ATTACHED REPORT 4

TRAFFIC SURVEY AND DEMAND ESTIMATION

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Table of Contents

M4.1 INTRODUCTION

The Study on Transport Master Plan in the Phnom Penh Metropolitan Area has been undertaken by the Department of Public Works and Transport, Municipality of Phnom Penh (DPWT/MPP) in cooperation with Study Team dispatched by Japan International Cooperation Agency (JICA) which is responsible for implementation of the technical cooperation programme of the Government of Japan.

The objective of the Study is to formulate a master plan of the urban transportation system for Phnom Penh Metropolitan Area in consideration of land use plan proposed by the said Municipality. The master plan will be composed mainly of road network system, traffic management and mass transit system.

Purpose

Traffic survey has obtained the facts of existing conditions concerning the movement of people and goods in Phnom Penh Metropolitan Area. The results of the survey will reveal the existing problem regarding to the transportation that are important in the formulation of a reliable and economical plan for the improvement of transport system in the Study Area.

Traffic surveys consist of mainly interview and traffic count and require systematical approach and well-trained interviewers and/or surveyors with self-reliance supervisors. This manual provides guidelines for all personnel involved, from planning level to field survey level, about the 5W1H (When, Where, Who, What, Which, and How) of the traffic surveys.

Scope

The following chapters are describing the each type of traffic surveys, namely (i) Person-Trip Survey, (ii) Cordon Line Survey, (iii) Screen Line Survey, (iv) Roadside Traffic Volume Survey, (v) Intersection Traffic Movement Survey, (vi) Travel Speed Survey, (vii) Commodity Movement Survey, (viii) Parking Condition Survey, and (ix) User & Operator Survey.

Person-Trip Survey, Commodity Movement Survey, and User & Operator Survey will be carried out with direct interview method. On the other hand, Screen Line Survey, Roadside Traffic Volume Survey, and Intersection Traffic Movement Survey will be carried out with traffic counts. Cordon Line Survey and Parking Condition Survey will be required both interviewing and counting. Besides these, Travel Speed Survey will be carried out with floating car method.

M4.2 PERSON-TRIP SURVEY (HOUSEHOLD INTERVIEW) AND ARRANGEMENT

To grasp the present conditions concerning the movements of people, and to reveal the present and future transport related issues, Person-Trip (P.T.) Survey, in other words O.D. (Origin & Destination) Survey by Household Interview, shall be carried out throughout the Study Area.

Survey Area (Traffic Zone)

The Study Area shall be divided into specific sub-survey area, in other word inner traffic zone. The inner traffic zone arrangement (zoning) shall be depended upon the size of the Study Area and available socio-demographic data, such as population census, commercial and/or industrial statistics, or land use pattern. For example, the small-size traffic zone (*C Zone*) shall be commune to sub-district level or much smaller block(s) with similar pattern of land use, such as residential, commercial, or in-

dustrial area. The middle-size traffic zone (*B Zone*) shall be sub-district to combined sub-district level. The large-size traffic zone (*A Zone*) shall be district to combined district level. On the other hand, outside the Study Area, intensive traffic zone, such as province leveled zoning shall be applied.

Sampling Ratio

The sample size required to achieve a precision of *r* units with [100 (1-α)] percent confidence is:

$$n = \frac{[Z_{1-(1/2)\alpha}]^2}{r^2} \cdot \frac{(1-p)}{p}$$

Where n = sample size

p = *observed value of the proportion of the data item in the population (e.g., percentage of trip types of all trips made in an area)*

r = *relative error from the true mean value (margin of error or precision, expressed as a fraction of the mean value)*

α = *fraction of area under normal curve representing events not within confidence level (Thus, 1-*α *is desired level of confidence)*

$Z_{1-(1/2)\alpha}$ = *standard normal statistic corresponding to the 1-*α *confidence level (found in tables in any statistics book)*

For example, suppose planner wished to estimate the total number of trips for one trip type within an urban area, and it was estimated that 10 percent of all trips in the area (p = 0.10) were indeed of this trip type. Assume that planners require an estimate of this number within ± 5 percent (r = 0.05) of the real value 95 percent of the time (α = 0.05). That is:

$$n = [(1.96)^2/(0.05)^2] \times [(1-0.10)/0.10] = 13,830$$

Thus, 13,830 observations are needed to achieve the specified level of precision.

Because some survey method rely on voluntary questionnaire return, and given that many individuals contacted will not respond, the sample size in such cases must be adjusted by the expected response rate.

Suppose the sampling method used would be direct interview in which, even though, planner expected to have only 50 percent response rate considering the absence of some household members during the survey. Assume that average household size of the Study Area is 5.7 persons per household according to the Population Census in 1998, and at least one of the members of each household might be younger than aged 5 years old, thus shall be discarded. In such situation, the required sample household number would be:

$$N = [n / (h-1)] \times (1/s) = [13,830 / (5.7-1)] \times (1/0.50) = 5,885$$

Where N = *sample size (household)*

n = *sample size (individual)*

h = *average household size*

s = *expected response rate*

As a result, almost 6,000 households, it is roughly 3 percent [= 6,000 / (1,150,000 / 5.7)] of projected number of household in the Study Area is needed to be sampled, since the projected population within the Study Area would be reaching around 1.15 million in year 2000. Consequently, sampling ratio with

not less than 3 percent of households from each sub-district (traffic zone) shall be required to be visited and interviewed to accomplish the enough level of accuracy.

Contents of the Survey

The main purpose of the survey is to obtain the information on all trips made by all member of the household, except those who are five (5) years old or younger, on the day previous to the interview. With this context, following items regarding to the daily trips shall be collected from the sampled households.

- Household Attributes, such as number of household members, vehicle ownership by categories (car, motorbike, and bicycle), household income, address of the residence, parking space, etc.
- Personal Attributes, such as gender, age, occupation, sector, driving license possession, place of work and/or school, number of daily trips, etc.
- Trip Descriptions, such as trip origin and destination, trip purpose, number of sub-trips, criteria for selection of existing and proposed trip mode (time, cost, reason why, etc.)

Procedure and Accomplishment of the Interview

Household selected preceding to the interview from each traffic zone at random basis shall be questioned by the direct interview method. Basic procedure of the interview shall be followings:

a. Prior to the interview, the manager/controller and the supervisor shall be made a courtesy call to each district and/or sub-district office to show the request letter provided by the municipality office and name list of the interviewers with schedule of the interview to obtain the permission of entering into and implementing the interview within their administrative area, if required, and to request the announcements to the residents throughout the survey area.
b. On the interview day, the supervisor and interviewers shall be showing up to the district or sub-district office in order to receive necessary advice and/or information, provided by the administrative officer, regarding to the smooth implementation of the interview in each survey area.
c. After assigning of each survey area to each interviewer, the interviewer shall find the house listed in the sampling list. The zone code list(s) and/or reference map(s) will help him/her to find the house. If he/she is not able to find the house, he/she shall ask the neighbors or commune chief about the location of the house. And if he/she encounters the following circumstances, he/she shall consult directly to the supervisor:
    i. All member of the household have been transferred.
    ii. A household in the sampling list cannot be identified in the address listed.
    iii. A household in the sampling list has been demolished or vacant.
d. The household listed in the sampling list shall be identified before carrying out the interview. Names, ages, and gender of all member of the household in the sampling list with total number of the household members and number of vehicle ownership with parking space condition shall be recorded.
e. Household members shall be interviewed one by one or one after the other. All questions in the home interview form shall be asked. One personal interview form shall be for one person who is older than five years old.
f. When the interview on one person is finished, check the forms whether there is any missing information or not. If none, proceed to another person.
g. If the interviewer is not able to finish the interviews on all members of the household due to ab-

sence of some members of household or any other reasons, a call-back card informing the date of re-visit shall be left.

h. When all members have been interviewed, all forms regarding to one household shall be put into one envelope and written the code number of the household and other information on the envelope. And then, proceed to another household.

i. Interviewer shall be expected to make interview to four (4) to six (6) households per day, including re-visits and time used in going from one house to another. Therefore, around twenty-five (25) households shall be interviewed per week under the condition of visiting households from Tuesday to Saturday to grasp each household daily trip situations during the weekday (Monday to Friday). Weekend (Saturday and Sunday) and National Holiday's trip information shall be avoided unless otherwise the Authority would like to do so for special purposes, such as tourism and/or to grasp daily frustrations within the week.

It is very important that the interviewers shall be polite at all times. Introducing him/herself politely like this; "Good morning/afternoon, Sir/Madam. I am (give your name), from the Phnom Penh Metropolitan Area Transport Master Plan Study Team. You have probably heard that we are conducting a Person-Trip Survey by household interview." The interviewers shall be aware of following points:

a. Interviewer may be asked to enter and take seat, but shall not expect always like this courtesy. He/She shall be friendly with person he/she is interviewing, but shall not discuss any controversial subjects, such as politics, religion, and so on. He/She shall avoid argument or a prolonged discussion on any questions in the survey form or which made by the interviewees. He/She shall be prompt in doing his/her work, and shall not waste time. When he/she has finished the interview, thanks the interviewees and proceeds to the next household.

b. If any person refuse to answer the question in the survey form, interviewer shall explain to him/her that the information made by him/her shall be strictly confidential, that it shall not be accessible to any other person except to specified members of the Study Team, and that it shall be used for transport master planning purpose only. And also, the interviewer has to explain that the statements made by the interviewees shall not be self-incriminating.

c. However, after all tactful means have been resorted to and interviewer still fails to obtain the necessary information, he/she shall write down, "Refused to Answer" into the remarks of the sampling list, and report this matter to the supervisor as soon as possible. Interviewers shall not argue nor lose their attitude in any circumstances.

<u>Detail of the Interview Form</u>

I. Household & Personal Attributes Form (Refer to Figure M4.2-1)

Household Attributes

1. Trip Date (day - month): Enter the date of trip made (basically, one day before interviewing day)
2. Number of Cars for Full-Time Use: Enter total number of household owned car that any of household members may be able to use full-time base for any purpose.
3. Number of Cars for Part-Time Use: Enter total number of company or government hold car or the other car beside the household own car that one of household members may be able to use part-time base for specific purpose, such as commuting to/from office, and/or going to/coming from business direct from/to their home.
4. Number of Motorcycles: Enter total number of household own motorcycles.

5. Number of Bicycles: Enter total number of household own bicycles.
6. Number of Residents: Enter total number of household members; it includes not only family member but also relatives, boarding students, and living-in employee or maid, and so on.
7. Number of Residents Over 5 Years Old: Enter total number of household members who are older than 5 years old. (Number of residents minus number of residents who are 5 years old or younger)
8. Monthly Income: Enter the corresponding number of monthly income level (1~7) indicating below the form. For example, if husband earns around 400,000 Riel (roughly US$100) and his wife earns around 200,000 Riel (roughly US$50) per month, total household income becomes around 600,000 Riel (roughly US$150), then enter "3", since it falls within "500,000~750,000" Riel.
9. Total Daily Trips (Sum of Each Person's Trips): Enter total number of daily trips made by each person of the household members who are older than 5 years old. For example, household owner made 6 trips, while his wife made 4 trips, their son and daughter made 3 trips each, and owner's parents and baby did not make any trips, in this case, it shall be 16 trips (= 6 + 4 + 3 + 3).
10. Parking for Private Vehicles (Do you have private parking space?): Enter either "1" or "2" into the first row according to the first question's answer is either "Yes" or "No". And enter either "1" or "2" into the second row according to the second question's answer is either "On-Street" or "Off-Street". For the third row and the forth row, enter the corresponding number (1~7) indicating below the form in accordance with its "Payment Method" and "Amount Paid", respectively. For example, if household owner parks his/her car on the sidewalk or shoulder of the street, the first answer shall be "No", and the second answer shall be "On-Street", then "Payment Method" may be "Weekly" with "Amount Paid" around "100,000" Riel per week for night watch, the answers for the first to the forth rows shall be "2", "1", "4", and "3" respectively, since amount paid falls within "10,000~15,000" Riel per day.
11. Vehicle Type & Age: Enter type of owned car by name of maker-model, such as "Toyota-Camry", "Mitsubishi-L2000", and their year of product, such as "1995", "1998", if interviewed household owns car(s).
12. Address: Enter building and street numbers into the first row "Address", name of the household owner into the second row "Family Name". Then enter sub-district name into the third row "Zone Name", while the forth row "Zone No." shall be referred to the code number lists provided separately.

