Transportmetrica, Vol. 1, No. 3 (2005), 247-260

TRAVEL CHARACTERISTICS SURVEY – METHOD OF EXPANDING HOUSEHOLD INTERVIEW SURVEY DATA

DAVID K.B. TO[1], K.T. YAU[2] AND ALFRED LAM[3]

Received 15 December 2003; received in revised form 11 March 2005; accepted 2 July 2005

In 2002, the Transport Department conducted a large-scale Travel Characteristics Survey with a view to collecting the public's views and attitudes towards the transport system, and the necessary data for the re-calibration and enhancement of the comprehensive transport model in Hong Kong for planning purposes. In the Survey, about 1.4% of the population or 30,000 households were successfully interviewed. Information on the socio-economic data of the selected households and a 24-hour trip log for each household member were collected. Like most interview surveys requiring respondents to provide very detailed trip information for a full reference day, under-reporting of trips inevitably occurred in this Survey. Very serious underestimation of trips would result if the data was simply expanded according to the sampling factors. This paper presents the method adopted for expanding the survey data to match with independent data with a view to addressing the under-reporting problem and obtaining the overall territorial trip pattern for further use.

KEYWORDS: Travel characteristics survey, household interview survey, survey data expansion, under-reporting of trips, origin-destination trip matrices, transport modes

1. INTRODUCTION

The main objective of the Travel Characteristics Survey (TCS) 2002 (Arup – Wilbur Smith Joint Venture, 2003) was to collect information on the travel characteristics of the people of Hong Kong for the re-calibration and updating of the Third Comprehensive Transport Study (CTS-3) model. The CTS model is the major analytical transport planning tool being adopted for producing traffic forecast and evaluating strategic highway projects in Hong Kong. To achieve the objective of TCS 2002, it was necessary to collect comprehensive information that could permit the development of mathematical relationships between socio-economic data, network properties, and trip making patterns.

High population density, metropolitan life style, high private vehicle ownership costs, and efficient public transport system in Hong Kong resulted in travel characteristics of Hong Kong residents being quite different from those in other large cities in the world. In particular, the people in Hong Kong are served by a variety of quality and inexpensive public transport services that are privately run and do not receive any direct government subsidies. Previous TCS results (MVA Asia Limited, 1993) showed that Hong Kong people relied heavily on public transport – about 90% of travelling was made by public transport. In contrast, it was found in the 2001 National Household Travel Survey (NHTS) that less than 2% of all urban travel in the United States was made by public transport (Pucher and Renne, 2003).

To provide data and information for policy decision and travel demand management (Stropher, 1998), new data items were included in the HIS of TCS 2002. However, data items included in the previous HISs were also included for studying changes in travel characteristics and re-calibrating and updating the CTS-3 model.

[1] Transport Planning Division, Transport Department, The Government of the HKSAR, 41/F, Immigration Tower, 7 Gloucester Road, Wan Chai, Hong Kong SAR, P.R. China. (E-mail: kbto@td.gov.hk).

[2] Transport Planning Division, Transport Department, The Government of the HKSAR, 41/F, Immigration Tower, 7 Gloucester Road, Wan Chai, Hong Kong SAR, P.R. China.

[3] Transport Planning Division, Transport Department, The Government of the HKSAR, 41/F, Immigration Tower, 7 Gloucester Road, Wan Chai, Hong Kong SAR, P.R. China.

Travel characteristics data in TCS 2002 were collected from household interview survey (HIS). A stratified sampling methodology was adopted in the HIS. Similar sampling methodology was adopted in the NHTS in the United States (U.S. Department of Transportation, 2003) and National Travel Survey (NTS) in the United Kingdom (Stratford et al., 2003). After all the HIS data had been collected, it was necessary to calculate weightings for the data to represent the territorial situation.

Similar to other interview surveys requiring respondents to provide very detailed trip information for a full reference day, under-reporting of trips inevitably occurred in the HIS. Very serious underestimation of trips will result if the data is simply expanded according to the sampling factors. Literature review had been conducted but relevant research paper on the correction for under-reporting of trips for cities with development density and transport system similar to Hong Kong could not be found. This paper presents the method adopted for expanding the survey data through matching with independent data with a view to adjusting the trip expansion factors of the HIS data so that they could better represent the trip patterns of the people in Hong Kong.

2. SURVEY DETAILS

To minimise the cost of collecting HIS data while collecting travel characteristics at an error rate of 5% or less at 95% confidence level for the re-calibration and updating of the CTS-3 model, the sample size of the HIS was chosen to be about 1.4% of the population. This sample size was also determined based on the sample size and response rate of a similar survey (MVA Asia Limited, 1993) undertaken in Hong Kong in 1992. In addition, the experience gained in conducting the 1992 survey provided useful references in the design and execution of the HIS.

