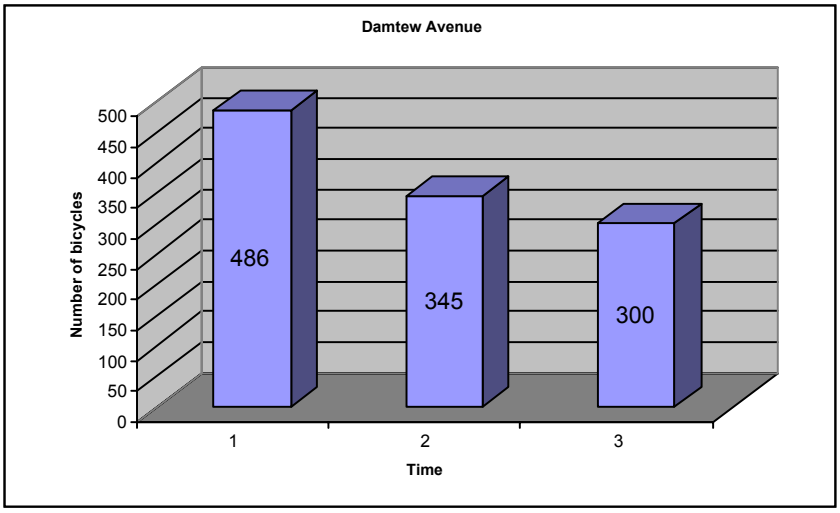
DAMTEW AVENUE 27/6	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
northward	128	31	7	336	18,674699	66,932271	166	502
southward	112	32	1	150	22,068966	50,847458	145	295
total	240	63	8	**486**	20,257235	60,97867	311	**797**
12:00-12:30								
northward	136	41	2	106	22,905028	37,192982	179	285
southward	157	31	2	239	16,315789	55,710956	190	429
total	293	72	4	**345**	19,512195	48,319328	369	**714**
18:00-18:30								
northward	129	27	1	94	17,197452	37,450199	157	251
southward	160	23	0	206	12,568306	52,956298	183	389
total	289	50	1	**300**	14,705882	46,875	340	**640**

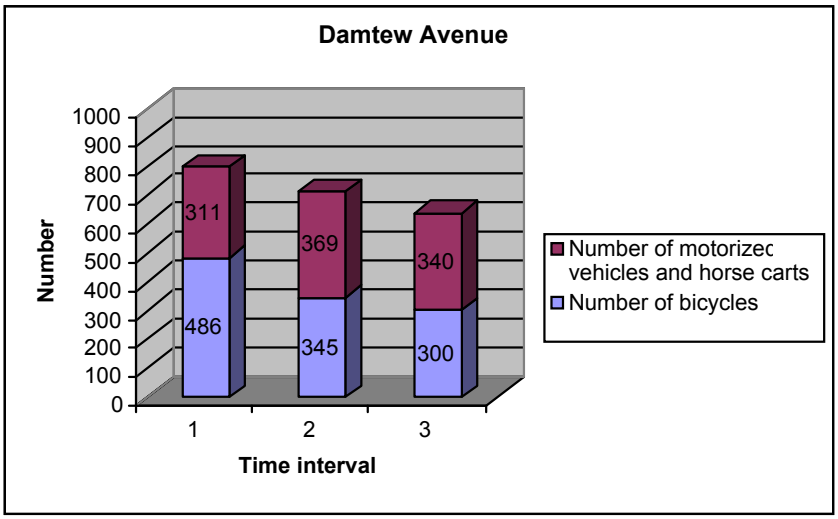
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30

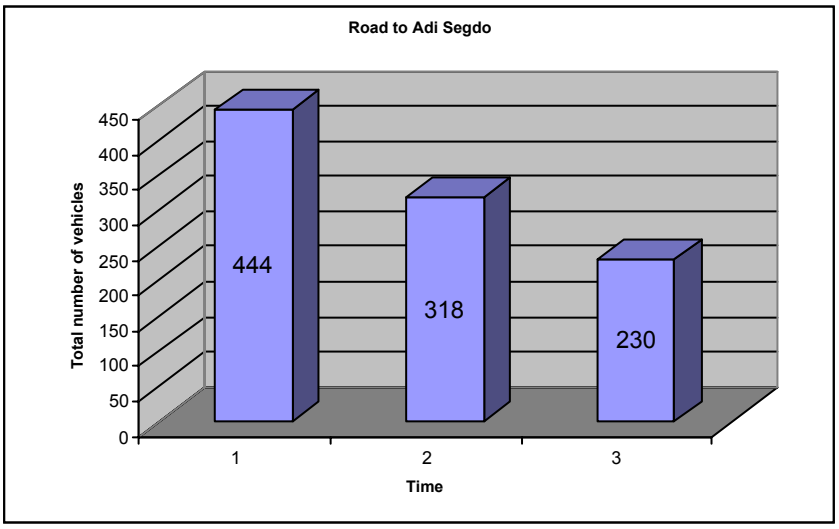




APPENDIX 2

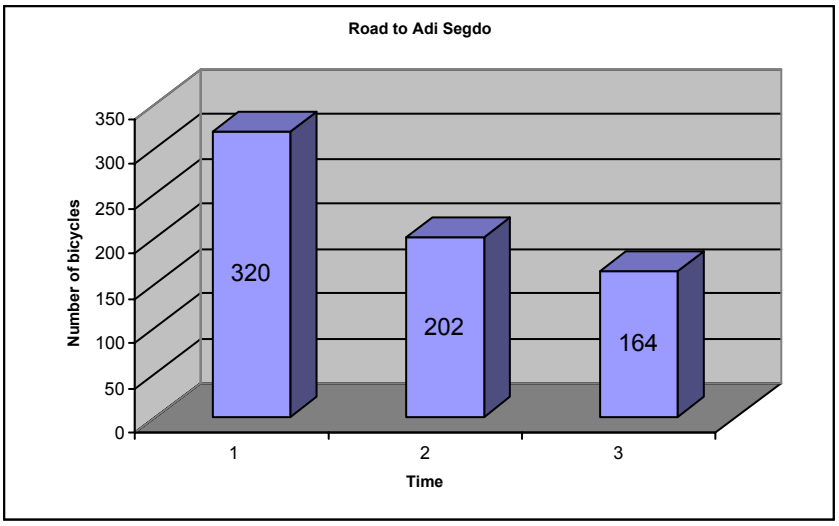
ROAD TO ADI SEGDO 1/7	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
northward	31	11	8	147	22	74,61929	50	197
southward	49	16	9	173	21,62162	70,04049	74	247
total	80	27	17	**320**	21,77419	72,07207	124	**444**
12:00-12:30								
northward	48	10	4	132	16,12903	68,04124	62	194
southward	40	10	4	70	18,51852	56,45161	54	124
total	88	20	8	**202**	17,24138	63,52201	116	**318**
18:00-18:30								
northward	22	7	2	103	22,58065	76,86567	31	134
southward	26	8	1	61	22,85714	63,54167	35	96
total	48	15	3	**164**	22,72727	71,30435	66	**230**

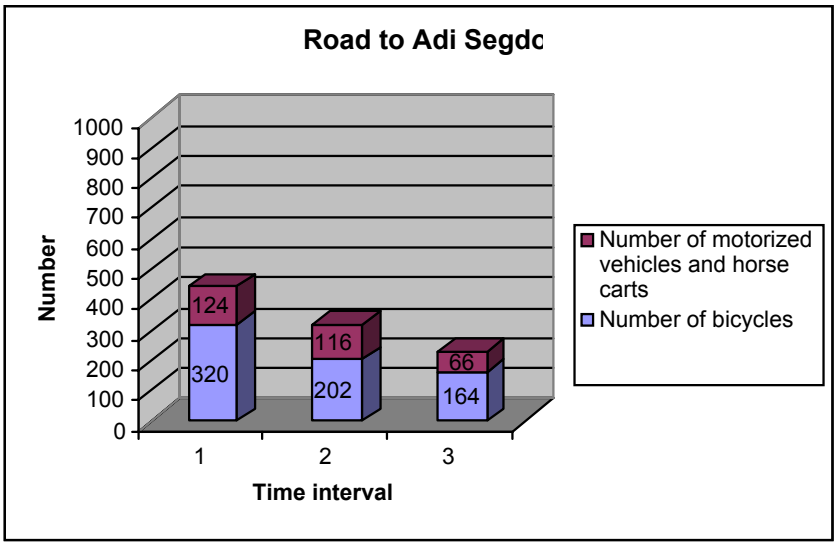
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30