Personal Attributes

1. Personal Interview: Enter either "1" or "2" according to interview succeeded "Yes" or not "No".
2. Sex: Enter either "1" or "2" according to the interviewee's gender is "Male" or "Female".
3. Age: Enter actual age of the interviewees, and then enter also the corresponding code number in the coding list provided separately.
4. Occupation: Enter the job name of the interviewees, and then enter also the corresponding code number of the occupation categories indicating below the form.
5. Sector: Enter the corresponding code number of the occupation sector indicating below the form.
6. Driving License: Enter either "1" or "2" according to the interviewee's possession of driving license(s) is "Yes" or "No".
7. Place of Work/School: Enter name of company/government office/organization, and then enter also its location by zone code, if interviewee(s) are already retired and/or housekeeper, no

need to fill up this column, and if interviewee(s) do not have any particular place of work, such as motodop and/or cyclo driver(s), or site worker(s), fill the interviewee's most frequently staying place and/or site location.

8. Number of Daily Trips: Enter the sum of daily trips made by each interviewee(s), which described in the second individual form(s) showing trip informations.

II. Level of Service Variable & Trip Attributes Form (Refer to Figure M4.2-2)

Trip Attributes

1. Trip Number: Enter trip number starting from "1" to at least "2", or "3", "4", "5" according to the interviewee's daily number of trips. If interviewee(s) made more than 5 trips per day, use additional form(s).

2.1 Zone (Trip Origin): Enter the address of trip origin and its code number according to the coding list provided separately. In most case, the Origin of Trip No.1 shall be the address of the interviewee's residence. However, if he/she stayed friend or relative house previous night, or he/she has night shift job, such as law enforcement and/or medical service related occupation, in this case Origin of Trip No.1 shall be the address of his/her friend or relative house or working place. And the Origin of Trip No.2 shall be the Destination of Trip No.1. Therefore, it is not necessary to fill up the Origin of Trip No.2, and so on.

2.2 Zone (Trip Destination): Enter the address or name of trip destination and its code number according to the coding list provided separately. If the interviewee's destination is outside the Study Area, enter province or municipality name and its code number. In case of the interviewee is not able to answer the exact address of his/her destination, either one of the following informations shall be obtained:

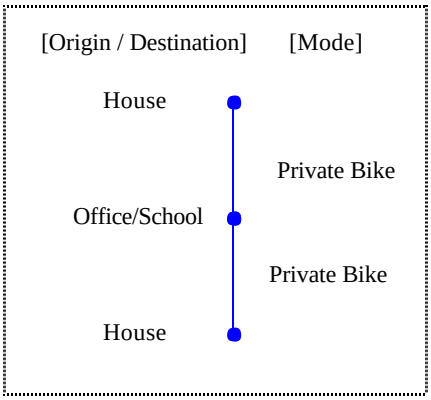
a. Direction and Nearest Street Corner
   Example: Northeast / Monivong & Sihanouk Blvds.
b. Direction and Nearest Land Mark (Monument, Market, Government Building, etc.)
   Example: Southwest / Independent Monument

3. Trip Purpose: Enter the corresponding code number (1~6) of the trip purpose indicating below the form. If the trip purpose does not match any of six (6) classifications mentioned above, enter "0" as "Others".
   a. Work trips: Trips made to a person's place of employment such as factory, a store, or an office.
   b. Business trips: Trip made in the course of performing a normal day's work. The origin of such trips is often the place of employment.
   c. School trips: Trips made by students to an institution of learning.
   d. Shopping trips: Trips made to a retail establishment regardless of the size or type of purchase. Trips made to a store "just to look" are shopping trips even though no purchase is made.
   e. Social or recreation trips: cultural trips made to recreation or entertainment facilities (e.g., pagoda, civic meetings, concerts, sporting events, etc.) Travel to social activities (parties, visiting friends, dinner, etc.) would be included.
   f. Home trips: Trips made to a house from where a person visited regardless its primary purpose of trips.

Meaning of the "Trip(s)"

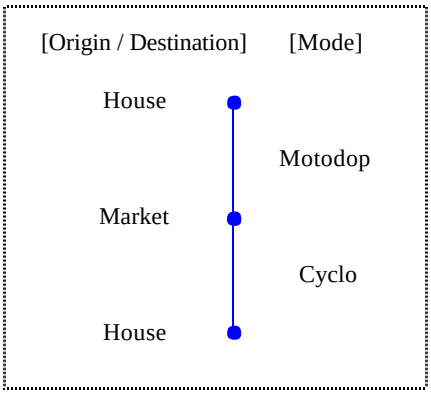
Followings are samples of "Trip(s)". The word of "Trip(s)" here is not meaning only something special journey, such as tour trip to resort and/or overseas. This is simply technical term to represent the daily basis movement, such as movement between your house and working place, school, market, etc., or between two different places where you visited. Therefore, number of daily trips is usually more than "Two", unless otherwise you stayed overnight somewhere beside your house or you were backing home from night shift or any other purpose and no other trip was made within same day.

Sample-1:



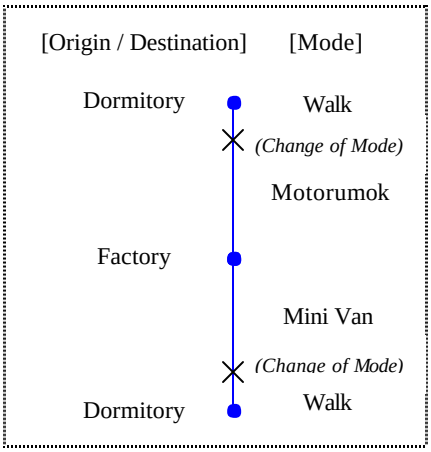
In this sample, interviewee went office or school by his/her motorbike, and then returned his/her house and no other trip was made within the same day. Therefore, number of daily trips shall be "Two" and mode of trip 1 and 2 shall be both "Private Bike." In addition, purpose of trip 1 shall be "Work" or "School" respectively and trip 2 shall be "Home." In this case, interviewee shall be also obtained each trip time.

Sample-2:



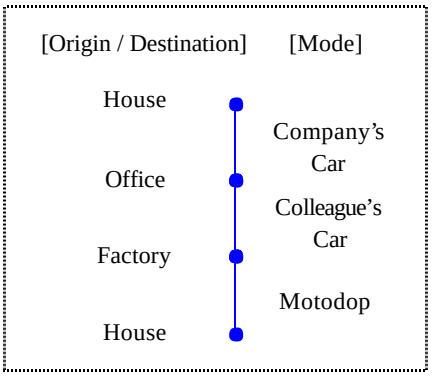
In this sample, interviewee went market by motodop (motorbike taxi), and then returned his/her house by cyclo and no other trip was made within the same day. Therefore, number of daily trips shall be "Two," mode of trip 1 shall be "Motodop," and trip 2 shall be "Cyclo." In addition, purpose of trip 1 shall be "Shopping" or sometimes "Work" or "Business" (It depends on his/her nature of business) and trip 2 shall be "Home." In this case, interviewee shall be also obtained each trip time as well as waiting time at near the house and/or market to wait for motodop and/or cyclo respectively, if he/she had to do so.

Sample-3:



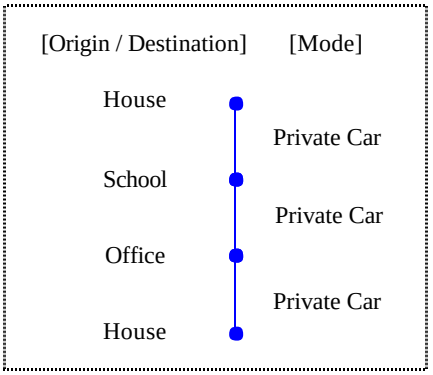
In this sample, interviewee went picking-up point by walk and took factory-hired motorumok (motorbike trailer) up to factory. Then he/she returned by company's mini-van up to nearest dropping point and walk to his/her dormitory. No other trip was made within same day. Therefore, number of daily trips shall be "Two," mode of trip 1-1 and 1-2 shall be "Walk" and "Motorumok," and trip 2-1 and 2-2 shall be "Mini-Van" and "Walk" respectively. In addition, purpose of trip 1 shall be "Work" and trip 2 shall be "Home." In this case, interviewee shall be also obtained each trip time as well as his/her waiting time at picking-up point and/or factory to wait for company-hired or operated motorumok or mini van, correspondingly.

Sample-4:



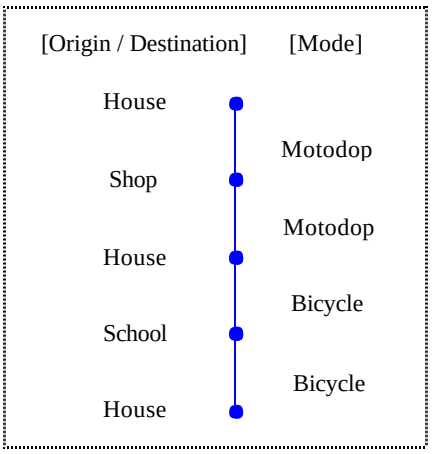
In this sample, interviewee went office by company's car that he/she drove back previous night, and then went factory by his/her colleague driven car, after that, he/she went back his/her house directly by motodop. Therefore, number of daily trips shall be "Three," mode of trip 1 and 2 shall be "Car," and trip 3 shall be "Motodop." In addition, purpose of trip 1, 2, and 3 shall be "Work," "Business," and "Home," respectively. In this case, interviewee shall be also obtained each trip time as well as waiting time at near the factory to wait for motodop, if he/she had to do so.

Sample-5:



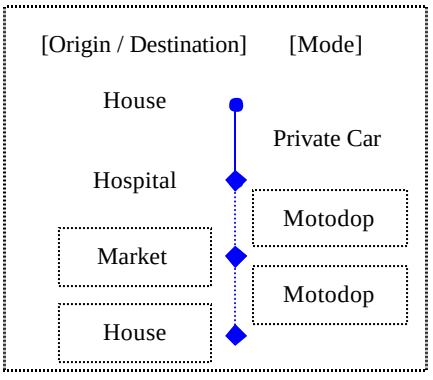
In this sample, interviewee went his/her children's school to drop them before going to his/her office by his/her private car in the morning. In the afternoon, he/she went back to the house directly by the car. No other trip was made within same day. Therefore, number of daily trips shall be "Three," mode of trip 1, 2, and 3 shall be all "Car." In addition, purpose of trip 1, 2, and 3 shall be "Other," "Work," and "Home," respectively. In this case, interviewee shall be also obtained each trip time.

Sample-6:



In this sample, interviewee went shop where he/she employed as shop clerk by motodop in the morning. Then he/she went back to the house to take lunch by motodop. In the afternoon he/she went to school and after school he/she went back to the house. No other trip was made within same day. Therefore, number of daily trips shall be "Four," mode of trip 1 and 2 shall be "Motodop," and mode of trip 3 and 4 shall be "Bicycle." In addition, purpose of trip 1, 2, 3, and 4 shall be "Work," "Home," "School," and "Home," correspondingly. In this case, interviewee shall be also obtained each trip time and waiting time to catch motodop for trip 1 and 2, if he/she had to do so.

Sample-7:



In this sample, interviewee went hospital by his/her partner's car for night shift. Following day he/she go back to house by motodop, but he/she just stopped at market to get something. No other trip was made within previous day or following day. Therefore, number of daily trips for first day shall be only "One," and mode of trip shall be "Car," if this is the previous day of interviewing. The movement from hospital (working place) through market to house shall be discarded, because this day was not previous day of interviewing. In addition, purpose of trip shall be "Work" only. Interviewee shall be also obtained a trip time.