The Census and Statistics Department (C&SD) developed a database (hereafter, referred to as the C&SD database) of all residential address locations in Hong Kong from the information collected in the Population Census conducted by C&SD in 2001 which covered all households in Hong Kong. From the C&SD database, 42,800 address locations were randomly drawn from over 2.1 million address locations in the whole territory using the stratified sampling approach with stratification by 16 broad areas in Hong Kong by 4 levels of car availabilities (<0.125, 0.125 to 0.25, >0.25 and ≤0.5, and >0.5 car per household).

The fieldwork of the HIS was carried out from 10 September to 21 December 2002 to avoid the summer and Christmas holidays. During the HIS, about 3,000 selected locations were found to be unoccupied, non-residential use, or demolished. Upon the completion of the HIS, 30,005 households were successfully interviewed representing a sample rate of about 1.4% and an overall response rate of about 75%. The HIS sample rate was much higher than that of the 2001 NHTS in the United States with a sample size of 69,817 households (i.e. about 0.6%) (Hu and Reuscher, 2004) and the 2003 NTS in the United Kingdom with a sample size of 8,258 households (i.e. about 0.4%) (Department of Transport, 2004).

Through face-to-face interviews in the HIS, the following information was collected:

- Household information (address, size, type of housing, household income etc.)
- Personal information for each member (age, sex, driving capability, activity status e.g. student/worker, level/rank, etc.)
- Type and number of vehicles available for use and parking details

- Detailed trip information of members/visitors aged 3 or above for a reference weekday (origin and destination addresses, departure and arrival times, trip purpose, mode and place of interchange for each trip leg, waiting time for taxi trips, tolled road/tunnel used for private car and taxi trips, etc.)

3. HIS DATA EXPANSION

The data collected in the HIS were expanded in two stages to provide information at 3 levels viz., household, person and trip levels. The first stage involved the expansion of household and person data collected in the HIS using the control totals on number of households and population by person types in the C&SD database. The second stage involved the trip data expansion to cater for under-reporting of trips by comparing the initial trip data generated after the demographic expansion against other independent observed data or transport statistics and then developing trip expansion factors accordingly.

4. DEMOGRAPHIC EXPANSION

The demographical expansion was conducted at both the household and person levels. Household data collected were first expanded by their sampling fractions, with adjustments to the invalid and response rate in each stratum and type of housing; and then by the number of households in Hong Kong provided by C&SD, with breakdowns by the 18 District Council (DC) districts estimated by using the distribution of households by DC districts as at mid-2002 published by C&SD in the report of "Population and Household Statistics Analysed by District Council District". The estimated number of domestic households as at September – November 2002 (the main fieldwork period) provided by C&SD was 2,152,874.

Person-based data collected were first expanded by the household expansion factors derived above; and then by the number of residents by type (sex and age provided by C&SD for the main fieldwork period in September - November 2002), with breakdowns by DC districts estimated by using the distribution of population by DC districts as at mid-2002 published by C&SD in the report of "Population and Household Statistics Analysed by District Council District".

Following the above controlled expansion, some of the key characteristics of households and residents are summarised in Table 1 and compared with the 2002 mid-year population and household statistics published by C&SD.

The above comparison demonstrates that the expanded household and population characteristics of the HIS data match closely with the C&SD statistics and can provide a sound basis for the subsequent expansion of trip data.

5. TRIP DATA EXPANSION

After the demographic expansion of the HIS data to match the demographical controls in terms of population and number of households at District Council levels, further adjustments of the expansion factors of trip data records would be required to address any under-reporting of trip-making by survey respondents. The trip expansion factors were adjusted based on comparisons of travel demands derived from the HIS data with observed traffic flows in the road network and recorded patronage figures of various public transport services. To facilitate travel demand comparisons, travel demands for

different trip purposes, time periods and transport modes in the form of origin-destination trip matrices were extracted from the HIS data.

TABLE 1: Comparison of demographical characteristics

Characteristics	TCS 2002	2002 mid-year*
Average Household Size	3.1	3.1
Total Household Number	2,152,874	2,133,300
Monthly Household Income		
<$10,000	31.9%	28.6%
$10,000 - $29,999	46.1%	46.4%
$30,000 or more	22.0%	25.0%
Median	$15,800	$16,100
Total Population	6,756,100	6,724,800
Sex		
Male	48.5%	48.6%
Female	51.5%	51.4%
Economic Activity Status		
Economically active	52.9%	51.9%
Economically inactive	47.1%	48.1%
Workers	3,296,700	3,216,600
Students (full-time)	1,393,300	1,376,500

*Source: "Population and Household Statistics Analysed by District Council District 2002", C&SD.