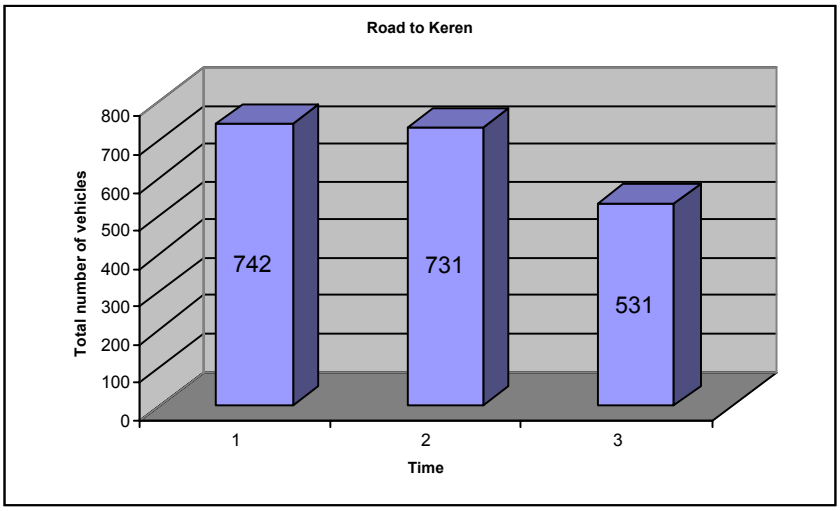




APPENDIX 2

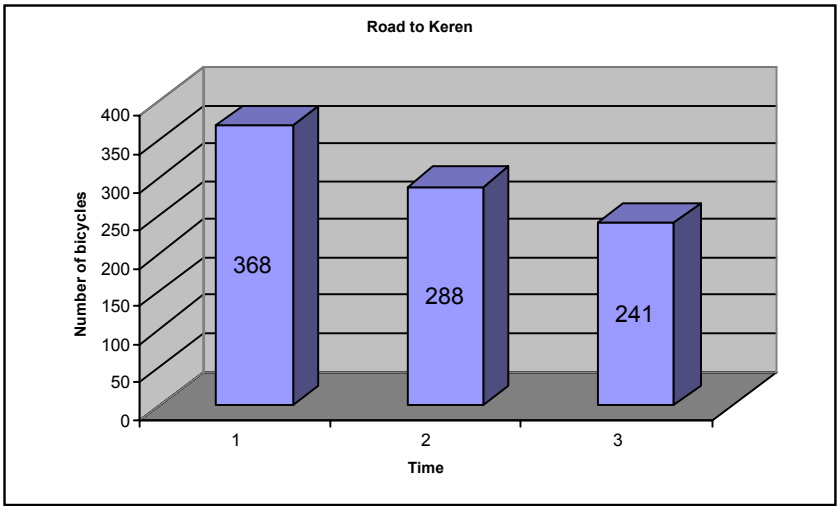
ROAD TO KEREN 1/7	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
northward	85	53	0	109	38,405797	44,129555	138	247
southward	171	62	3	259	26,271186	52,323232	236	495
total	256	115	3	**368**	30,748663	49,595687	374	**742**
12:00-12:30								
northward	229	66	0	211	22,372881	41,699605	295	506
southward	120	26	2	77	17,567568	34,222222	148	225
total	349	92	2	**288**	20,767494	39,398085	443	**731**
18:00-18:30								
northward	128	31	0	148	19,496855	48,208469	159	307
southward	105	26	0	93	19,847328	41,517857	131	224
total	233	57	0	**241**	19,655172	45,386064	290	**531**

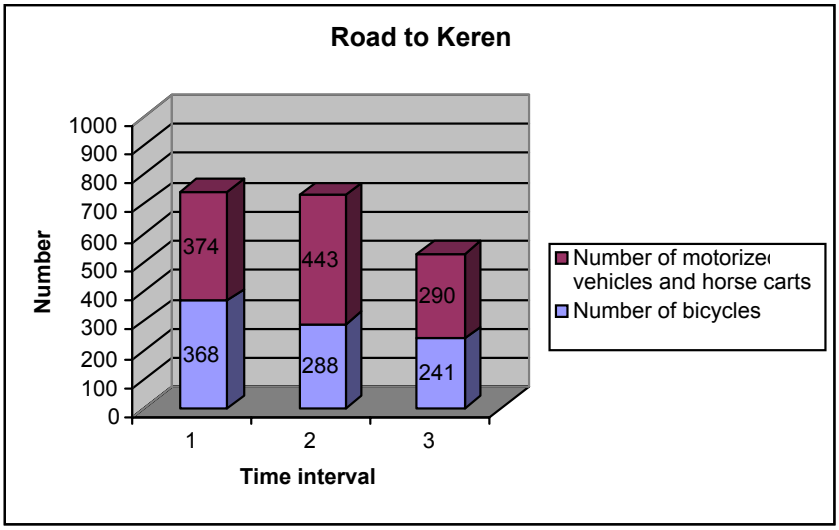
APPENDIX 2



Legend

1 7:30 - 8:00
2 12:00 - 12:30
3 18:00 - 18:30





APPENDIX 2

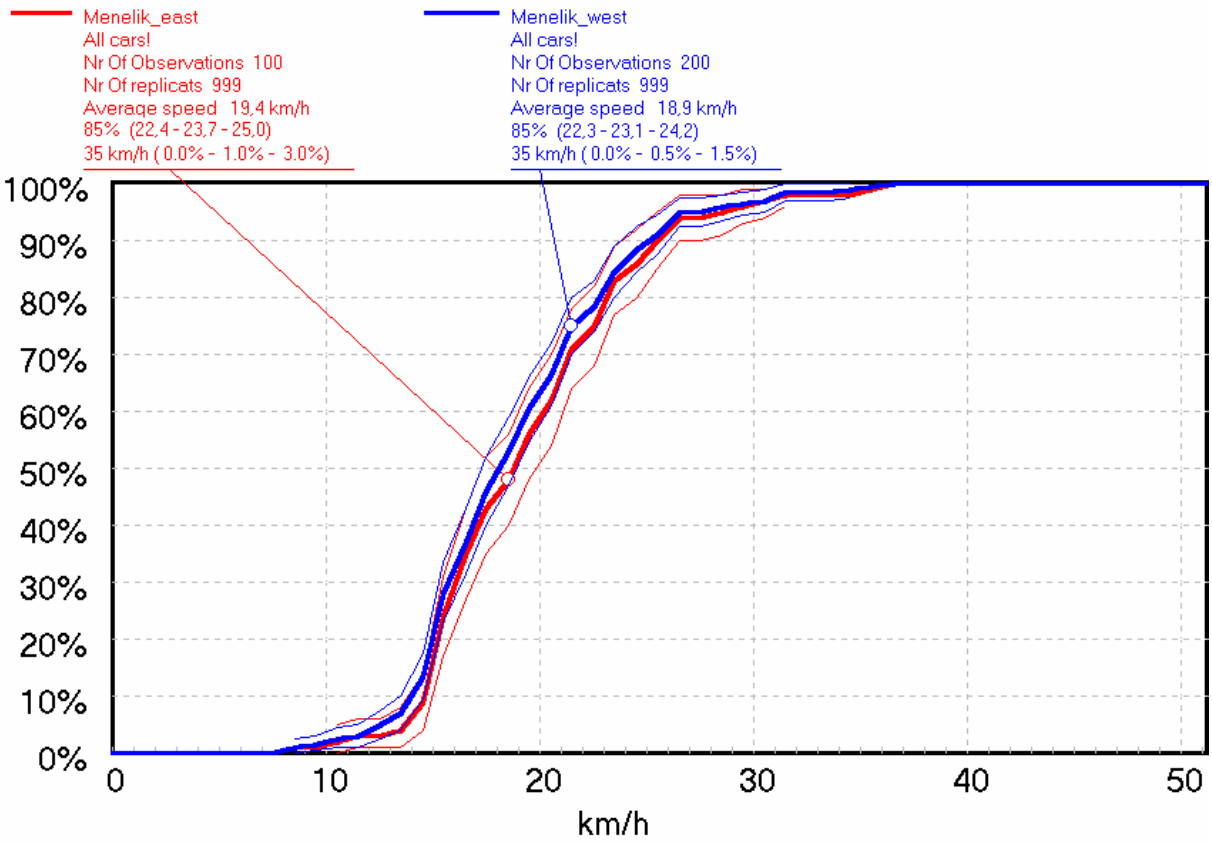
OLD ROAD TO KUSHET 2/7	Cars	Trucks and buses	Horse-carts	Bicycles	% heavy traffic	% bicycles	Total number of motorized vehicles + horses	Total number of vehicles
7:30-8:00								
westward	27	8	0	40	22,85714	53,33333	35	75
eastward	39	6	0	42	13,33333	48,27586	45	87
total	66	14	0	**82**	17,5	50,61728	80	**162**
12:00-12:30								
westward	68	2	0	16	2,857143	18,60465	70	86
eastward	41	5	0	29	10,86957	38,66667	46	75
total	109	7	0	**45**	6,034483	27,95031	116	**161**
18:00-18:30								
westward	32	5	0	33	13,51351	47,14286	37	70
eastward	43	8	0	26	15,68627	33,76623	51	77
total	75	13	0	**59**	14,77273	40,13605	88	**147**