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Home Interview Survey
(Household & Personal Attributes)

Page ……….. of …………

1. Trip Date (day - month) ☐☐
2. No. of Cars for full time use ☐
3. No. of Cars for part-time use ☐
4. No. of Motercycles ☐
5. No. of Bicycles ☐
6. No. of residents ☐
7. No. of Residents over 5 years old ☐
8. Monthly Income[*3] (in Cambodian Riel) ☐
9. Total Daily Trips ☐
(Sum of each person's trips)

10. Parking for Private Vhiecles
• Do you have private parking space?
1. Yes 2. No. ☐
1. On-Street 2. Off-Street ☐
- Payment Method[*4] ☐
- Amount Paid[*5] ☐

11. Vehicle Age

Type	Age
☐	☐
☐	☐
☐	☐

Address
Address: ☐
Family Name: ☐☐
Zone Name: ☐
Zone No. ☐

For Official Use Only

Date	Time
☐	☐
☐	☐
☐	☐

No. of Person	Personnel Interview 1. Yes 2. No.	Sex 1. Male 2. Female	Age	Occupation[*1]	Sector[*2]	Driving License 1. Yes 2. No.	Place of Work/Study	No. of Daily Trips
1			☐	☐	☐		☐	
2			☐	☐	☐		☐	
3			☐	☐	☐		☐	
4			☐	☐	☐		☐	
5			☐	☐	☐		☐	
6			☐	☐	☐		☐	
7			☐	☐	☐		☐	
8			☐	☐	☐		☐	

1st Surveyor:_______________________

Date:______________-__________, 2000

2nd Interviewer:_____________________

Date:______________-__________, 2000

Supervised by:______________________

Checked by:________________________

[*1] Occupation: 1. Freelance / Self Employee 2. Clerk 3. Driver 4. Housewife 5. Student 6. Company Executive 7. Company Employee 8. Public Servant 0. Other

[*2] Sector: 1. Agriculture 2. Mining 3. Industry 4. Construction 5. Transport 6. Government Services 7. Commerce 8. Finance / Insurance 0. Other Services

[*3] Monthly Income: 1. (〜250,000) 2. (250,000〜500,000) 3. (500,000〜750,000) 4. (750,000〜1,000,000) 5. (1,000,000〜1,250,000) 6. (1,250,000〜1,500,000) 7. (1,500,000〜)

[*4] Payment Method: 1. Free 2. Hourly 3. Daily 4. Weekly 5. Monthly 6. Annually 0. Others [in Cambodian Riel]

[*5] Amount Paid 1. (〜5,000) 2. (5,000〜10,000) 3. (10,000〜15,000) 4. (15,000〜20,000) 5. (20,000〜25,000) 6. (25,000〜30,000) 7. (30,000〜) [in Cambodian Riel]

Figure M4.2-1 Example of Household & Personal Attributes Form

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Home Interview Survey
(Level of Service Variables & Trip Attributes)

Answering Person's No. ( )

Page ……….. of …………

Trip No.	Zone		[*1] Trip Purpose	No. of Sub-Trip	Dry Season's Sub-Trip					Rainy Season's Sub-Trip					If there is available bus service,			
	Trip Origin	Trip Dest.			[*2] Sub-Trip Mode	Waiting Time [in min.]	Travel Time [in min.]	[*3] Trip Cost/ Expense	[*4] Why do you use this?	[*2] Sub-Trip Mode	Waiting Time [in min.]	Travel Time [in min.]	[*3] Trip Cost/ Expense	[*4] Why do you use this?	[*5] Will you use it?	[*6] What do you expect?	[*7] How much can you pay?	[*8] How long can you wait?
☐	☐	☐	☐	1														
				2														
				3														
				4														
				5														
☐	☐	☐	☐	1														
				2														
				3														
				4														
				5														
☐	☐	☐	☐	1														
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☐	☐	☐	☐	1														
				2														
				3														
				4														
				5														
☐	☐	☐	☐	1														
				2														
				3														
				4														
				5														

[*1] 1. Home 2. Work 3. Business 4. School 5. Social 6. Shopping 0. Others

[*2] 1. Passenger Car 2. Taxi 3. Light Bus/Pass.Van 4. Pick-up/Cargo Van 5. Truck/Trailer 6. Large Bus 7. Motorcycle 8. Motodop 9. Motorumo 10. Cyclo 11.Bicycle 0. Walking 00. Others

[*3] 1. (〜250) 2. (250〜500) 3. (500〜750) 4. (750〜1,000) 5. (1,000〜) [in Cambodian Riel]
[Average Fare for One-way Motodop/Mortorumo/Cyclo/Bus/Taxi ride, or Average Expenses (ex. Parking Fee and Fuel & Oil Cost) of One-way Drive for Private Vehicle User]

[*4] 1. convenience 2. cheapness 3. fastness 4. safety 5. luxuries 6. reliability 7. weather 8. luggage(s) 9. accompany(ies) 0. no particular reason

[*5] 1. Yes 0. No

[*6] 1. convenience 2. cheapness 3. fastness 4. safety 5. luxuries 6. reliability 0. no idea

[*7] 1. (〜250) 2. (250〜500) 3. (500〜750) 4. (750〜1,000) 5. (1,000〜) [in Cambodian Riel]

[*8] 1. (〜5) 2. (5〜10) 3. (10〜15) 4. (15〜20) 5. (20〜30) 6. (30〜) [in minutes]

Figure M4.2-2 Example of Level of Service Variable & Trip Attributes Form

M4.3 CORDON LINE SURVEY AND ARRANGEMENT

Cordon Line is one kind of imaginary line at boundary of the Study Area to verify the total number of both entering and leaving vehicles that are not based on the Study Area, and therefore that are not obtainable through Person-Trip Survey (Household Interview) and/or Commodity Movement Survey which are basically targeting the movement of vehicle and personnel or goods within the Study Area. In addition, information of origin and destination from the passenger and/or driver of the sampled vehicles are also collected through this survey to obtain the characteristics of the vehicle and personnel or goods crossing the boundary of the Study Area.

Classified Vehicle Counting

This Survey shall be conducted for 24 hours from 06:00 in the morning to 06:00 in the following morning at the high night-traffic routes such as National Route No.1 to No.6. And at least 12 hours, preferably 14~16 hours, survey from 06:00 in the morning to 18:00 or 20:00~22:00 in the evening shall be conducted at the low night-traffic routes such as National Route No.21 and Street 369. Both traffic entering and leaving the Study Area shall be counted separately according to the vehicle's classifications (i.e. passenger car, pick-up, bus, truck & trailer, motorcycle, etc.) and recorded for every 15-minute interval.

Roadside OD Interview

This Survey shall be conducted for at least 12 hours from 06:00 in the morning to 18:00 in the evening at both National Route No.1 to No.6, Route No.21 and Street 369. Not less than 10~20% from the entire traffic shall be stopped at random basis and then interviewed their origin and destination with the other necessary informations regarding the trips and occupancy or cargo items. If high rate of motorcycle related traffic is observed, at least 5~10% from entire motorcycle traffic shall be stopped and interviewed accordingly.

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Classified Vehicle Counting Form (Cordon Line / Screen Line / Road Side)

Page ……. of …….

Station Number: ☐☐ Street Number: ☐☐☐ Zone: Direction / From: _____ To: _____ ☐☐☐ ☐☐☐ Date: Month / Day: ☐☐☐☐

Hours	1. Passenger Cars	2. Taxi	3. Light Bus / Pass.Van	4. Pick-up / Cargo Van	5. Large Bus	6. Truck / Trailer	7. Motorumo	8. Motodop / Motorcycle	9. Cyclo	10. Bicycle	11. Others / Walking
06:00 - 06:15											
06:15 - 06:30											
06:30 - 06:45											
06:45 - 07:00											
07:00 - 07:15											
07:15 - 07:30											
07:30 - 07:45											
07:45 - 08:00											
08:00 - 08:15											
08:15 - 08:30											
08:30 - 08:45											
08:45 - 09:00											
09:00 - 09:15											
09:15 - 09:30											
09:30 - 09:45											
09:45 - 10:00											
10:00 - 10:15											

Figure M4.3-2 Example of Survey Form for Classified Vehicle Counting

Staff and Item Arrangements

Interviewers shall be stationed to interview drivers at interview bay arranged according to the drawing indicated below. Maximum duration of interview to one driver should not exceed 5 minutes. Writing Boards and/or Desks, Chairs, and Parasols, Traffic Corns and/or Sign Posts are necessary.

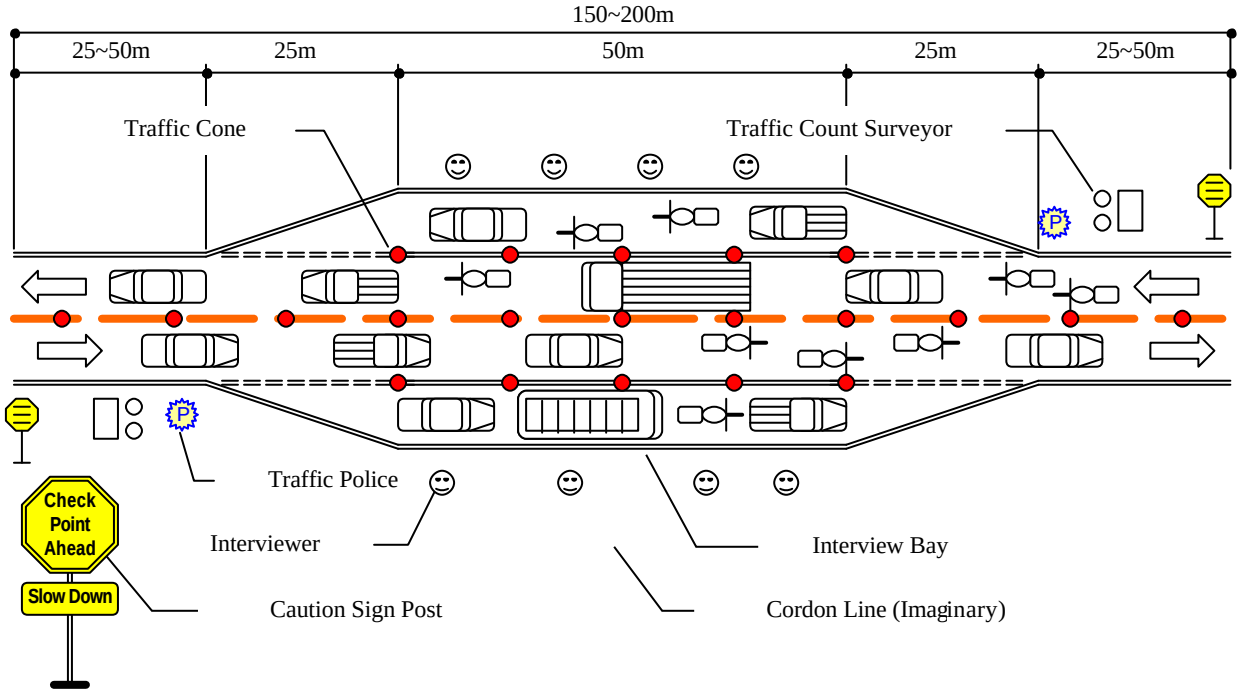


Figure M4.3-2 Typical Cordon Line Arrangement of Personnel & Items

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Roadside OD Interview Form (Cordon Line)

Surveyor …… □□ Date / / ( )/ 2000□□□□ Station …… □□ Direction ……□

Time: From_____,_____ □□□□ To_____,____ □□□□ Page …….. of ……

Vehicle Type	Number Plate	No. of Pass.	Origin	Destination	For Passenger Car, Taxi / Bus / Pass.Van		For Truck/Trailer Pick-up / Cargo Van.	
					Purpose		Load	Commodity
1 Passenger Car 2 Taxi 3 Mini Bus / Pass.Van 4 Pick-up / Cargo Van 5 Large Bus 6 Truck / Trailer 7 Motorumo 8 Motercycle / Motodop 9 Cyclo 10 Bicycle 11 Others / Walking			□□	□□	1 Home 2 Work 3 Business 4 School 5 Social 6 Shopping 0 Others		4/4 3/4 2/4 1/4 0/4	□□
1 6 2 7 3 8 4 9 5 10 11			□□	□□	1 6 2 0 3 4 5		4/4 3/4 2/4 1/4 0/4	□□
1 6 2 7 3 8 4 9 5 10 11			□□	□□	1 6 2 0 3 4 5		4/4 3/4 2/4 1/4 0/4	□□

Figure M4.3-3 Example of Survey Form for Roadside OD Interview

M4.4 SCREEN LINE SURVEY AND ARRANGEMENT

Screen Line is one kind of imaginary line to check both inbound and outbound traffic volumes between CBD (Central Business Districts) or Urbanized Area and the other Suburban Areas within the Study Area, and to adjust the result of the traffic volume estimation from the person-trip survey (i.e. household interview), at geographical and/or demographical border within the Study Area (i.e. river, canal, strait, railway, bridge, crossing point along the circumferential road, etc.).

Classified Vehicle Counting

This Survey shall be conducted for 24 hours from 06:00 in the morning to 06:00 in the following morning at high rate of night traffic routes like main arterials. And at least 12 hours, preferably 14~16 hours, survey from 06:00 in the morning to 18:00 or 20:00~22:00 in the evening shall be conducted at low rate of night traffic routes like sub arterials. Both traffic inbound for and outbound from the CBD shall be counted separately according to the vehicle's classifications (i.e. passenger car, pick-up, bus, truck & trailer, motorcycle, etc.) and recorded for every 15-minute interval.

Roadside OD Survey

This Survey is option, and if necessary to be carried out, the survey shall be conducted for at least 12 hours from 06:00 in the morning to 18:00 in the evening at both main and sub arterials. Not less than 10~20% from the entire traffic shall be stopped at random basis and then interviewed their origin and destination with the other necessary informations regarding to the trips and occupancy. If high rate of motorcycle traffic is observed, at least 5~10% from entire motorcycle traffic shall be stopped and then interviewed accordingly.

Staff and Item Arrangements

Arrangement of the survey shall be as same as the Cordon Line Survey, if Roadside OD Survey is required, and if it is not required, the arrangement shall be as same as the Roadside Traffic Counts.

M4.5 ROADSIDE TRAFFIC COUNTS AND ARRANGEMENT

To verify the traffic movements and to evaluate the result of the traffic assignment programme and/or traffic flow itself, following survey shall be carried out at selected sections of main and sub arterial streets and/or wherever necessary within the Study Area.