The various origin-destination trip matrices were assigned onto the road and public transport networks to simulate the traffic flows in the road network and passenger movements in the public transport system. As the HIS data were to be used for re-calibrating and updating the CTS-3 model, the trip expansion factors were adjusted so that the traffic and passenger demands derived from the HIS data could match observed figures in the morning and evening peak periods. After adjustments had been made to the HIS data for the peak periods, the HIS data for the rest of the day were adjusted so that the HIS data would match observed daily figures of traffic flows and passenger movements.

The derivation of expansion factors of trip records in the HIS database is discussed in the ensuing sections.

5.1 Trip purposes

Trips were categorised by the following 5 trip purposes, based on the places and activities at the trip origins/destinations:

- Home-Based Work (HBW) – between home and work place for work;
- Home-Based School (HBS) – between home and school place for attending lectures/lessons;
- Home-Based Others (HBO) – between home and places that are not work place (for work) or schools (for attending lectures/lessons);
- Employers' Business (EB) – between work places for work; and
- Non-Home Based (NHB) – the rest of the above.

The segregation of trips into different purposes was to cater for the variations in the degree of under-reporting of trips for different trip purposes. As HBW and HBS trips were normally made regularly, they were less prone to be under-reported by survey respondents and occurred mainly in more specific time periods. Therefore, adjustments to trip expansion factors for HBW and HBS were done separately with trips for other trip purposes.

5.2 Definition of time periods

It is important to segregate the trip matrices by time periods to replicate the different trip pattern pertaining to each period as reflected in the observed control data available. It also helps to improve the allocation of under-reported trips to different trip purposes. This is because the trip purpose mix would vary among different time periods, for instance, regular trips such as HBW and HBS would be more concentrated in the peak periods. Since the transport statistics used as controls could not be easily distinguished by trip purposes, segmentation by time periods would be the only basis to cater for the under-reporting expansion by trip purposes.

Based on the analysis on the HIS trip records and observed traffic flow pattern, the peak periods were found to be generally 2.5 hours long from 7:00 – 9:30 am in the morning, and from 5:15 –7:45 pm in the evening. Accordingly, the daily trip matrices obtained from the HIS were separated into three periods, representing the AM peak (7:00 – 9:30 am), PM peak (5:15 –7:45 pm) and the average Off-peak (the remaining 19 hours) trip data.

5.3 Transport mode hierarchy

The transport modes for data expansion were defined as private vehicles (including cars/passenger vans and motorcycles/scooters), taxi, mass transit railway (MTR) (the subway system), Kowloon-Canton Railway (KCR) (the railway service between urban and sub-urban areas), light rapid transit (LRT) (the light rail system serving sub-urban areas), tram, ferry, public light bus (PLB) (16 seats light bus), franchised bus and special purpose bus (SPB) (non-franchised bus including school bus, company bus and tourist bus), of which independent traffic statistics are available as controls.

It is not uncommon that a trip would involve more than one mechanised trip leg by different modes of transport. From the result of the previous TCS (MVA Asia Limited, 1993), it was found that about 15% of trips involved more than one mechanised trip leg. As such, it is necessary to establish a mode hierarchy to categorise the trip records by transport mode taken. The use of mode hierarchy has been adopted in various versions of the CTS model to group person trips simulated by the model to one single mode so that double counting of the same trip would not occur as a result of the trip involving more than one transport mode in the trip assignment process. The mode hierarchy was set to account for the majority of trips being made by public transport, so the non-public transport modes were at the lower levels. The rail modes (MTR, KCR and LRT) and the ferry were at higher levels because passengers using these modes would normally consider these modes as the ‘main’ modes while the connecting trip legs, if any, made on PLB and franchised bus as ‘feeder’ modes. The tram was considered a rail mode, so it was placed after LRT in the mode hierarchy.

In the data expansion process, the same mode hierarchy was adopted for consistency bearing in mind that the expanded trip data will be adopted in future in the re-calibration of the CTS model. The adopted mode hierarchy is shown in Table 2.

According to the above hierarchy setting, if a trip involved more than one mode, the mode higher in the hierarchy would be considered as the ‘main’ mode based on which the trip record would be expanded. For example, a trip involving MTR and taxi was considered as a MTR trip and expanded according to the MTR statistics first.