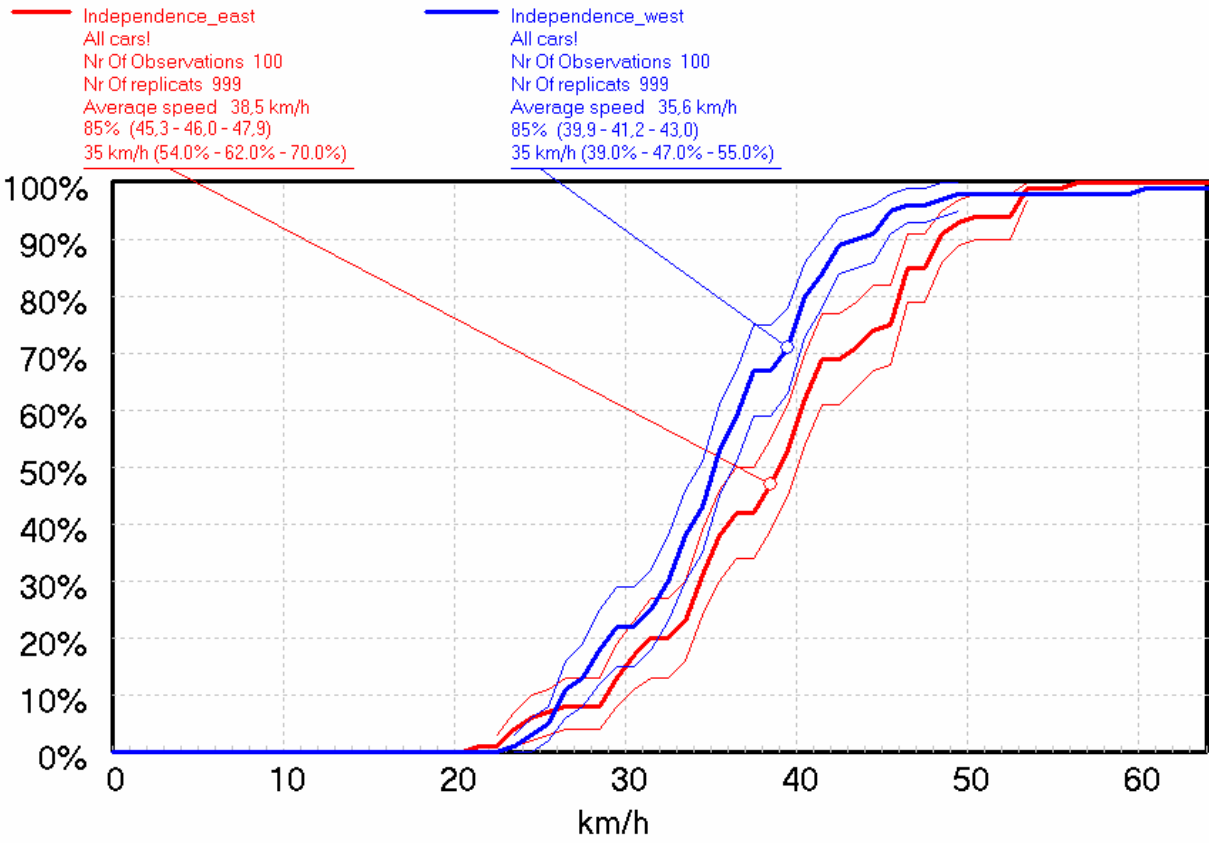
APPENDIX 3

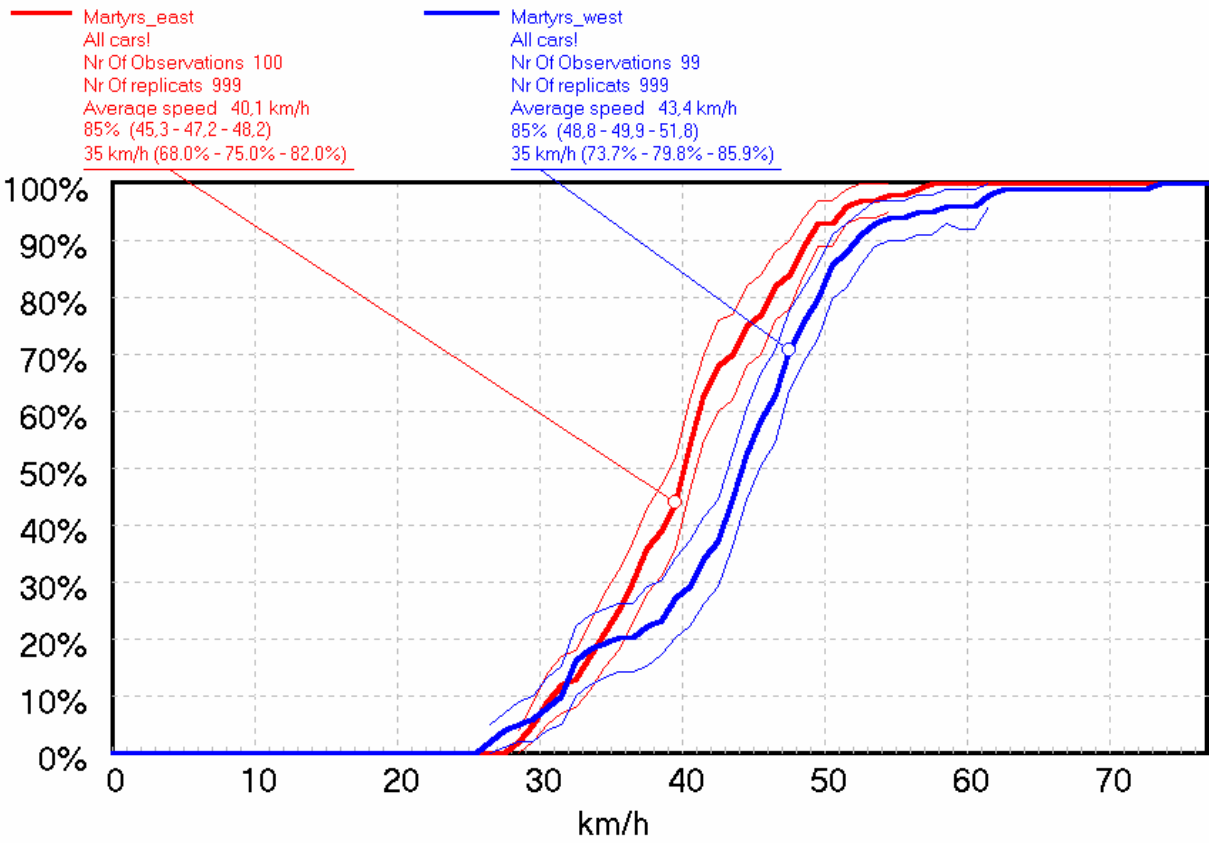
FORM FOR SPEED MEASUREMENTS

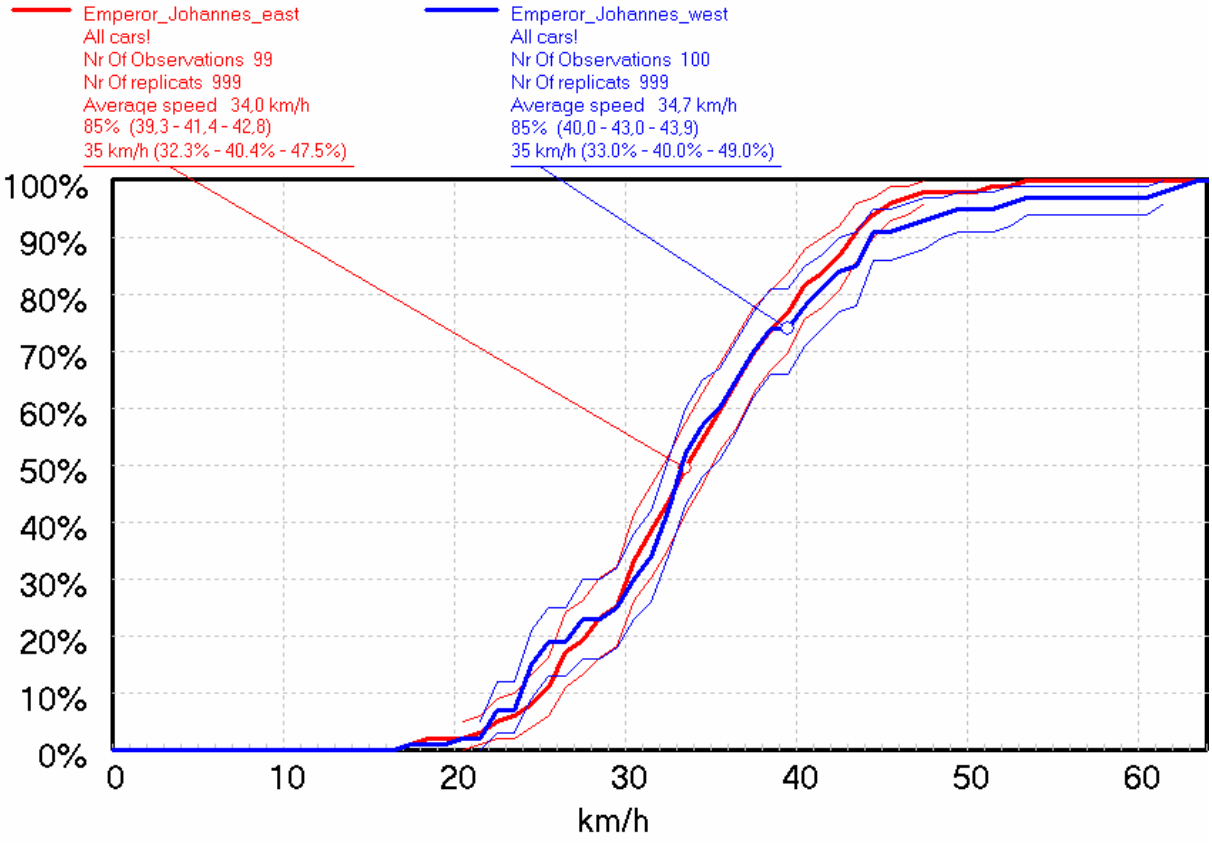