Classified Vehicle Movement Counts

This Survey shall be conducted for 24 hours from 06:00 in the morning to 06:00 in the following morning at the high rate of night traffic routes such as main arterials. And at least 12 hours, preferably 14~16 hours, survey from 06:00 in the morning to 18:00 or 20:00~22:00 in the evening shall be conducted at the low rate of night traffic routes such as sub arterials. Both directional traffic volume shall be counted separately according to the vehicle's classifications (i.e. passenger car, pick-up, bus, truck & trailer, motorcycle, etc.) and recorded for every 15-minute interval.

Staff and Item Arrangements

Basically, one (1) survey team shall consist of 4~6 staffs with one (1) supervisor, although one (1) supervisor may be able to cover two (2) or three (3) stations. And if necessary, one (1) more team shall be arranged for 24-hours operation to make a shift roll, or maximum of a half number of additional staff shall be arranged for 12~16 hours operation to make a rotation. Each of staff shall be stationed at both sides of the selected section of the road, and maneuver tarry counter(s) or manually count by marking that representing each vehicle's classifications. For example, Staff A counts motorcycles, and Staff B counts light and heavy vehicles, and Staff C counts cyclo, bicycles and pedestrians, something like this manner. Writing Boards and/or Desks, Chairs, and Parasols will be necessary at both sides of each counting station.

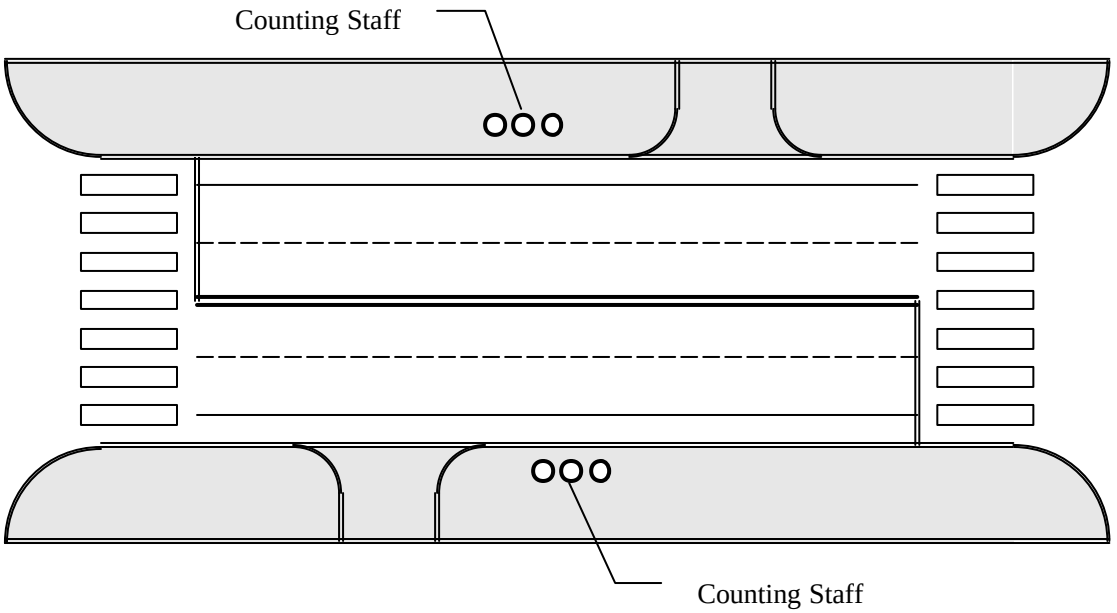


Figure A4.5-1 Typical Arrangements of Staff for Roadside Traffic Counts

Sheet No.:

Street /
Along:
Location /
Between:
&:
Direction /
From:
To:
Date:
Weather:
Surveyed by:
Supervised by:

Key Map

Vehicle Category / Hours	I: Light Vehicles				II: Heavy Vehicles		III: Motorcycles		IV: Cycles		V: Others
	Passenger Cars / 4WD	Sedan-Type Taxi	Mini Bus / Pass. Van	Pick-up / Small Truck	Standard & Large Bus	Large Truck / Trailer & Tractor	Motorumok	Motodop / Motorbike	Cyclo	Bicycle	Walking
06:00 - 06:15											
06:15 - 06:30											

Figure 4.5-2 Example of Field Form for Roadside Traffic Counts

Time			North Bound					
			I: Light Vehicles	II: Heavy Vehicles	III: Motor-cycles	IV: Cycles	V: Others	I ~ IV: Total
Passenger Car Unit			1.00	3.00	0.50	0.50	-	PCU
06:00	~	06:15						0
06:15	~	06:30						0
06:30	~	06:45						0
06:45	~	07:00						0

Figure 4.5-3 Example of Input Form for Roadside Traffic Counts

M4.6 INTERSECTION TRAFFIC MOVEMENT COUNTS AND ARRANGEMENT

To verify the traffic movement both inbound for and outbound from the CBD (Central Business Districts), and to ensure the result of the traffic assignment programme and/or traffic signal sequences, following survey shall be carried out at main intersections in the Study Area.

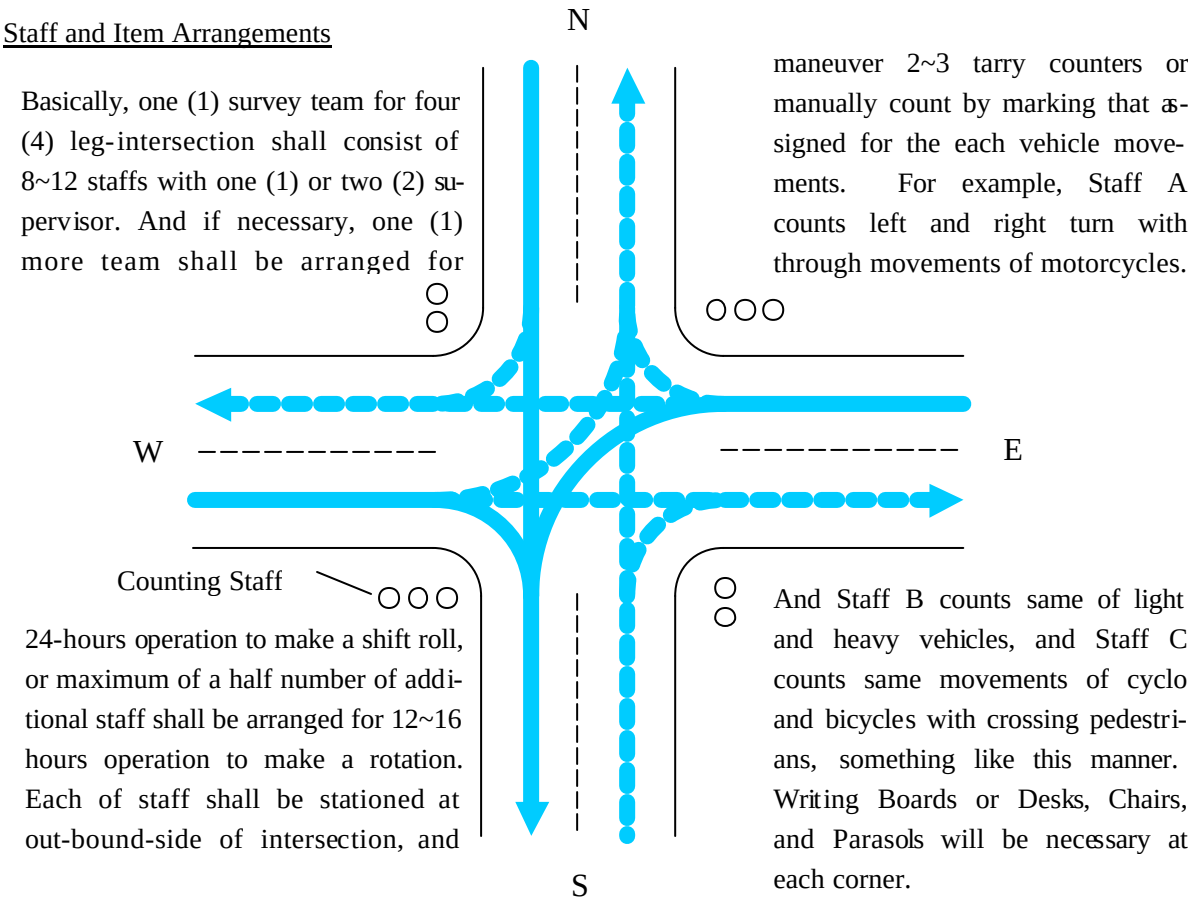
Classified Vehicle Movement Counts

This survey shall be conducted for at least 2~3 hours each during the morning-peak-hours and evening-peak-hours, preferably continuous 12~16 hours from 06:00 in the morning to 18:00~22:00 in the evening. Basically, the traffic outbound from the intersections shall be counted separately according to the vehicle's movements and classifications (i.e. left/right turn or through movements by light vehicle, heavy vehicle, motorcycle, bicycle, etc.) and recorded for every 15-minute interval.

Classified Vehicle Movement Locus (Traffic Flow)

After the survey, classified vehicle movement counts shall be summarized by direction and classifications with inbound total and outbound total figured out from passenger car unit (pcu) equivalent value (i.e. heavy vehicle = 3.0 pcu, motorcycle = 0.5 pcu, etc.), and if required, these traffic movements shall be indicated by direction and volume as shown in Example M4.6-3.

Staff and Item Arrangements



Basically, one (1) survey team for four (4) leg-intersection shall consist of 8~12 staffs with one (1) or two (2) supervisor. And if necessary, one (1) more team shall be arranged for 24-hours operation to make a shift roll, or maximum of a half number of additional staff shall be arranged for 12~16 hours operation to make a rotation. Each of staff shall be stationed at out-bound-side of intersection, and maneuver 2~3 tarry counters or manually count by marking that assigned for the each vehicle movements. For example, Staff A counts left and right turn with through movements of motorcycles. And Staff B counts same of light and heavy vehicles, and Staff C counts same movements of cyclo and bicycles with crossing pedestrians, something like this manner. Writing Boards or Desks, Chairs, and Parasols will be necessary at each corner.

Figure 4.6-1 Staff Arrangement at 4-leg Intersection

Intersection /		Location /		Key Map
of:	with:	(N / E / S / W)		N / E / W / S
Date:	Weather:	Surveyed by:		
Category / (I / II / III / IV / V)		Supervised by:		

Vehicle Category	I: Light Vehicles				II: Heavy Vehicles		III: Motorcycles		IV: Cycles		V: Others
	Passenger Cars / 4WD	Sedan-Type Taxi	Mini Bus / Pass. Van	Pick-up / Small Truck	Standard & Large Bus	Large Truck / Trailer & Tractor	Motorumok	Motodop / Motorbike	Cyclo	Bicycle	Walking
Direction											
Hours										Total quarters	Total hours
06:00 - 06:15										-	
06:15 - 06:30										-	

Figure M4.6-2 Example of Intersection Traffic Movement Counts Field Form

Time	South Bound							
	I: Light Vehicles				II: Heavy Vehicles			
	R. Turn	Through	L. Turn	Total	R. Turn	Through	L. Turn	Total
Passenger Car Unit	1.00	1.00	1.00	1.00	3.00	3.00	3.00	3.00
06:00 ~ 06:15				0				0
06:15 ~ 06:30				0				0
06:30 ~ 06:45				0				0
06:45 ~ 07:00				0				0

Figure M4.6-3 Example of Intersection Traffic Movement Counts Input Form

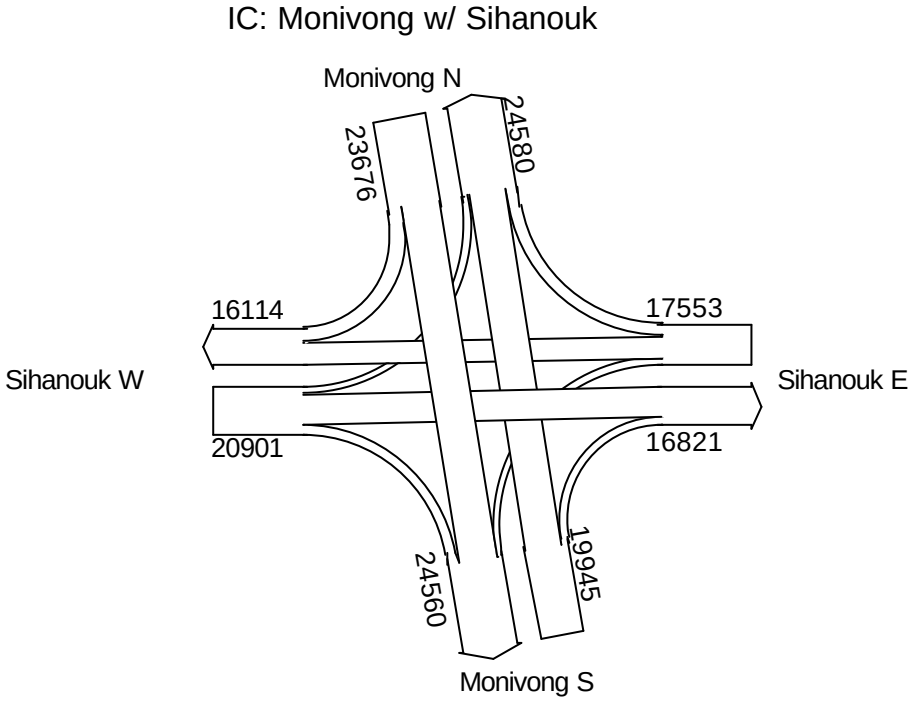


Figure M4.6-4 Example of Intersection Traffic Movement Locus (Traffic Flow)

M4.7 TRAVEL SPEED SURVEY AND ARRANGEMENT

Travel speed survey shall be carried out to grasp necessary data and informations to determine the bottleneck points of the entire traffic flow and to classify each section of road in accordance with each corresponding "Level of Service" (LoS). Several routes shall be selected along the arterial streets such as major radial roads and circular roads in the Study Area.