TABLE 2: Transport mode hierarchy

Order	Category	Transport mode
1	Public transport	MTR
2		KCR
3		LRT
4		Tram
5		Ferry
6		PLB
7		Franchised bus
8	Non-public transport	Private vehicle
9		Taxi
10		SPB

After expansion by the 'main' mode, any minor mode trip legs attached would have to be considered in the subsequent expansion of the corresponding minor modes. While transfer within the public transport network could in theory be catered for in the public transport network, the issue became more complicated for trips involving transfers between public transport and non-public-transport modes because these trips were simulated by the CTS model separately in the highway and public transport networks. This is particularly the case for taxi trips as a relatively high proportion of the riders used them as feeder to other public transport modes, particularly, MTR or KCR. This issue was addressed by first extracting the 'minor' trip legs after expansion by the 'main' mode and then by assigning them to the road network as 'pre-load' matrices before adjusting other taxi trips to match with the observed control data.

5.4 Trip adjustment process

The expansion of HIS trip data was based on the following traffic counts undertaken by Transport Department (Traffic and Transport Survey Division, 2003a,b) and traffic statistics prepared by transport operators:

- 2002 Annual Traffic Census (ATC) traffic counts in vehicles and vehicular classification and occupancy data on major roads and various screenlines (to derive passenger flows by period for private vehicle, taxi, SPB, franchised bus, and PLB);
- Monthly taxi boarding statistics (September to November 2002);
- Passenger statistics for MTR (with breakdown of in flow by stations), KCR (with breakdown of in/out flows by stations), LRT, tram, franchised bus, ferry and PLB during September to November 2002;
- Passenger link and boarding/alighting flows (November 2002) for all line segments and stations in the MTR system by time periods (AM: 8:15 – 9:15am, PM: 6:00 – 7:00 pm, Mid-day: 3:00 – 4:00 pm);
- Passenger link and boarding/alighting flows (November 2002) for all line segments and stations in the KCR East Rail system by time periods (AM: 8:00 – 9:00am, PM: 6:00 – 7:00 pm and Mid-day: 3:00 – 4:00 pm);
- The daily passenger link flows (November 2002) for all line segments in the MTR system.

The above data were assembled from reliable records and observations. The traffic count results may be subject to the general counting errors while other transport statistics may be subject to seasonal variations. However, it is expected that the maximum errors and variations may be about 10% and are significantly less than the corresponding figures obtained from HIS.

Figure 1 illustrates the approach of trip data expansion. Data expansion was carried out iteratively according to the following steps:

1. Initial Trip Tables Formulation – Trip matrices were extracted from the HIS database (after initial expansion by demographical data) for different trip purposes, transport modes, and the three time periods.
2. Trip Matrix Estimation – The initial trip matrices were loaded onto the transport model network. Matrix estimation techniques were applied to adjust the matrices on a traffic sector to sector basis[4] in order to match the output assignment results with input controls, such as, the observed traffic volumes across selected major screenlines, railway station in/out counts etc.
3. Retention of Trip Characteristics – The output matrices were checked against transport statistics and traffic count results. The statistics included total boardings and trip length distribution of the initial matrices. The matrices were further adjusted if required, e.g. by a 3-D balancing[5] process to retain the trip length distribution pattern.
4. If satisfactory results were obtained, the next step would be carried out. Otherwise, steps (2) and (3) above were repeated.
5. Derivation of Trip Expansion Factors – Trip expansion factors were estimated for different trip purposes on an aggregated sector-to-sector basis. They were applied to the trip records in the database according to time period and transport mode segments.
6. Re-assignment of Adjusted Trip Matrices – The adjusted trip matrices were re-assigned onto the transport model networks after the sector-to-sector expansion factors were incorporated into the trip records. The assignment results were then checked for acceptability. At this point, trip legs involving transfer to other transport modes lower in the hierarchy were also extracted as 'preload' matrices for the subsequent mode(s).

The EMME/2 transport planning software was applied for estimating the under-reported trips in the HIS trip data. A total of 150 initial trip matrices, categorised by the 10 transport modes, 5 trip purposes and 3 time periods (as defined above), were extracted from the HIS database after the demographical expansion. Table 3 summarises the initial number of trips for all trip purposes in the HIS database after the demographical expansion. They formed the basis of the trip data expansion process.

The stepwise trip expansion process by mode hierarchy increased the total number of trips made on a daily basis from the initial 8,316,300 to 12,304,000, reflecting an overall 32% under-reporting by respondents.