Road name:
Date:
Time:
Weather conditions:

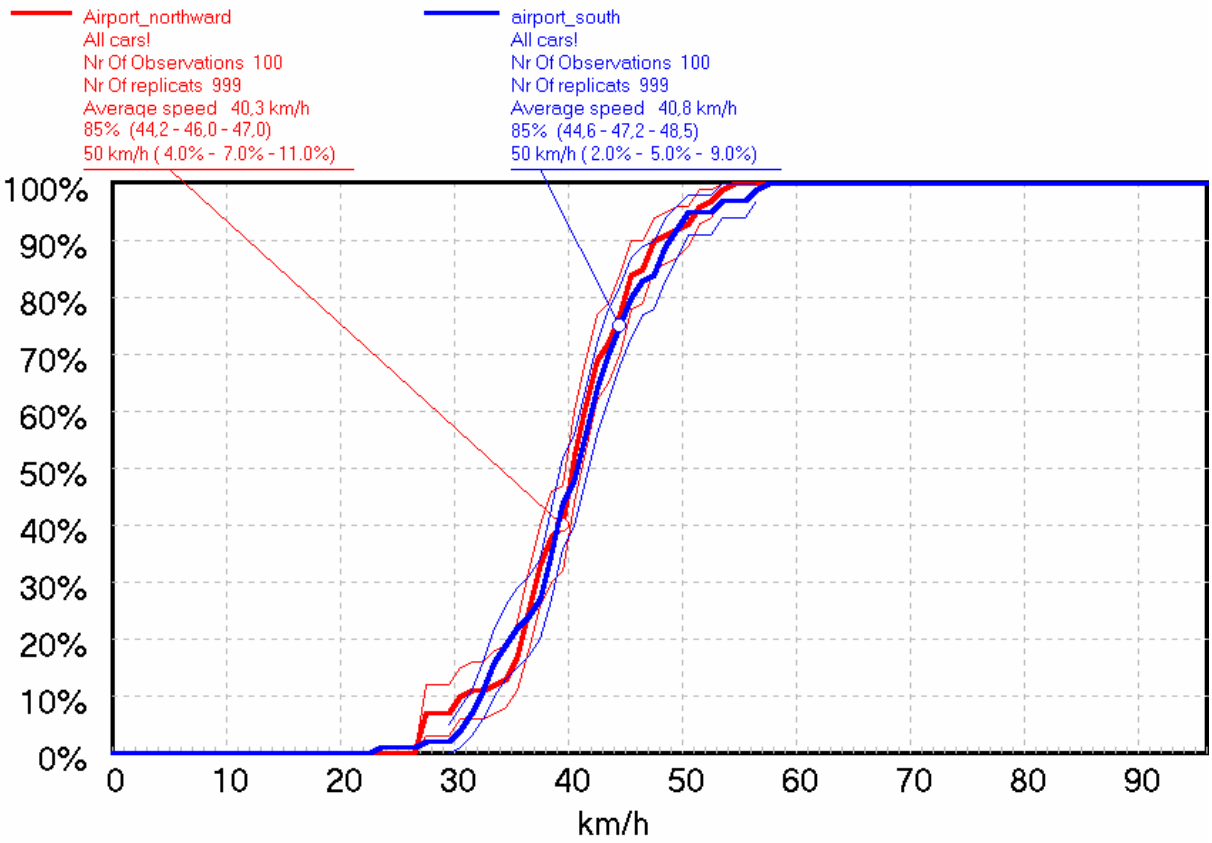
Direction of vehicles: **Angle:**	**Direction of vehicles:** **Angle:**