Survey Method and Time Duration

Floating car method shall be applied for this survey. Along each route of survey, at least one pair of cars shall be provided for checking both directions of traffic flow at the same time. Basically this survey shall be carried out during the peak time as well as off-peak time. In addition, to avoid misjudgment, several repetitions of survey shall be carried out during the designated periods of survey to obtain the average information. For example, at least three (3) repetitions of through running are recommended during the morning and evening peak-hours, and at least two (2) repetitions of through running are recommended during the other time such as lunchtime, and morning or afternoon off-peak hours. Before conducting the survey, several checkpoints shall be selected along the survey routes; mainly those checkpoints are major intersections with and/or without traffic signals and roundabouts crossing with the other arterial roads. During the surveys, time of passing the checkpoints and time of stop and re-start, in case of brief stopping, shall be recorded with cumulative distances, and if possible, reason of brief stopping on the survey form for judgments.

Staff and Item Arrangements

Two surveyors and one driver with a well-maintained car shall be required for each direction of survey route. One of the surveyors shall read the time of passing the checkpoint by second, and the same time, the driver also shall read out the odometers of the car by nearest 50m. The other surveyor shall record these data with reason of brief stopping, if necessary. Writing Board, Digital Watch, and Pencil or Pen is necessary.

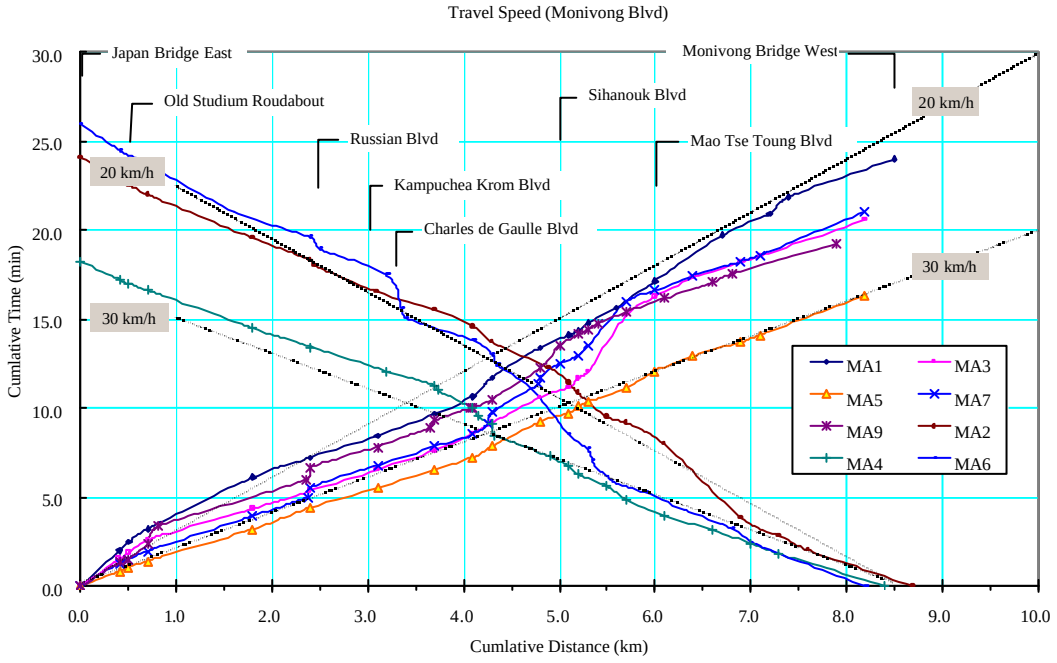


Figure M4.7-1 Example of Output for Travel Speed Survey

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Travel Speed Survey Form

Date: Page ……….. of …………

Route No.:__________________ Vehicle No.:_______________ Travel Time: From_____________ To:_____________

Supervisor:__________________ Recorder:_________________ Direction: From_____________ To:_____________

#	Check Point	Cumulative Distance (km)	Cumulative Time (hr:min:sec)			Stop Time (Second)		Sectional Distance (km)	Sectional Time (Second)	Average Speed (km/h)	Remarks

LT …..Left Turn (Upper box)
P …..Pedestrian (Upper box)
PK …..Parking (Upper box)
4W …..4-Way Stop (Upper box)
S …..Signal (Lower box)

Figure M4.7-2 Example of Survey Form for Travel Speed Survey

M4.8 COMMODITY MOVEMENT SURVEY AND ARRANGEMENT

Commodity movement survey shall be carried out to collect necessary data and information for estimating the movement of goods and cargo vehicles regarding to the road sector in the Study Area. Major transports related companies/factories (i.e. cargo, petroleum, construction, industry companies/factories, and some public service) shall be selected for to be interviewed in accordance with the size and category of the companies/factories at random basis in advance. Moreover, inter-regional terminals (i.e. airport, railway station, river port, and land port [container yard]) shall be also appointed for additional interview to cover feeder movements of inter-regional transport. Besides that, some international organizations (i.e. the Cambodia Red Cross, the World Food Programme [WFP], and the Cambodian Mine Action Center [CMAC]), based in the Study Area and operating their own fleets for relief activities, shall be appointed as well to cover still relatively large part of the role regarding the commodity movement throughout the country.

Interview Item and Method

Several teams of interviewers shall be deployed throughout the Study Area to collect necessary data with a request letter provided by the authority concerned, such as DPWT, MPWT, Ministry of Commerce or Municipality Office. At the selected companies/factories/warehouses, inter-regional terminals, and/or international organizations, if the records of freight operations are obtainable, they shall be collected, and if they are not obtainable, the cargo trucks coming into and going out from those facilities shall be interviewed directly at random basis. Table M4.8-1 and Figure M4.8-1 shows outline of the commodity movement survey and its survey form. In addition, record of vehicle registration of the appointed and not-appointed companies/factories/organizations shall be utilized for estimating the total number of cargo-related vehicle and vehicle-trip within the Study Area. Moreover, results of Cordon Line and/or Screen Line surveys will be utilized for adjusting these numbers.

Table M4.8-1 Outline of the Commodity Movement Survey

#	Survey Item	Contents
(1)	Company Attributes	- Name & Address of Company
		- Category
		- Number of Fleet
(2)	Trip Informations	- Number Plate (if possible)
		- Number of Trip per Day
		- Origin & Destination
		- Trip Time
		- Loading Items
		- Loading Volume

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA Study 2000
Commodity Movement Interview

Sheet No..... of .....

Surveyor:_____ Date: _____ / _____/ 2000

Location Name:_____ Location's Zone Code:_____

****

No. of Cargo Truck	Trip Time Hr. - Min.	Destination		Origin		Commodity Code	Commodity Weight (Ton)
		Name	Code	Name	Code		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Commodity Code: 1. Agriculture 2. Forest 3. Marine 4. Mineral 5. Metal & Machine 6. Chemical
7. Light Industry / Electronics 8. Miscellaneous Industry 9. Construction 0. Others.

Company Category: 1. Retail 2. Wholesales 3. Warehouse 4. Manufacture 5. Freight Industry 6. Construction
0. Others.

Figure M4.8-1 Example of Survey Form for Commodity Movement Interview

M4.9 PARKING CONDITION SURVEY AND ARRANGEMENT

Parking condition survey shall be carried out in designated area and/or blocks in CBD (Central Business Districts) area to obtain the data regarding to the parking supply and demand of mainly passenger car, and supplementary motorcycle and cyclo. This survey consists of Parking Space Inventory Survey and On-Street Parking (Count and Interview) Survey.

Parking Space Inventory Survey

This survey shall be conducted within the CBD area and/or wherever demand of parking is highly required, such as city markets or private supermarket and its adjacent area. Following data shall be collected through the field observation and recorded with systematical order such as by block or sub-district (traffic zone) basis and district basis. If plans of parking space are obtainable, surveyor or supervisor shall request officially to obtain these plans. If they are not obtainable, surveyor shall sketch the layout of parking space with key map to refer the location of parking space.

- Address & Name
- Pay or Free
- Parking Fee, in case of Pay Parking
- Number of Parking Space

On-Street Parking Survey

This survey consists of both interview and counting survey, and shall be conducted during the daytime of weekday along congesting main and sub arterials. For on-street parking (including on-sidewalk parking), the number of parking vehicles by type by block shall be counted separately for each side of the street every one hour, or if possible every quarter or half an hour. And same time, the other team of interviewers shall carry out the driver interview to obtain the information regarding the parking condition (i.e. parking style, parking fee, payment method, frequency, etc.), trip purpose, walking distance to the destination, etc. In addition, reference question regarding the proposed public transport system shall be also interviewed.

Table M4.9-1, Figure M4.9-1 and M4.9-2 shows outline of the Parking Condition Survey.

Table M4.9-1 Outline of the Parking Condition Survey

#	Survey Item	Contents
(1)	Inventory Survey	- Number of Parking Space - Fee (if charged)
(2)	Vehicle Counting	- Number of Parking Vehicles by Time, Type (6 categories), and Section
(3)	Interview	- Vehicle Type - Parking Style (off-street/on-sidewalk/on-street) - Payment Method & Amount Paid - Frequency of Parking - Distance to Destination - Trip Purpose - Reference Questions regarding Proposed Public Transport Service

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2001
(Supplement Parking Condition Survey)

Block No.:

Date: Weather: Surveyed by:

Street /
Along: Supervised by:

Location /
Between: &: Side / (N / S / E / W)

Key Map

Vehicle Category	I: Light Vehicles				II: Heavy Vehicles		III: Motorcycles		IV: Cycles		V: Others
	Passenger Cars / 4WD	Sedan-Type Taxi	Mini Bus / Pass. Van	Pick-up / Small Truck	Standard & Large Bus	Large Truck / Trailer & Tractor	Motorumok	Motodop / Motorbike	Cyclo	Bicycle	Container / Generator / Others
Condition / Hours	On-Sidewalk		On-Shoulder		On-Sidewalk	On-Shoulder	On-Sidewalk	On-Shoulder	On-Sidewalk	On-Shoulder	On-Street
06:00 ~ 07:00											
07:00 ~ 08:00											
08:00 ~ 09:00											

Figure M4.9-1 Example of Survey Form for Parking Condition Survey (1) -Counting Sheet-

Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Parking Condition Survey

(2) Interview Sheet

Interviewer: Date: Type of Vehicle: 1. Pass Car / Wagon 2. Pickup / Cargo Van 3. Motorcycle 4. Cyclo 5. Bicycle 0. Others Page ..... of .....

Parking Location: Street

Traffic Zone Code

Parking Style	(Paid) Off-Street	(Paid) On-Sidewalk	(Paid) On-Street	(Unpaid) Off-Street	(Unpaid) On-Sidewalk	(Unpaid) On-Street
	1	2	3	4	5	6

Driver No.	1 Parking Period hours	1 Parking Period minutes	2 Time of Interview hour	2 Time of Interview minutes	3 *1 Payment Method	4 Amount Paid	5 No. of Parkings Per Week	6 Distance to Destination (m)	7 *2 Trip Purpose	8 If there is available bus service, *3 Will you use it?	*4 What do you expect?	*5 How much can you pay?	*6 How long can you wait?
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

*1 1. Free 2. Hourly 3. Daily 4. Weekly 5. Monthly 6. Annually 0. Others
*2 1. Home 2. Work 3. Business 4. School 5. Social 6. Shopping 0. Others
*3 1. Yes 0. No
*4 1. convenience 2. cheapness 3. fastness 4. safety 5. luxuries 6. reliability 0. no idea
*5 1. (~250) 2. (250~500) 3. (500~750) 4. (750~1,000) 5. (1,000~) [in Cambodian Riel]
*6 1. (~5) 2. (5~10) 3. (10~15) 4. (15~20) 5. (20~30) 6. (30~) [in minutes]

Figure M4.9-2 Example of Survey Form for Parking Condition Survey (2) -Interview Sheet-

M4.10 PASSENGER / DRIVER / OWNER INTERVIEW AND ARRANGEMENT

Passenger, and Driver & Owner Interview shall be carried out in order to figure out the response of the para-transit users and operators in case where masstransit and/or regulation on para-transit operation would be introduced and their present means of feeder transport or present situations confronted.