[4] The trip expansion factors were derived on an aggregated sector-to-sector basis instead of direct zone-to-zone adjustments based on the matrix estimation results. This is to average out the adjustment effects hence avoid over-adjustment of individual cells of the initial matrices caused by any model inconsistencies or discrepancies, while maintaining acceptable validation results. For this purpose, entire territory of Hong Kong was divided into 18 sectors.

[5] It is a built-in module in the EMME/2 software which is an alternative to the normal "furness" process commonly applied for adjusting trip distribution using an initial matrix as seed and controlled to specified trip end totals. The additional feature is to also specify the trip length distribution pattern as another dimension of control (therefore referred as 3-dimensional or 3-D). By adopting the trip length distribution pattern underlying the initial matrix, the trip distribution can be adjusted with a view to retaining the initial trip length distribution.

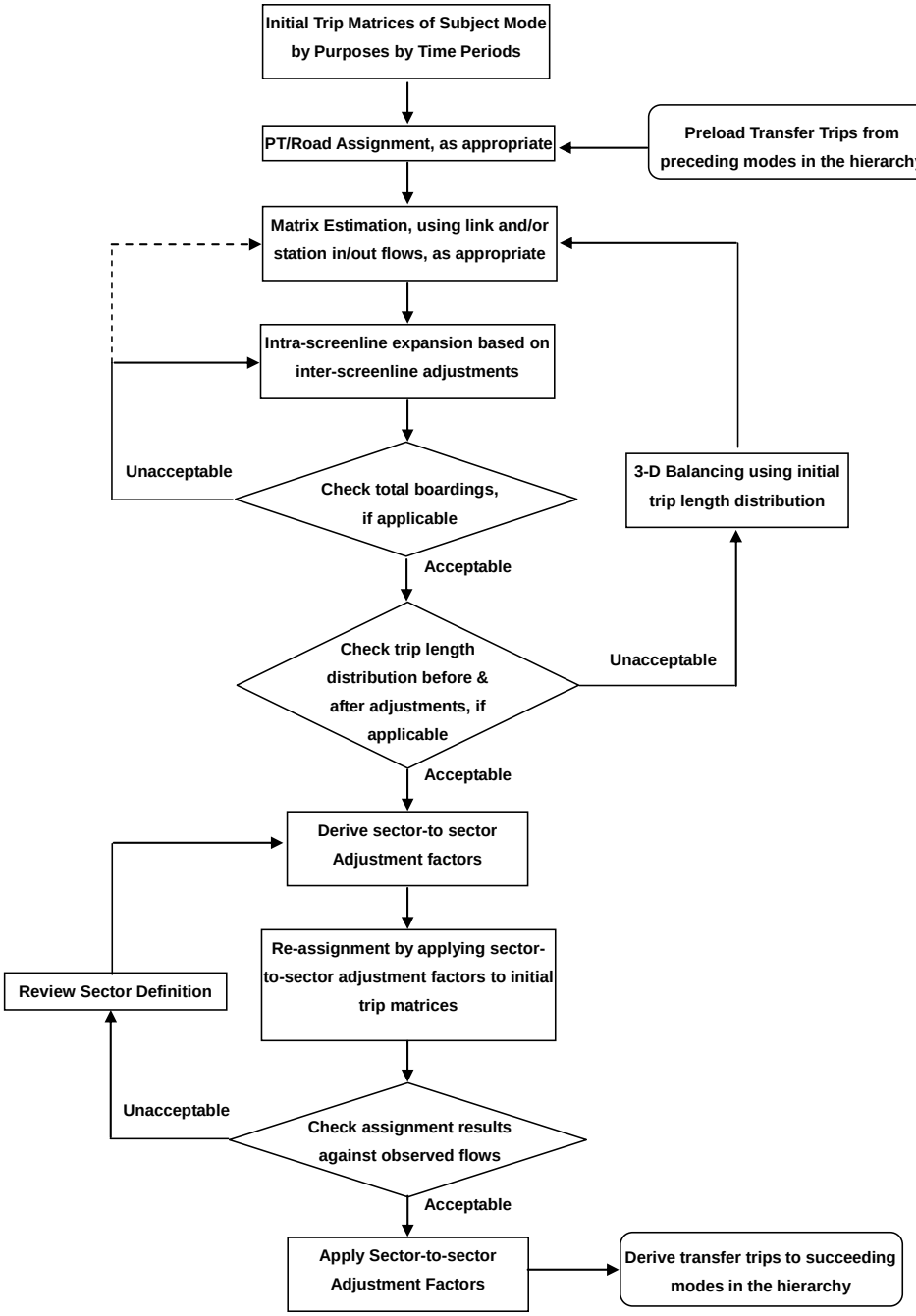

FIGURE 1: Process of estimation of under-reported trips for individual modes

TABLE 3: Initial number of trips before trip adjustments

Mode	Period			
	AM (2.5 hours)	PM (2.5 Hours)	Remainder	Daily
MTR	542,200	422,000	1,045,900	2,010,100
KCR	105,400	72,100	251,400	428,900
LRT	73,700	35,800	166,800	276,300
Tram	22,600	18,100	69,600	110,400
Ferry	16,300	12,700	43,100	72,100
PLB	237,600	145,300	593,800	976,700
Bus	725,200	452,500	1,600,200	2,777,900
Private vehicle	203,300	130,600	442,700	776,600
Taxi	29,500	25,800	139,300	194,600
SPB	212,800	72,800	407,300	692,900
Total	2,168,700	1,387,500	4,760,100	8,316,300

The expanded trips by modes within each time period were further expanded by allocating different sets of trip expansion factors to two trip purpose groups: one comprising HBW and HBS trips that were more regular and less prone to under-reporting; and, the other comprising the less regular HBO/NHB/EB trips. This was carried out with careful consideration to the following factors:

- significance of different trip purposes within particular time period against the magnitude of trips to be expanded;
- proportion of different trip purposes within particular time periods after expansion;
- proportion of trips of particular purpose among different periods of the day; and
- magnitude of trips on a daily basis after expansion.

Table 4 shows the initially and finally expanded trips for different time periods. It can be seen that under-reporting is generally less serious in the peak periods, especially AM peak. This may be related to the fact that the HBW and HBS trips having higher share of the trips in the peak periods are less subject to under-reporting.

TABLE 4: Comparison of initially and finally expanded trips for different time periods

Period	Initial	Final	Under-reporting