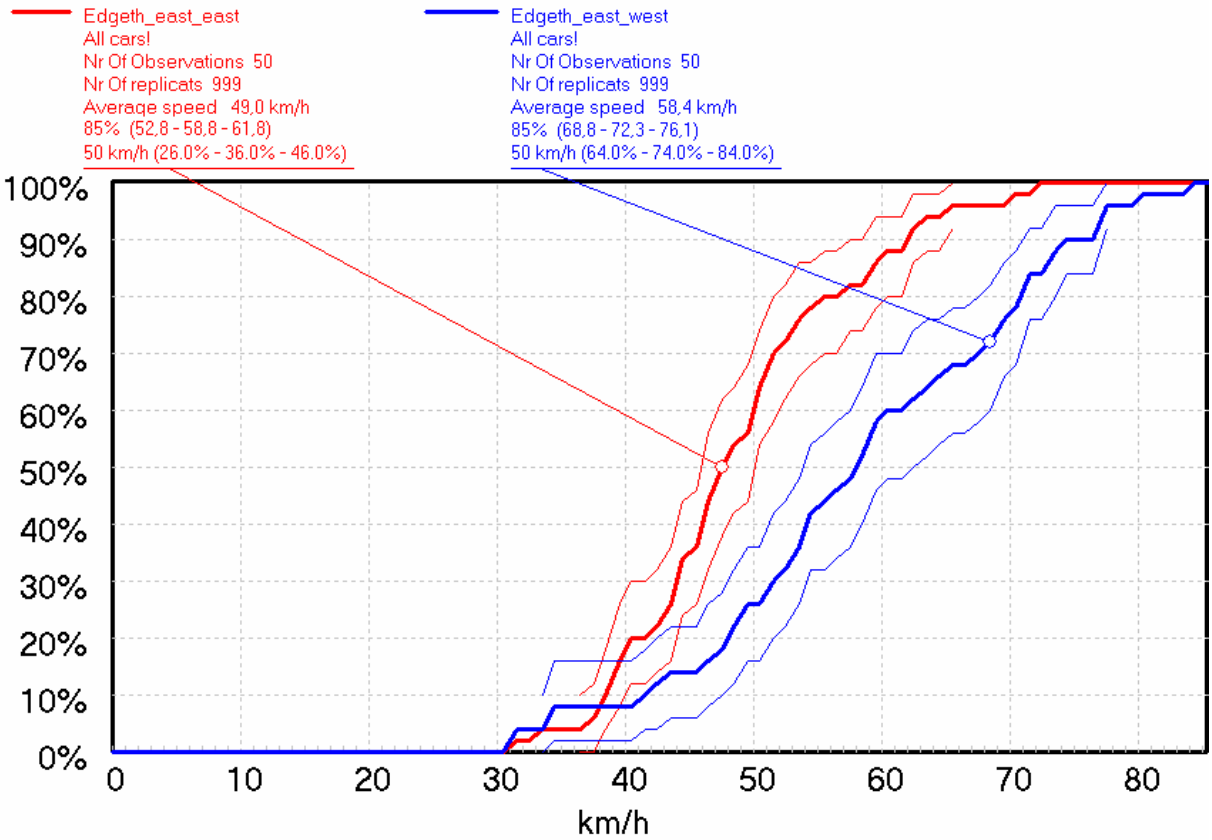

Menelik_east
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 19,4 km/h
85% (22,4 - 23,7 - 25,0)
35 km/h (0.0% - 1.0% - 3.0%)
Menelik_west
All cars!
Nr Of Observations 200
Nr Of replicats 999
Average speed 18,9 km/h
85% (22,3 - 23,1 - 24,2)
35 km/h (0.0% - 0.5% - 1.5%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
km/h

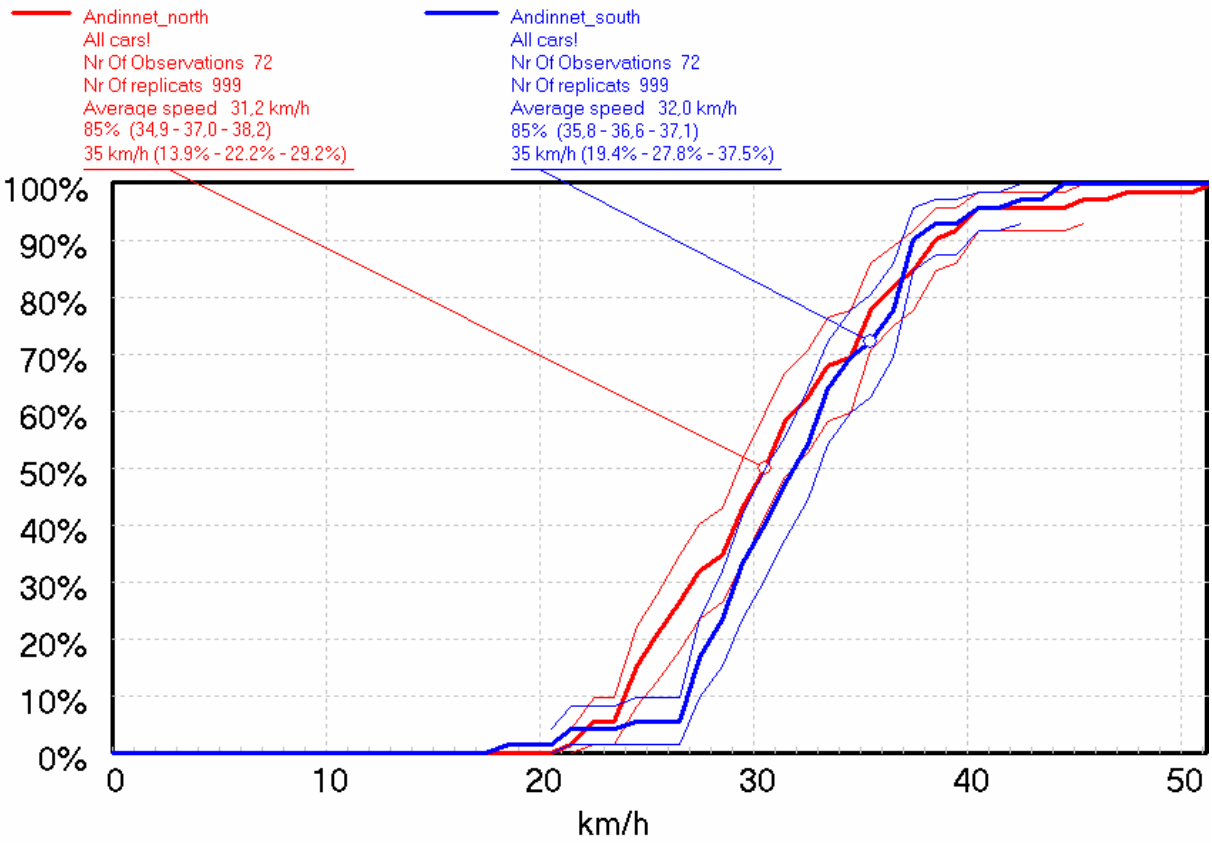

Independence_east
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 38,5 km/h
85% (45,3 - 46,0 - 47,9)
35 km/h (54.0% - 62.0% - 70.0%)
Independence_west
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 35,6 km/h
85% (39,9 - 41,2 - 43,0)
35 km/h (39.0% - 47.0% - 55.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
km/h