Interview Method

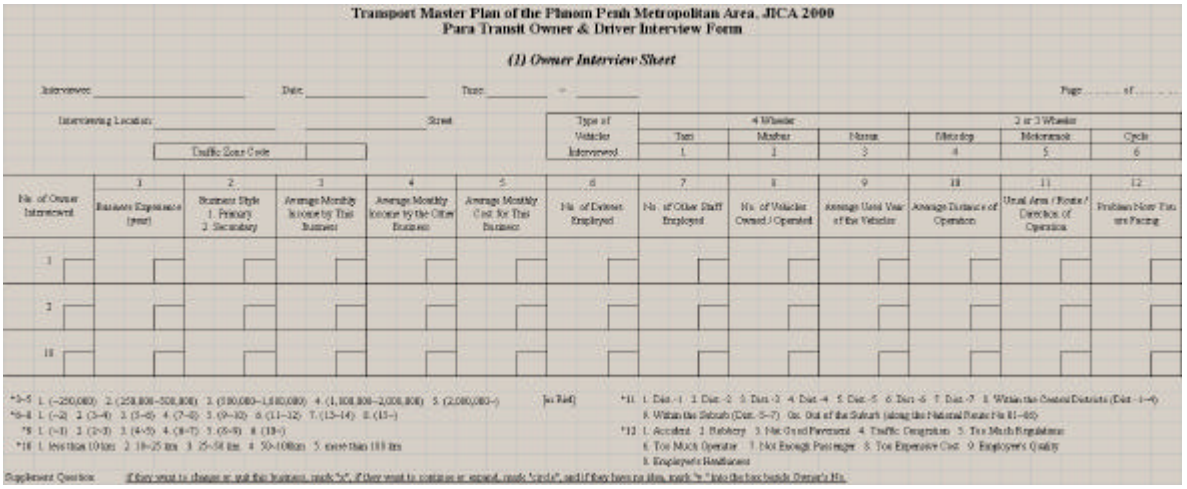
To obtain the characteristics of para-transit users and operators, these surveys shall be conducted at major transport interchange facilities, such as bus and taxi-bus terminals and/or airport, railway station, river port by direct interview method during the daytime of particular weekday such as Tuesday, Wednesday or Thursday. Weekend and National Holiday, and also Monday or Friday, shall be omitted to avoid collecting biased informations. Interview shall cover following contents as shown in Table M4.10-1 & M4.10-2

Table M4.10-1 Outline of Interview (User)

Survey Item	Contents
Personal Attributes	- Gender & Age
	- Occupation & Sector
	- Driving License Hold
	- Place of Work / Study
Trip Descriptions	- Origin & Destination
	- Trip Purpose
	- Number of Sub Trips
Criteria for Selection of Existing Mode	- Transport Mode
	- Waiting Time
	- Travel Time
	- Trip Cost / Expense
	- Reason
Criteria for Selection of Proposed Mode	- Intention of Use
	- Expectation to the Service
	- Affordable Trip Cost
	- Acceptable Waiting Time

Table M4.10-2 Outline of Interview (Operator)

Survey Item	Contents
Owner Only	- Number of Owned Vehicles
	- Number of Employees
Owner / Driver	- Nature of Business
	- Area / Route of Operation
	- Frequency of Operation
	- Average Number of Passenger
	- Charge and Cost
	- Problems for Operation
	- Future Plan



Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Para Transit Owner & Driver Interview Form

(1) Owner Interview Sheet

Interviewer: _____ Date: _____ Time: _____ ~ _____ Page ____ of ____

Interviewing Location: _____ Street _____

Traffic Zone Code

Type of Vehicle Interviewed	4 Wheeler			2 or 3 Wheeler		
	Taxi	Minibus	Nissan	Motordop	Motorcycle	Cycle
	1	2	3	4	5	6

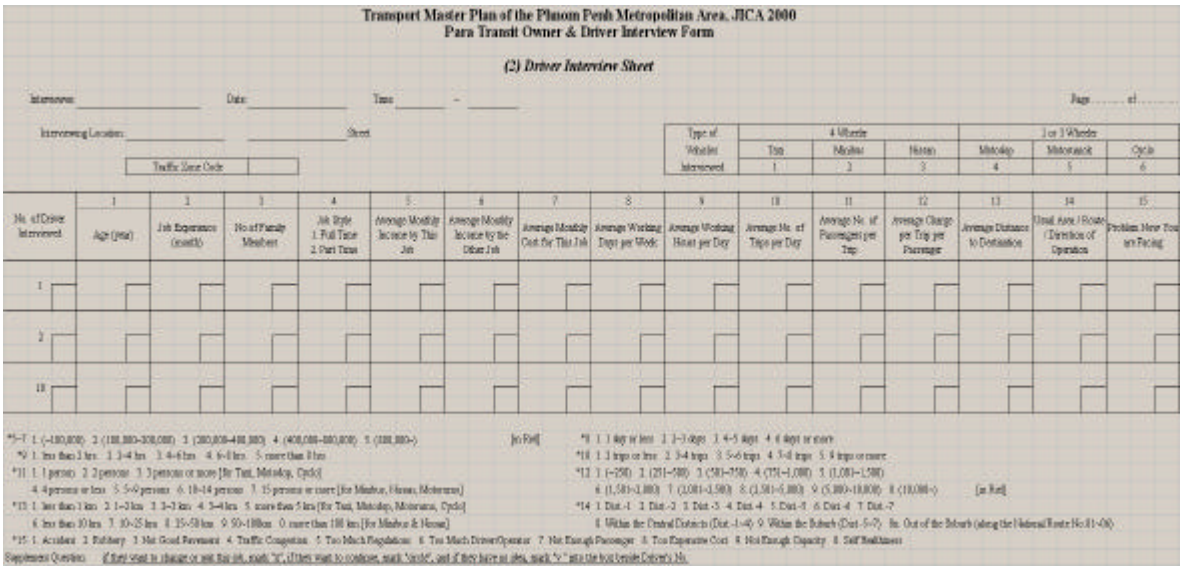
No. of Owner Interviewed	1 Business Experience (year)	2 Business Style 1. Primary 2. Secondary	3 Average Monthly Income by This Business	4 Average Monthly Income by the Other Business	5 Average Monthly Cost for This Business	6 No. of Driver Employed	7 No. of Other Staff Employed	8 No. of Vehicles Owned / Operated	9 Average Used Year of the Vehicles	10 Average Distance of Operation	11 Usual Area / Route / Direction of Operation	12 Problem Now You are Facing
1												
2												
10												

*3~5 1. (~250,000) 2. (250,000~500,000) 3. (500,000~1,000,000) 4. (1,000,000~2,000,000) 5. (2,000,000~) [to Rial]
*6~8 1. (~2) 2. (3~4) 3. (5~6) 4. (7~8) 5. (9~10) 6. (11~12) 7. (13~14) 8. (15~)
*9 1. (~1) 2. (2~3) 3. (4~5) 4. (6~7) 5. (8~9) 6. (10~)
*10 1. less than 10 km 2. 10~25 km 3. 25~50 km 4. 50~100km 5. more than 100 km

*11 1. Dist.-1 2. Dist.-2 3. Dist.-3 4. Dist.-4 5. Dist.-5 6. Dist.-6 7. Dist.-7 8. Within the Central Districts (Dist.-1~4) 9. Within the Suburb (Dist. 5~7) 10. Out of the Suburb (along the National Route No.1~65)
*12 1. Accident 2. Robbery 3. Not Good Pavement 4. Traffic Congestion 5. Too Much Regulations 6. Too Much Operator 7. Not Enough Passenger 8. Too Expensive Cost 9. Employee's Quality 10. Employee's Restlessness

Supplement Question: If they want to change or quit the business, mark "x", if they want to continue or expand, mark "circle", and if they have no idea, mark "v" into the box beside Owner's No.

Figure M4.10-1 Example of Survey Form for Operator Interview (1) -Owner-



Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Para Transit Owner & Driver Interview Form

(2) Driver Interview Sheet

Interviewer: _____ Date: _____ Time: _____ ~ _____ Page _____ of _____

Interviewing Location: _____ _____ Sheet

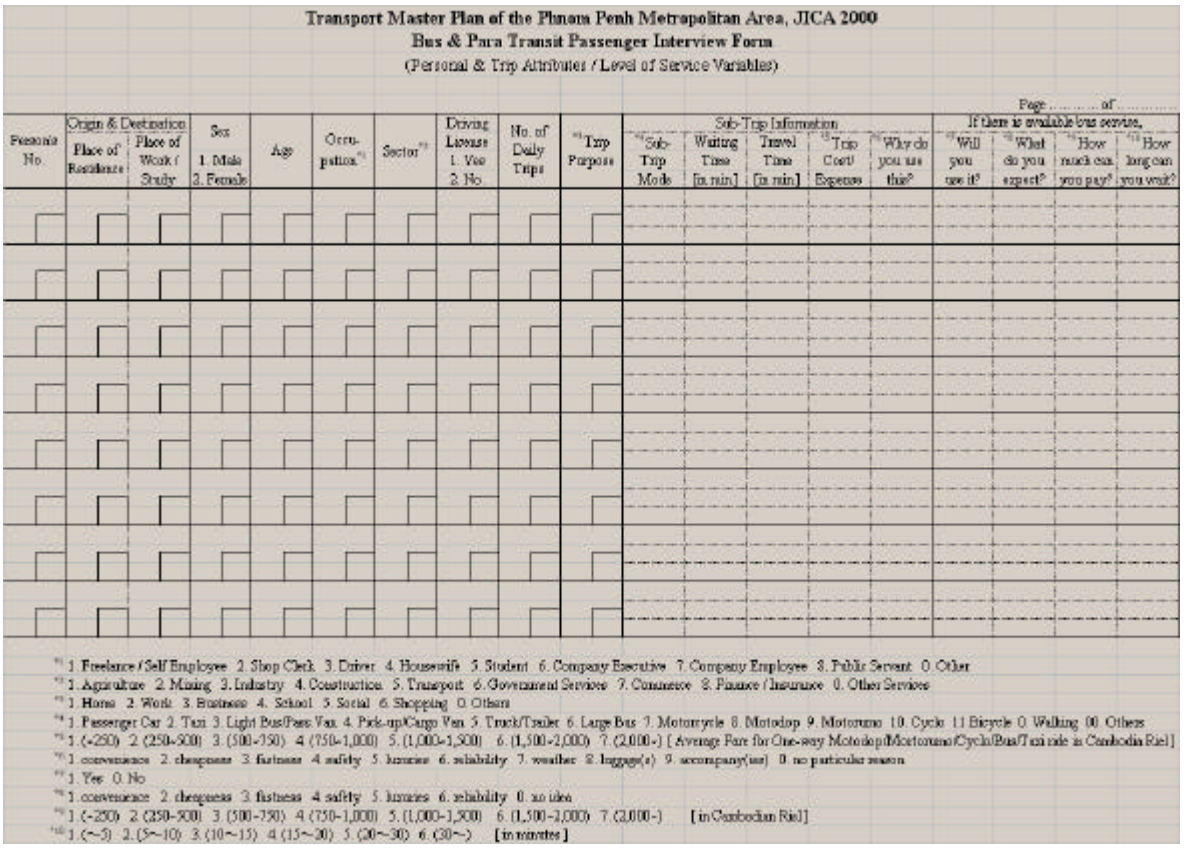
Traffic Zone Code

Type of Vehicle Interviewed	4 Wheels			3 or 2 Wheels		
	Taxi	Minibus	Human	Motodop	Motorcycle	Cycle
	1	2	3	4	5	6

No. of Driver Interviewed	1 Age (year)	2 Job Experience (month)	3 No of Family Members	4 Job Style 1. Full Time 2. Part Time	5 Average Monthly Income by This Job	6 Average Monthly Income by the Other Job	7 Average Monthly Cost for This Job	8 Average Working Days per Week	9 Average Working Hours per Day	10 Average No. of Trips per Day	11 Average No. of Passengers per Trip	12 Average Charge per Trip per Passenger	13 Average Distance to Destination	14 Usual Area / Route / Direction of Operation	15 Problem Now You are Facing
1															
2															
10															

*5~7 1. (~100,000) 2. (100,000~300,000) 3. (300,000~400,000) 4. (400,000~500,000) 5. (500,000~) [in Riel]
*8 1. 1 day or less 2. 2~3 days 3. 4~5 days 4. 6 days or more
*9 1. less than 3 hrs 2. 3~4 hrs 3. 4~6 hrs 4. 6~8 hrs 5. more than 8 hrs
*10 1. 1 trips or less 2. 3~4 trips 3. 5~6 trips 4. 7~8 trips 5. 9 trips or more
*11 1. 1 person 2. 2 persons 3. 3 persons or more [for Taxi, Motodop, Cycle]
4. 4 persons or less 5. 5~9 persons 6. 10~14 persons 7. 15 persons or more [for Minibus, Human, Motorcycle]
*12 1. (~250) 2. (251~500) 3. (501~750) 4. (751~1,000) 5. (1,001~1,500)
6. (1,501~2,000) 7. (2,001~3,500) 8. (3,501~5,000) 9. (5,000~10,000) 10. (10,000~) [in Riel]
*13 1. less than 1 km 2. 1~2 km 3. 3~3 km 4. 5~6 km 5. more than 5 km [for Taxi, Motodop, Motorcycle, Cycle]
6. less than 10 km 7. 10~25 km 8. 25~50 km 9. 50~100km 0. more than 100 km [for Minibus & Human]
*14 1. Dist.-1 2. Dist.-2 3. Dist.-3 4. Dist.-4 5. Dist.-5 6. Dist.-6 7. Dist.-7
8. Within the Central Districts (Dist.-1~4) 9. Within the Suburb (Dist.-5~7) 0. Out of the Suburb (along the National Route No.01~06)
*15 1. Accident 2. Pathway 3. Not Good Pavement 4. Traffic Congestion 5. Too Much Regulations 6. Too Much Driver/Operator 7. Not Enough Passenger 8. Too Expensive Cost 9. Not Enough Capacity 0. Self Bankruptcy
Supplement Question: (If they want to change or quit this job, mark "C", if they want to continue, mark "circle", and if they have no idea, mark "x") are the taxi/vehicle Driver's No.