AM (2.5 hrs)	2,168,700	2,761,900	21%
PM (2.5 hrs)	1,387,500	2,112,500	34%
Rest	4,760,100	7,429,500	36%
Daily	8,316,300	12,304,000	32%

The initially and finally expanded trips by main modes are set out in Table 5. The under-reporting for public transport modes was less than the non-public transport modes, with taxi being the worst reported mode with only about 20% of the trips reported. This could be due to the special nature of taxi trips that are most often used for non-commuting or irregular purposes, therefore more prone to be under-reported by the respondents. In addition, a relatively high proportion of taxi trips (as compared to the other modes) could be made by visitors or non-residents that were not interviewed in the HIS.

Table 6 compares the total public transport boardings obtained from the initially and finally expanded HIS trip database with the ridership statistics of the relevant modes. The finally expanded boardings for all other public transport modes were within 10% difference from the operators' statistics on a daily basis. The discrepancy in taxi boardings could be explained by factors as discussed above. Overall, the total boardings of all the modes were 4% higher than the statistics. It should also be noted that the

degrees of under-reporting for the number of boardings in various modes of public transport can range from the maximum of 75% for taxi to the minimum of 15% for MTR.

TABLE 5: Comparison of initially and finally expanded daily trips by main modes

Mode	Initial	Final	Under-reporting
Private vehicle	777,000	1,579,000	51%
Taxi	195,000	1,006,000	81%
SPB	693,000	1,057,000	34%
MTR	2,010,000	2,471,000	19%
KCR	429,000	664,000	35%
PLB	977,000	1,147,000	15%
Bus	2,778,000	3,691,000	25%
Other PT	459,000	689,000	33%
Total	8,316,000	12,304,000	32%

TABLE 6: Comparison of public transport boardings (000's /day)

Mode	Operator stat. (1)	Initial (2)	Final (3)	(2)/(1)	(3)/(1)
MTR	2,375	2,015	2,475	0.85	1.04
KCR	865	621	870	0.72	1.01
LRT	337	278	337	0.82	1.00
Tram	248	119	248	0.48	1.00
Ferry	157	98	157	0.62	1.00
PLB	1,752	1,433	1,711	0.82	0.98
F. Bus	4,538	3,694	4,819	0.81	1.06
Taxi	1,000	248	1,094	0.25	1.09
Total	11,272	8,506	11,711	0.75	1.04

The assignment results using the expanded trip matrices for private vehicle, taxi, SPB and the road-based public transport (comprising franchised bus and PLB) are summarised in Table 7. In general, the expanded assignment results compare acceptably with the ATC flows.

One of the criteria in the design of the expansion process is to maintain the travel properties as far as possible. The 3-D balancing process was carried out for this purpose in terms of trying to keep the original trip length distribution. Figure 3 shows a comparison of the trip length distributions for private vehicle trips before and after the trip expansion process. It can be seen that the distribution can be maintained within reasonable range.