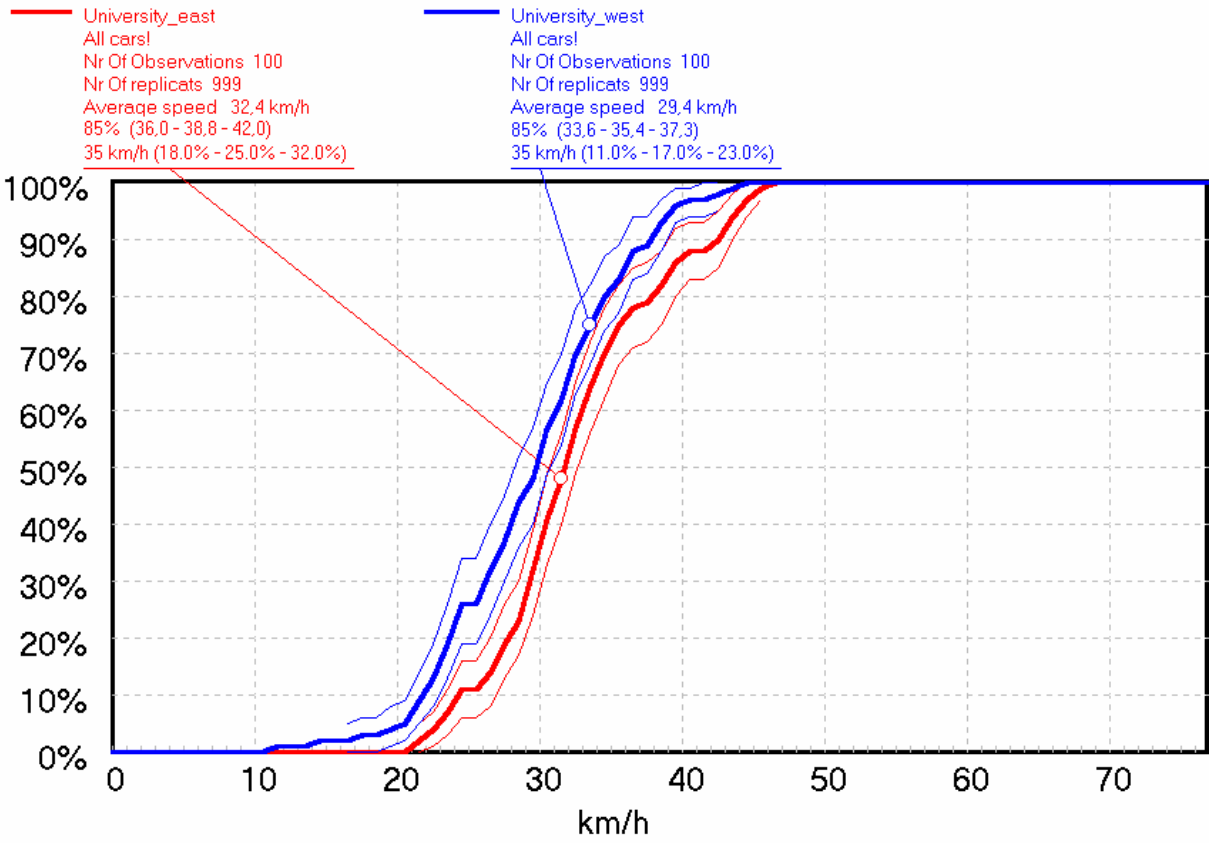

Martyrs_east
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 40,1 km/h
85% (45,3 - 47,2 - 48,2)
35 km/h (68.0% - 75.0% - 82.0%)
Martyrs_west
All cars!
Nr Of Observations 99
Nr Of replicats 999
Average speed 43,4 km/h
85% (48,8 - 49,9 - 51,8)
35 km/h (73.7% - 79.8% - 85.9%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
km/h

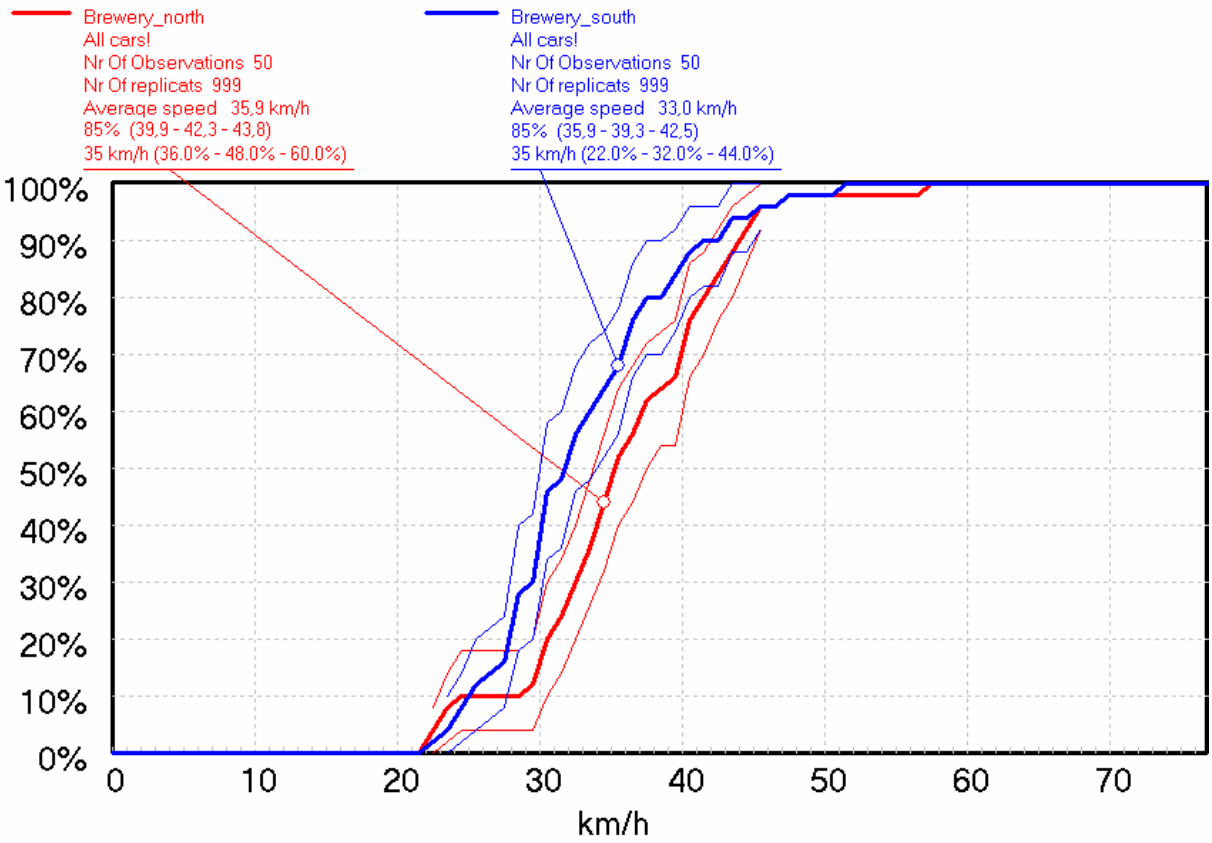

Emperor_Johannes_east
All cars!
Nr Of Observations 99
Nr Of replicats 999
Average speed 34,0 km/h
85% (39,3 - 41,4 - 42,8)
35 km/h (32.3% - 40.4% - 47.5%)
Emperor_Johannes_west
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 34,7 km/h
85% (40,0 - 43,0 - 43,9)
35 km/h (33.0% - 40.0% - 49.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
km/h