Figure M4.10-2 Example of Survey Form for Operator Interview (2) -Driver-



Transport Master Plan of the Phnom Penh Metropolitan Area, JICA 2000
Bus & Para Transit Passenger Interview Form
(Personal & Trip Attributes / Level of Service Variables)

Page _____ of _____

Persons No	Origin & Destination: Place of Residence	Origin & Destination: Place of Work / Study	Sex 1. Male 2. Female	Age	Occupation *1	Sector *2	Driving License 1. Yes 2. No	No. of Daily Trips	*3 Trip Purpose	Sub-Trip Information: *4 Sub-Trip Mode	Sub-Trip Information: Waiting Time [in min]	Sub-Trip Information: Travel Time [in min]	Sub-Trip Information: *5 Trip Cost/ Expense	Sub-Trip Information: *6 Why do you use this?	If there is available bus service, *7 Will you use it?	If there is available bus service, *8 What do you expect?	If there is available bus service, *9 How much can you pay?	If there is available bus service, *10 How long can you wait?

*1 1. Freelance / Self Employee 2. Shop Clerk 3. Driver 4. Housewife 5. Student 6. Company Executive 7. Company Employee 8. Public Servant 0. Other
*2 1. Agriculture 2. Mining 3. Industry 4. Construction 5. Transport 6. Government Services 7. Commerce 8. Finance / Insurance 0. Other Services
*3 1. Home 2. Work 3. Business 4. School 5. Social 6. Shopping 0. Others
*4 1. Passenger Car 2. Taxi 3. Light Bus/Pass Van 4. Pick-up/Cargo Van 5. Truck/Trailer 6. Large Bus 7. Motorcycle 8. Motodop 9. Motorumo 10. Cycle 11 Bicycle 0. Walking 00. Others
*5 1. (~250) 2. (250~500) 3. (500~750) 4. (750~1,000) 5. (1,000~1,500) 6. (1,500~2,000) 7. (2,000~) [Average Fare for One-way Motodop/Motorumo/Cyclo/Bus/Taxi ride in Cambodia Riel]
*6 1. convenience 2. cheapness 3. fastness 4. safety 5. luxuries 6. reliability 7. weather 8. luggage(s) 9. accompany(ies) 0. no particular reason
*7 1. Yes 0. No
*8 1. convenience 2. cheapness 3. fastness 4. safety 5. luxuries 6. reliability 0. no idea
*9 1. (~250) 2. (250~500) 3. (500~750) 4. (750~1,000) 5. (1,000~1,500) 6. (1,500~2,000) 7. (2,000~) [in Cambodian Riel]
*10 1. (~5) 2. (5~10) 3. (10~15) 4. (15~20) 5. (20~30) 6. (30~) [in minutes]

Figure M4.10-3 Example of Survey Form for User Interview

M4.11 TRAFFIC DEMAND ESTIMATION AND FORECAST

Framework

One of the most important parts of analysis in urban transport planning is the estimation of trip demand; thus traffic demand, on transport facilities and services. The standard approach to urban traffic demand modeling utilized by the transport planner is represented in a system of models generally known as the Urban Transport Modeling System (UTMS). UTMS is used to predict the number of trips made within an urban area by type of trips (work, non-work, etc.), time of day (peak-period, daily, etc.) and zonal origin-destination (O-D) pair, the mode of travel used to make these trips, and routes taken trough the transport network by these trips.

The final output of UTMS is a predicted set of modal flows on links in a network of transport (mainly roadways, sometimes with railways and waterways, rarely with airways). The demand for transport (represented by zonal O-D flows by mode) is assigned to the modal network creating the transport system as a function of these networks' performance (supply) characteristics. The major inputs to UTMS are a specification of the activity system generating these flows and the characteristics of the transport system that is to serve these flows.

UTMS consists of four major stages; therefore it is often referred to as the four-stage (or four-step) model, as shown in Figure M4.11-1. These four major stages are:

1. ***Trip Generation*** is the prediction of the number of trips produced by and attracted to each zone. That is the number of trip ends "generated" within the urban area. In other word, the trip generation phase of analysis predicts total flow out of and into each zone in the Study Area, but it does not predict where these flows are going to or coming from.
2. ***Trip Distribution*** is the prediction of origin-destination (O-D) flows. That is the linking of the trip ends predicted by the trip generation and attraction model together to form trip interchanges or flows.
3. ***Modal Split*** models predict the percentages of flow of each mode (auto, transit, walk, etc.) that are utilized and available for travel between each origin-destination pair.
4. ***Trip Assignment*** places the O-D flows for each mode on specific routes of travel through the respective model networks.

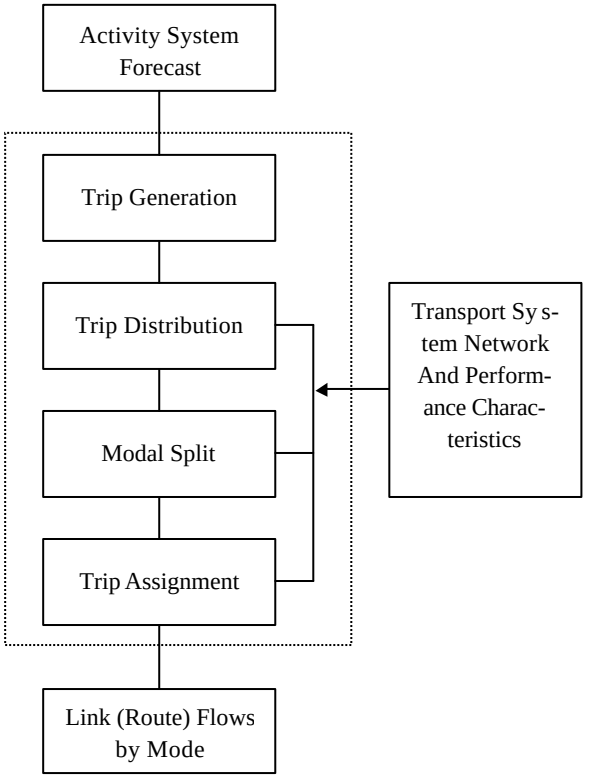


Figure M4.11-1
Urban Transport Modeling System (UTMS)

The four stages of UTMS thus correspond to a sequential decision process, in which people decide to make a trip (generation), decide where to go (distribution), decide what mode to take (modal split), and decide what route to use (assignment). Actually, this is unrealistic representation of travelers' decision making for most of trips. However, UTMS is still conventional model to represent trip-making behaviors. It rather represents a practical approach to reducing the extremely complex phenomenon of travel behavior into logically convenient works that can be dealt with using relatively simple techniques and reasonable amounts of data.

Activity System Forecast

Any kind of planning are established by the forecasting of future situation which are base on the past trend and present situation. Basic data on (present) travel behavior of people in the Study Area is mainly obtained from the findings of the Person-Trip (PT) Survey. And the data on present traffic condition is obtained from the findings of the other traffic surveys; both of which are conducted by the Study Team in 2000. On the other hand, the past trend in traffic conditions are only obtainable from the findings through World Bank Report in 1996 and JICA Expert Report in 1999 in the central districts of the Study Area only.

Moreover, past trend and present situation of other socio-demographic informations are very limited due to long-decades of disorder and still uncertain reliability of statistics that are recently updated by the authorities concerned. Currently available data sources for estimating past trend and present situation and will be utilized for forecasting of future situation regarding to the socio-demographic issues are Population Census, Employment & School Census, Vehicle Registration Record, Land Use Planning Map, and so on.

Trip Generation

Trip generation models are used to predict the trip ends generated by a household or a zone, usually on a daily or a peak-period basis. Trip ends are classed as being either a production (defined as the home end of a home-based trip or the origin of a non-home-based trip) or an attraction (defined as the non-home end of a home-based trip or the destination of a non-home-based trip). Basically separate model are used to predict productions and attractions. Variables used as predictors of trip productions may include household income, auto ownership, or size and number of workers or student per household, or total number of population, workers, or students, residential density, or distance of the zone from the central business district (CBD). On the other hand, trip attraction predictors may include zonal employment level (possibly disaggregated by occupation type), zonal floor space (disaggregated by business type), or accessibility to the work force (i.e., some weighted accessibility measures). Two general classes of trip generation models have traditionally been employed: linear regression models and cross-classification models.

Regression Models:

Given the high correlations which typically exist between trip generation and the variables listed above, ordinary least-squares regression is often used to estimate models that predict trip generation as a linear function of one or more of these variables. Several examples of typical trip gen-

eration regression models in this Study are:

(1) Production Models by Trip Purpose

Home: $[P\text{-}HOMEi] = 0.4709\ E^t i + 1.004\ Si + 4482\ U^d i + 22072\ H^d i + 2670$ *(11-1a)*

Work: $[P\text{-}WORKi] = 0.4688\ Pi + 10030\ W^d i - 56$ *(11-1b)*

School: $[P\text{-}SCHLi] = 0.2480\ Pi + 1369\ U^d i - 286$ *(11-1c)*

Shopping: $[P\text{-}SHOPi] = 0.2504\ Pi + 2891\ Sh^d i + 316$ *(11-1d)*

(2) Attraction Models by Trip Purpose

Home: $[A\text{-}HOMEi] = 1.123\ Pi + 212.7$ *(11-2a)*

Work: $[A\text{-}WORKi] = 0.4191\ E^c i + 0.2612.7\ E^i i + 1.154\ E^g i + 2585\ U^d i + 22824\ W^d i + 1066$ *(11-2b)*

School: $[A\text{-}SCHLi] = 0.5249\ Si + 893\ U^d i + 462$ *(11-2c)*

Shopping: $[A\text{-}SHOPi] = 0.1487\ Pi + 2908\ M^d i + 112.795\ Sh^d i + 192$ *(11-2d)*

Where, Pi = *Population of Zone i* $E^t i$ = *Total Employment of Zone i*

$E^c i$ = *Commercial Employment of Zone i* $E^i i$ = *Industrial Employment of Zone i*

$E^g i$ = *Governmental Employment of Zone i* Si = *Total Number of Students in Zone i*

$U^d i$ = *Urban Dummy for Zone i* $M^d i$ = *Market Dummy for Zone i, and*

$H^d i$ / $W^d i$ / $Sc^d i$ / $Sh^d i$ = *Purpose-Specific Dummy for Zone i*

Equations (11-1a/b/c/d) predict daily trip productions from each zone, and equations (11-2a/b/c/d) predict daily trip attraction to given zone, as a function of the number of population, employment, or student in given zone by trip purpose.

Regression models are relatively easy and inexpensive to construct from data that are typically available in planning studies in most of the developed countries. However, problems with the use of such models include:

1. Correlation among explanatory variables (particularly income and auto ownership) may create estimation problems that are so-called as "multicolinearity".
2. The assumption that the explanatory variables have linear, additive impacts on trip generation may be wrong.
3. The model's parameters may not be stable over time.
4. "Best fit" equations may yield counter-intuitive results [e.g., the negative coefficient implies trip productions or attractions decrease when that explanatory variables increase – something which one would not normally expect].
5. By using zonal averages, important socioeconomic variations within the zone may be obscured or may yield spurious results.