6. CONCLUSIONS

The above analysis shows that the degrees of under-reporting differ substantially for different time periods and modes. Thus, it would be necessary to adjust the trip expansion factors derived from demographic data. In order to ensure that the expanded trip data could be consistent with transport statistics and traffic count results such as screenline and station flows, it would also be necessary to derive different expansion factors using matrix estimation techniques for different sector-to-sector movements. It should be noted that traditional matrix estimation method may suffer from distortions of trip length distributions when controlling trip movements to traffic count results and the matrix estimation process might be complicated by the possible use of several modes in one trip. Therefore, a very complicated and iterative trip expansion process as described above was employed to address these issues. Using this method, it was found that the expanded HIS trip data matched well with other traffic count data and transport statistics

TABLE 7: Comparison of expanded assignment results against 2002 ATC screenline flows (000's /day)

Screenline	Private vehicle			Taxi			SPB			Road-based PT[#]		
	ATC observed (1)	TCS expanded (2)	(2) / (1)	ATC observed (3)	TCS expanded (4)	(4) / (3)	ATC observed (5)	TCS expanded (6)	(6) / (5)	ATC observed (7)	TCS expanded (8)	(8) / (7)
X-Harbour	183	183	1.00	41	43	1.07	97	89,500	0.92	705	696	0.99
HK External	105	94	0.90	25	23	0.93	57	52,800	0.92	371	357	0.96
Kln External	455	458	1.01	60	59	0.98	227	230,000	1.01	1,363	1,266	0.93
AA	345	319	0.92	120	136	1.13	126	110,200	0.88	1,043	1,101	1.06
CC	363	321	0.88	129	150	1.17	160	142,000	0.89	1,196	1,206	1.01
KK	203	209	1.03	51	53	1.04	82	95,100	1.17	646	656	1.02
FF	174	165	0.95	92	104	1.13	65	59,200	0.91	442	432	0.98
RR	194	215	1.11	7	7	1.00	143	126,300	0.89	701	693	0.99

Notes: The above figures represent average weekday person travel in the survey period.
[#] Road-based PT includes Franchised Bus and Public Light Bus.
The locations of the screenlines are shown in Figure 2.
X-Harbour = Cross Harbour Cordon, HK External = Hong Kong External Cordon, and Kln External= Kowloon External Cordon