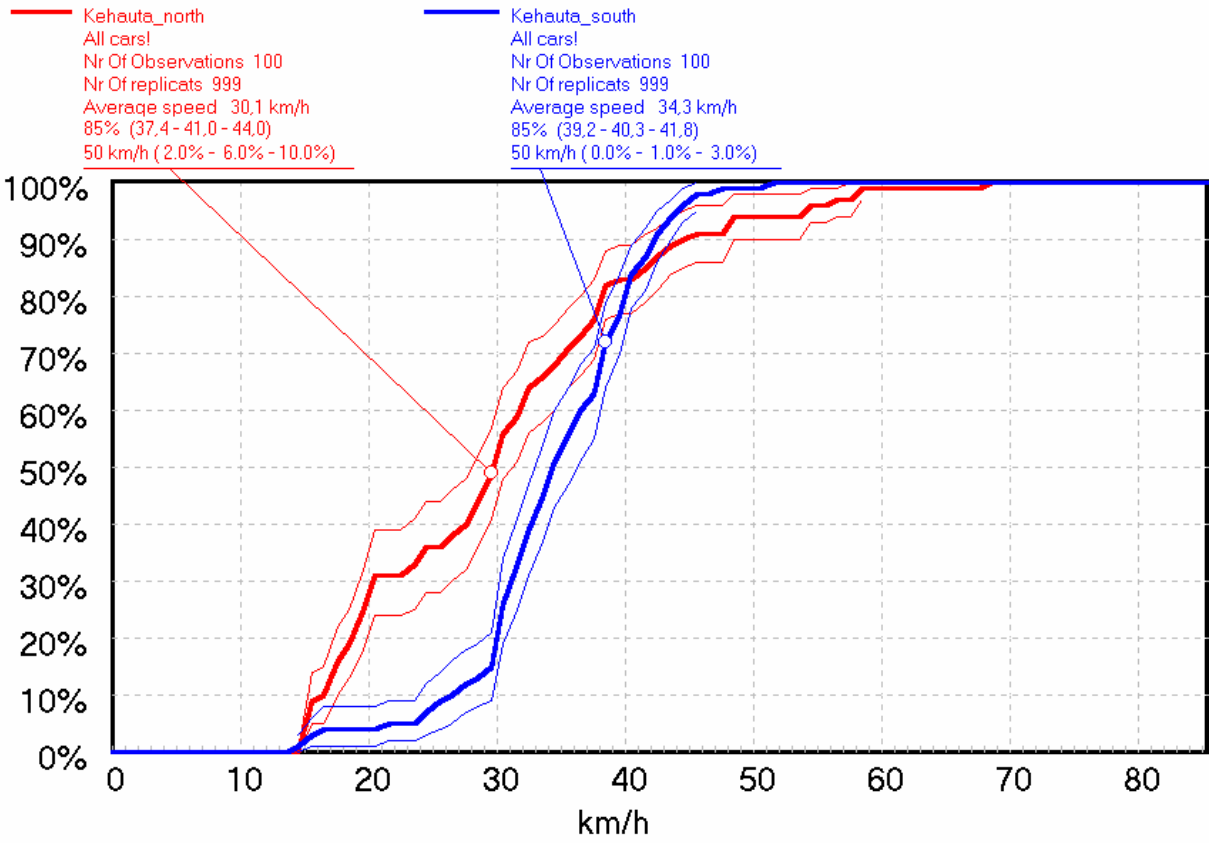

Airport_northward
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 40,3 km/h
85% (44,2 - 46,0 - 47,0)
50 km/h (4.0% - 7.0% - 11.0%)
airport_south
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 40,8 km/h
85% (44,6 - 47,2 - 48,5)
50 km/h (2.0% - 5.0% - 9.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
80
90
km/h

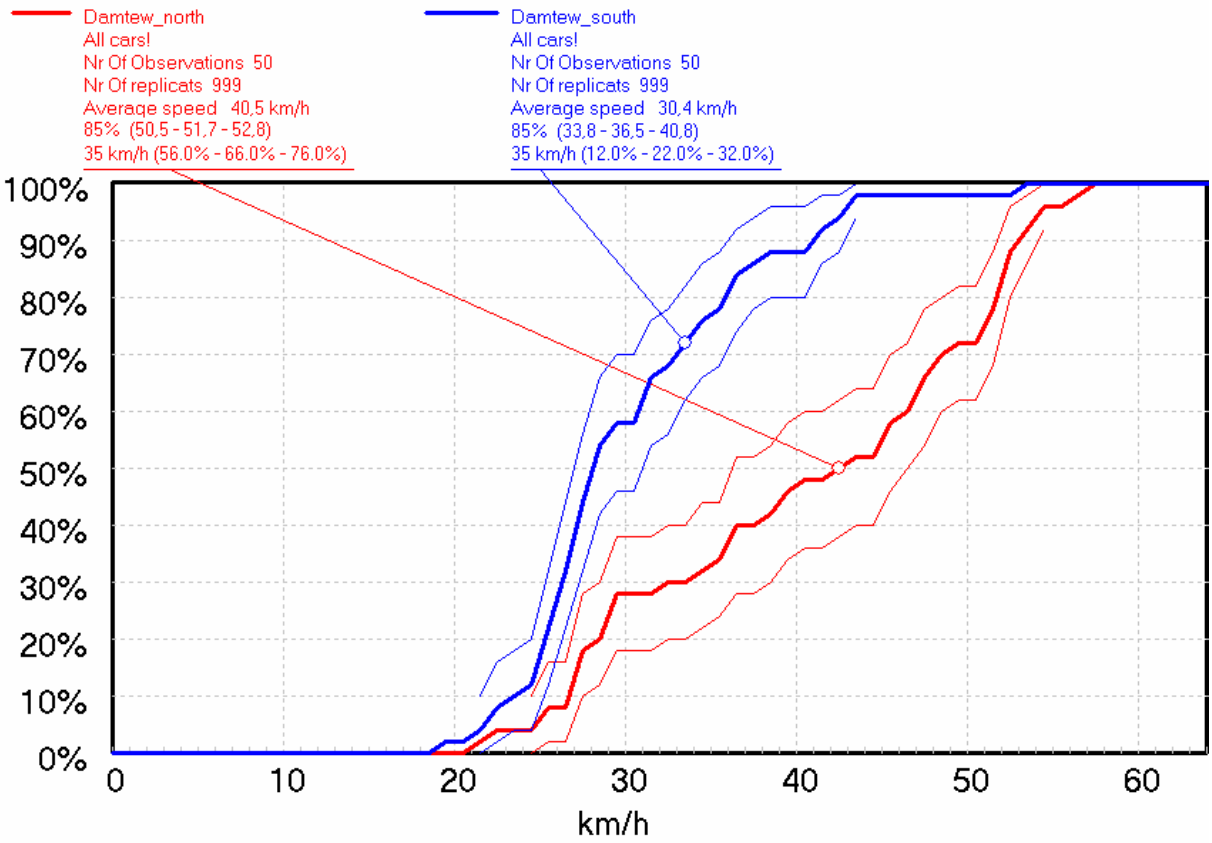

Edgeth_east_east
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 49,0 km/h
85% (52,8 - 58,8 - 61,8)
50 km/h (26.0% - 36.0% - 46.0%)
Edgeth_east_west
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 58,4 km/h
85% (68,8 - 72,3 - 76,1)
50 km/h (64.0% - 74.0% - 84.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
80
km/h