Cross-Classification Models:

Rather than grouping households spatially (i.e., by zones) as in regression models, cross-classification analysis classify individual household together according to common socio-economic characteristics (auto-ownership level, income, household size. etc.), so as to create relatively

relatively homogeneous groups. Average trip production rates are then computed for each group from observed data.

Cross-classification analysis can be similarly performed for trip attraction calculations. In such cases, classification is generally done with respect to employment type (e.g., manufacturing, retail, office, etc.) and possibly employment density (i.e., number of employee per acre). Since trip productions and attractions are calculated separately, one must ensure that the area wide production and attraction totals are the same. In general they will not be so. Therefore, this can be corrected by multiplying each zone's trip attraction by the ratio of total productions to total attractions. This approach to the problem is based on the expectation the trip production models are better predictors of trip rate the somewhat cruder trip attraction models.

Category analysis avoids the regression model's assumption of a linear, additive relationship between trip generation and its explanatory variables, as well as the pitfalls inbuilt in spatially aggregate models. On the other hand it requires considerably more detailed data than do typical regression models, both to initially construct and, more critically, to use in predicting future trip generations. As with regression models, the stability of the estimated rates over time may also be a concern.

Trip Distribution

The task of a trip distribution model is to "distribute" or "link up" the zonal trip ends (i.e., the productions and attractions for each zone as predicted by the trip generation model) in order to predict the flow of trips Tij from each production zone i to each attraction zone j.

Many types of trip distribution models exist. These include growth factor techniques such as the Frater method, which were use in early transportation studies but which are now used mostly for short-term updating of trip tables and estimation of "through trips" for urban areas: intervening opportunity models, which have seen limited use over the years, unwieldy to calibrate, and have never enjoyed generalized acceptance; disaggregate destination choice models; and, finally, the practically universally used gravity model.

The gravity model, in one form to another, has been in existence for over 100 years. It received its name from its earliest derivation as a similarity drawn between the "spatial interaction" of trip making and the gravitational interaction of physical bodies distributed over space. The most typical version of the gravity model used in transport planning applications is:

$$Tij = \frac{OiDjfij}{\sum_{j=1}^{n} Djfij} \qquad (11\text{-}3)$$

Where O_i = *total number of trips produced in zone i*
D_j = *total number of trips attracted to zone j*
f_{ij} = *"friction factor"*

The friction factor is an inverse function of the "cost" of travel (travel time, distance, monetary out-of-pocket cost, "generalized cost", etc.) between zones i and j, denoted here as C_{ij}. Common functional forms for the friction factor f_{ij} include:

$$f_{ij} = C_{ij}^{-b} \qquad (11\text{-}4a)$$

$$f_{ij} = e^{-bCij} \qquad (11\text{-}4b)$$

$$f_{ij} = \textit{graphical function of } C_{ij}$$

In all cases, the function f_{ij} must be experimentally calibrated for any given urban area in order to derive the value of the parameter *b* [if either Eqs. (11-4a) or (11-4b) are used] or the locus of the graphical function (if this latter method is used) which enables the mode to "best fit" observed data for the area under analysis.

Equation (11-3) automatically satisfies the logical constraint that the total number of trips predicted to leave any zone *i* is equal to the observed productions O_i. On the other hand, it does not satisfy the converse logical constraint that the total number of trips predicted to enter zone *j* is equal to the observed attraction D_j in general. The latter requirement is accomplished through a repetitious "balancing" procedure in which the trip attractions used in Eq. (11-3) are systematically adjusted until predicted and observed attractions are equal for all zones in the system.

Equation (11-3), in combination with the balancing procedure mentioned above, represents the standard formulation that has been used in the field of transport planning for more than three decades. Despite its widespread use, the gravity model suffers from numerous weaknesses, perhaps most notably its lack of a credible theoretical basis. Its predictive capabilities are unclear, especially in light of its explicit lack of behavioral assumptions (aside from the recognition that travel distance or time is an important determinant of spatial interaction). In fact, the amount of error involved in gravity model predictions has been shown to be large, even in "good fitting" models.

For inter-zonal model, following basic gravity model is applied to describe inter-zonal movements in the Study Area:

$$Tij = k \cdot \frac{Pi^{a} \cdot Aj^{b}}{dij^{-g}} \qquad (11\text{-}5)$$

Where, Tij: Inter-zonal Trips between Zone i and Zone j

Pi: Produced Trips from Zone i

Aj: Attracted Trips to Zone j

dij: Inter-zonal Impedance (Distance in kilometer) between Zone i and Zone j

k, a , b , and l : Parameters

For intra-zonal model, following modified model is applied to describe intra-zonal movements in the said area:

$$Tii = k \cdot (\sqrt{Pi \cdot Ai})^{a} \cdot Zi^{b} \qquad (11\text{-}6)$$

Where, Tii: Intra Zonal Trips within Zone i

Pi: Produced Trips from Zone i

Ai: Attracted Trips to Zone i

Zi: Intra-zonal Impedance (Area in hectare) of Zone i

k, a , and b : Parameters

Modal Split

Modal split models are used to predict the percentage of trips using each of the modes available to the given trip makers. Figure M4.11-1 shows modal split as taking place after trip distribution in the UTMS structure, in which case the model is known as a *trip-interchange* modal split model. However, in some version of UTMS, modal split is performed prior to distribution. In this latter case, the model is known as a *trip-end* model, since it "splits" trip ends (i.e., productions and attractions) rather than flows. Both type of models are summarized below.

Trip-End Models:

Trip-end modal split modeling is based on the assumption that transit ridership is primarily a function of socioeconomic variables; that is, virtually all transit riders are assumed to be "captive" riders – people who have no other choice but to ride transit. This assumption is most valid in areas that have relatively low transit service levels.

The major advantage of such models is that they are simple to apply and require relatively little data for calibration or prediction. In particular, since the trips have not been distributed yet (and thus the modal service characteristics associated with the trips are not known yet), the only variables that can be used in these models are those that were used in the trip generation stage: auto ownership, income, distance from the CBD, household size, zonal population density, etc. The major disadvantage of these models is that they are generally insensitive to transport policy change.

Figure M4.11-3 shows a typical trip-end modal split model, in which the percentage of trips from given zone made by transfer is expressed as a function of auto-ownership level and zonal population density. Therefore, for example, if a given zone has a population density of 50 persons per acre and an auto-ownership distribution of zero-, one-, and two-car households of 20 %, 50 %, and 30 %, respectively, then reading values off the curves of Fig. M4.11-2, one finds that the estimated percentage of trips by transfer for this zone is:

(85)(0.20) + (43)(0.50) + (34)(0.30) = 49%

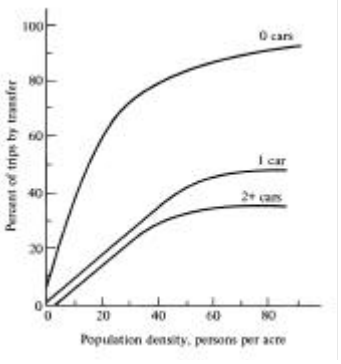


Figure 4.11-2 A Trip-end Modal Split Model

Trip-Interchange Models:

Since trip-interchange models are used after trip distribution, they can utilize the service characteristics (e.g., travel times, costs, etc.) of the alternative modes available for the given trip (along with any relevant socioeconomic characteristics such as income or auto ownership) to determine the modal splits. Typically this has been accomplished through the use of diversion curves, which express the percentage of transit trips as a function of one or more service ratios and socioeconomic categories, as shown in Figure M4.11-3.

Diversion curves require an extensive amount of data to construct, are difficult to update over time, and are restricted to simple binary modal choice situation (typically auto vs. transit). In recent years disaggregate modal choice models, in particular the multinomial logit model; have proved to be a very powerful approach to modal split modeling.

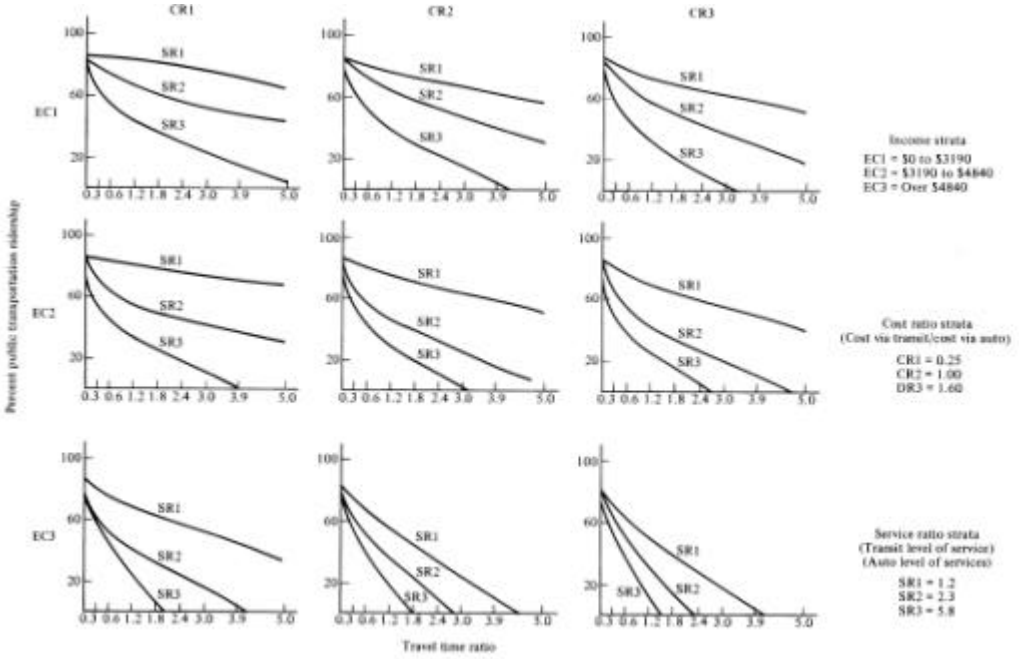


Figure M4.11-3 A Trip Interchange Modal Split Model using Diversion Curves

Trip Assignment

The last step in the UTMS sequence is the trip assignment of the predicted modal flows between each origin-destination (O-D) pair to actual routes through the given mode's network. Although manual assignment techniques are possible for very small networks, the networks involved in practical-sized issues usually require the use of digital computers for solution. Assignment procedures are based on the assumption that each individual chooses the route that he/she identifies as being the best for him/herself. In other words, each individual minimizes or "optimizes" his/her own travel time or cost.

Trip assignment techniques include:

- Minimum Path (All-or-Nothing) Assignment
- Equilibrium Assignment
- Stochastic Assignment

Each of these techniques is summarized below.

Minimum Path (All-or-Nothing) Assignment:

In this approach, uncongested minimum travel time paths (routes) are computed for each O-D pair, and all flows between these pair are loaded onto these routes. A given route receives "all or nothing" of a given O-D pair's flow. Advantage of this approach are that it is simple and inexpensive to use, it represents the routes most travelers would be expected to use without capacity and/or congestion effects, and the results are easy to understand and explain. On the other hand, the major disadvantage of this approach is that it clearly generates unrealistic flow patterns on the networks where capacity constraints and congestion effects exist.

Equilibrium Assignment:

Equilibrium assignment techniques explicitly recognize that transport network link costs generally depend on link flow levels. Therefore, these techniques look for a user-equilibrium solution in which link flows and costs are simultaneously solved for. Early approaches to this issue involved the use of approximate *capacity restraint* methods in which flow is incrementally loaded onto the network, thus allowing congestion to gradually "build up" and travel-time estimates to adjust in response to this. Advantages of the capacity restraint approach compared with all-or-nothing assignment are that the former more realistically estimates peak-hour flow characteristics than the later. It achieves a distribution of trips over a number of routes for any given O-D pair, and it is guaranteed to meet to a solution. On the other hand, the major disadvantage of this approach is that there is no guarantee that the flow pattern obtained is optimal in user-equilibrium terms, or in any other terms.

However, in the 1970s, true user-equilibrium algorithms were developed, based on mathematical programming formulations of the issue, which guarantee convergence to the user-equilibrium solution. Such algorithms are available within U.S. Department of Transportation's UTPS or JICA's STRADA computer modeling packages.

Stochastic Assignment:

Various stochastic approaches to traffic assignment have been proposed and these procedures recognize that several routes between an origin and a destination might be supposed to have equal travel times or otherwise be equally attractive to a traveler and, as a result, might be equally possible to be used by the traveler. Or, in other words, these procedures treat link costs as random variables that can vary among individuals (given their individual preferences, experiences, and perceptions) rather than deterministically (as which is done by the other assignment techniques). Suggested procedures include use of an incremental assignment in a stochastic simulation procedure, use of a multinomial logit model to predict route choice probabilities, and the use of a multinomial probit model within a "stochastic user-equilibrium" framework.

In this Study, Incremental Assignment (capacity restraint method) is applied.