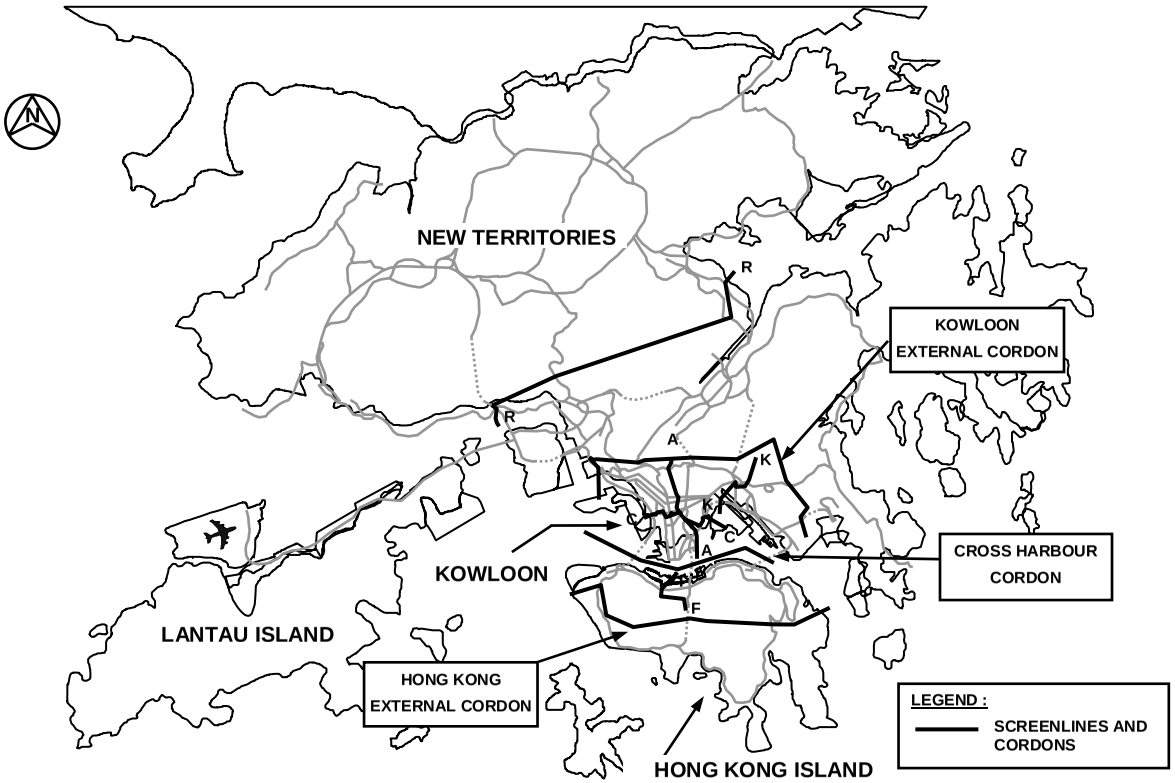

FIGURE 2: Major screenline locations

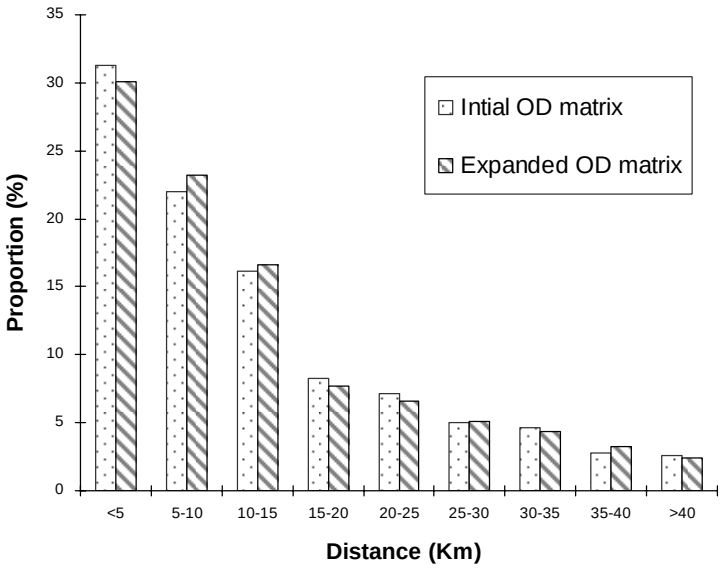

FIGURE 3: Comparison of private vehicle trip length distribution

while maintaining the original trip characteristics such as trip length distribution embedded in the original data. The availability of reliable traffic count data and transport statistics is of paramount importance to the successful accomplishment of trip expansion process.

ACKNOWLEDGEMENT

The authors of this paper are grateful to the Transport Department of the Government of the Hong Kong Special Administrative Region for the permission to publish the work undertaken in the Travel Characteristics Survey 2002.

REFERENCES

Arup – Wilbur Smith Joint Venture (2003) Travel Characteristics Survey 2002 Final Report. Transport Department, The Government of the Hong Kong Special Administrative Region.

Arup – Wilbur Smith Joint Venture (2003) Agreement No. CE 35/2001 Travel Characteristics Study 2002 – Feasibility Study. Technical Report, Transport Department, The Government of the Hong Kong Special Administrative Region.

Department of Transport (2004) National Travel Survey: 2003 Final Results. Transport Statistics Bulletin.

Hu, P.S. and Reuscher, T.R. (2004) Summary of Travel Trends, 2001 National Household Travel Survey. U.S. Department of Transportation, Federal Highway Administration.

MVA Asia Limited (1993) Travel Characteristics Survey Final Report. Territory Transport Planning Division, Transport Department, Hong Kong Government.

Pucher, J. and Renne, J.L. (2003) Socioeconomics of urban travel: Evidence from the 2001 NHTS. *Transportation Quarterly*, **57**, 49-77.

Stratford, N., Simmonds, N., Nicolaas, G., Costigan, P. (2003) National Travel Survey 2002. Department of Transport, UK.

Stropher, P.R. (1998) Household travel surveys: New perspectives and old problems. In Tommy Garling, Thomas Laitila and Kerstin Westin (eds.) *Theoretical Foundations of Travel Choice Modeling*. Pergamon, Elsevier Science Ltd.

Traffic and Transport Survey Division (2003a) Monthly Traffic and Transport Digest. Transport Department, The Government of the Hong Kong Special Administrative Region.

Traffic and Transport Survey Division (2003b) The Annual Traffic Census 2002. Transport Department, The Government of the Hong Kong Special Administrative Region.

U.S. Department of Transportation, Bureau of Transportation Statistics (2003) Highlights of the 2001 National Household Travel Survey. BTS03-05, Washington, D.C., U.S.A.