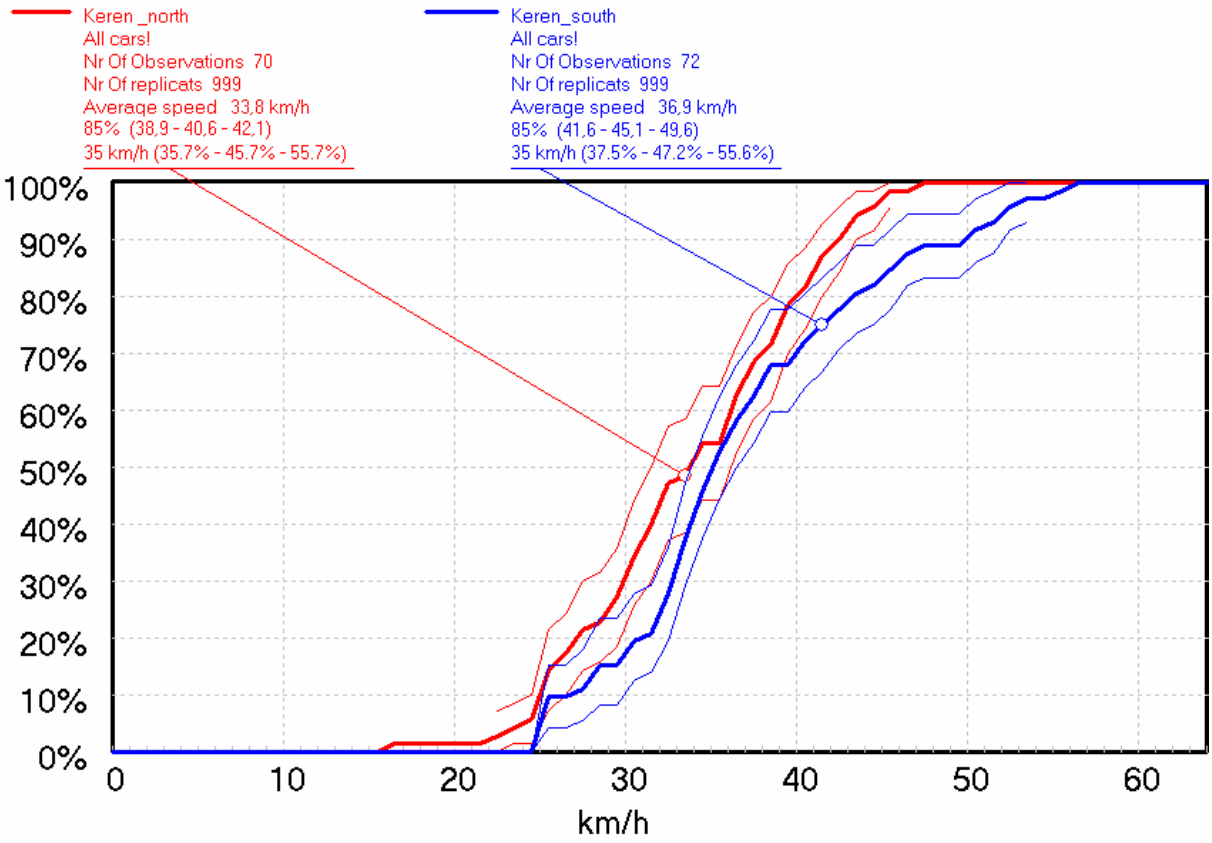

Andinnet_north
All cars!
Nr Of Observations 72
Nr Of replicats 999
Average speed 31,2 km/h
85% (34,9 - 37,0 - 38,2)
35 km/h (13.9% - 22.2% - 29.2%)
Andinnet_south
All cars!
Nr Of Observations 72
Nr Of replicats 999
Average speed 32,0 km/h
85% (35,8 - 36,6 - 37,1)
35 km/h (19.4% - 27.8% - 37.5%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
km/h

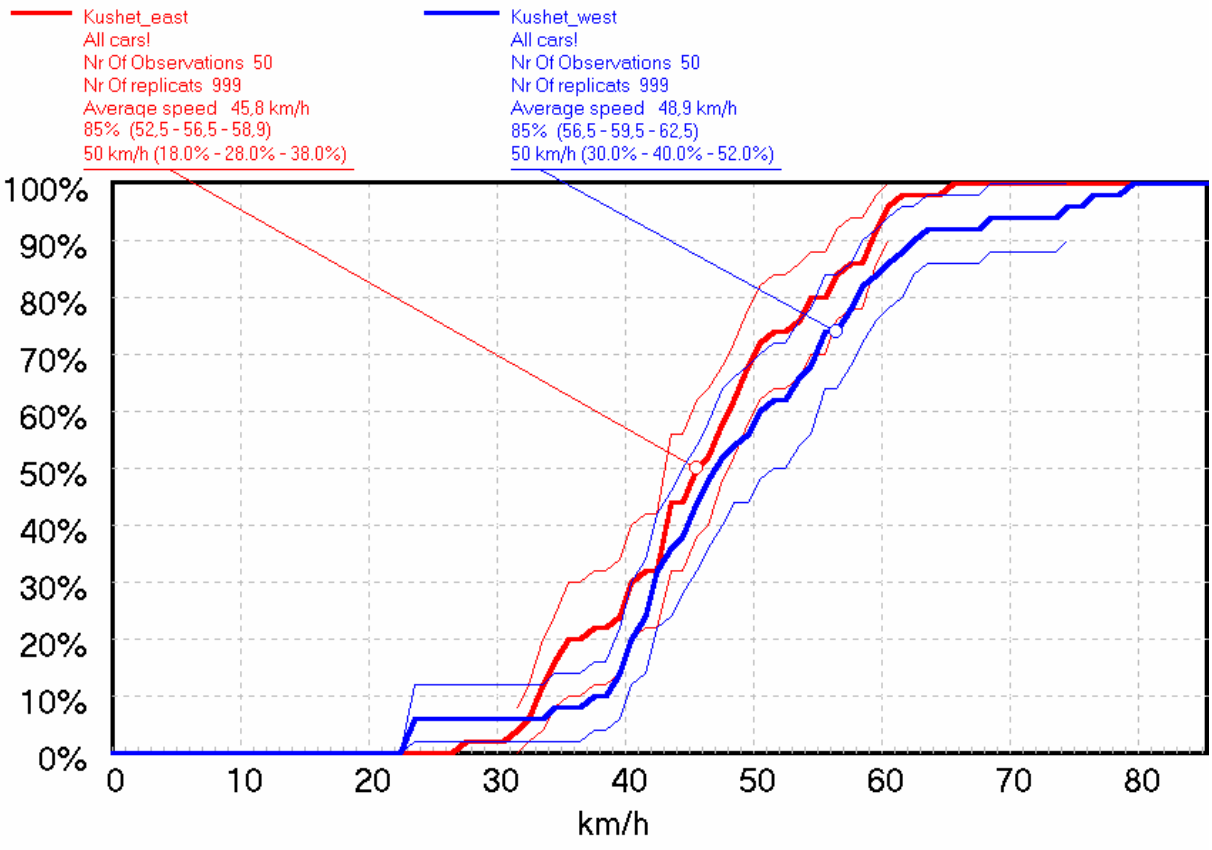

University_east
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 32,4 km/h
85% (36,0 - 38,8 - 42,0)
35 km/h (18.0% - 25.0% - 32.0%)
University_west
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 29,4 km/h
85% (33,6 - 35,4 - 37,3)
35 km/h (11.0% - 17.0% - 23.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
km/h


Brewery_north
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 35,9 km/h
85% (39,9 - 42,3 - 43,8)
35 km/h (36.0% - 48.0% - 60.0%)
Brewery_south
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 33,0 km/h
85% (35,9 - 39,3 - 42,5)
35 km/h (22.0% - 32.0% - 44.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
km/h


Kehauta_north
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 30,1 km/h
85% (37,4 - 41,0 - 44,0)
50 km/h (2.0% - 6.0% - 10.0%)
Kehauta_south
All cars!
Nr Of Observations 100
Nr Of replicats 999
Average speed 34,3 km/h
85% (39,2 - 40,3 - 41,8)
50 km/h (0.0% - 1.0% - 3.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
80
km/h


Damtew_north
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 40,5 km/h
85% (50,5 - 51,7 - 52,8)
35 km/h (56.0% - 66.0% - 76.0%)
Damtew_south
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 30,4 km/h
85% (33,8 - 36,5 - 40,8)
35 km/h (12.0% - 22.0% - 32.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
km/h


Keren _north
All cars!
Nr Of Observations 70
Nr Of replicats 999
Average speed 33,8 km/h
85% (38,9 - 40,6 - 42,1)
35 km/h (35.7% - 45.7% - 55.7%)
Keren_south
All cars!
Nr Of Observations 72
Nr Of replicats 999
Average speed 36,9 km/h
85% (41,6 - 45,1 - 49,6)
35 km/h (37.5% - 47.2% - 55.6%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
km/h


Kushet_east
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 45,8 km/h
85% (52,5 - 56,5 - 58,9)
50 km/h (18.0% - 28.0% - 38.0%)
Kushet_west
All cars!
Nr Of Observations 50
Nr Of replicats 999
Average speed 48,9 km/h
85% (56,5 - 59,5 - 62,5)
50 km/h (30.0% - 40.0% - 52.0%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
80
km/h