Cross-boundary Traffic Prediction – A Dynamic Approach

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Abstract

Cross-boundary traffic is changing rapidly in volume, pattern and composition. They are sensitive to many factors such as cross-boundary travel policies, transport facilities available and economic activities on both sides of the boundary. In order to provide timely and sufficient boundary-crossing facilities to facilitate people and vehicle flows, Planning Department has adopted a dynamic approach to predict the cross-boundary traffic – taking into account the changing environment and all the crossing points as a whole. The prediction process involves lots of data and information collection, formulation of a database system to keep track of the development in the Mainland, data analysis and correlation, development and application of mathematical and statistical models. This paper attempts to summarize the prediction process step by step, and highlight the main issues for attention as well as difficulties and the limitations. Traffic forecasts by control point, by transport mode and by design year can be produced for various planning work, such as resources planning and infrastructure development. The accuracy of the prediction and the adopted assumptions are monitored by comparison with actual flow and data. With the growing activities between Hong Kong and the Mainland, this paper also suggests areas worthy of further consideration to improve the quality of the prediction.

1. Introduction

People, both Hong Kong residents[1] and visitors, are concern about the time taken to cross the boundary. The trucking industry sometimes complains about the delay in crossing the boundary as it would imply a higher operating cost. Can we do something to facilitate people and cargo flows?

In 2005, there were a total of about 166 million passenger trips crossing the boundary; about 80% were made by Hong Kong residents. Most of these trips, about 86% were made by land and the rest, about 11% were by sea and 3% by air. At present, there are five land crossing points, including Lok Ma Chau (LMC), Man Kam To, Sha Tau Kok , Lo Wu (LW) and Hung Hom. LW and LMC are the dominant ones, with about 63% and 31% of the total passengers using the land crossings; or on average, with about 231,000 and 113,000 passenger trips per weekday. For the past five years, the total passenger trips had an annual growth rate of about 7.2%

In 2005, the total cross-boundary vehicle trips amounted to about 14.7 million; about 30% were made by container trucks, 37% by goods vehicles and 24% by private cars. The latter have increased significantly in the past few years, with an annual growth rate of

[1] According to Census and Statistics Department's definition, Hong Kong Resident Population includes Usual Residents and Mobile Residents. Usual Residents comprise Hong Kong Permanent Residents who have stayed in Hong Kong for at least three months during the either six-month periods before or after the reference moment, regardless of their whereabouts at the reference moment and Hong Kong Non-permanent Residents who are in Hong Kong at the reference moment. Mobile Residents are Hong Kong Permanent Residents who have spent one to less than three months during the either six-month periods before or after the reference moment, regardless of their whereabouts at the reference moment.

about 20% between 2001 and 2005. Within the same period, the total cross-boundary vehicle flow increased about 6.8% per annum.

To ensure smooth traffic crossing the boundary, we need realistic forecasts of passenger and vehicle flow by crossing point, by transport mode and by design year. They are of paramount importance in the process of planning crossing facilities to meet the demand. However, the cross-boundary traffic is changing rapidly over time in volume, pattern and composition. How can we obtain sensible and practical estimations?

Planning Department has adopted a classic 4-stage transport model to project the cross-boundary travel demand at each crossing point, taking into account all influencing factors such as transport network, land use development, cross-boundary public transport services available, passenger travel behavior and cross-boundary travel policy on both sides of the boundary. The four modeling stages are trip generation, trip distribution, modal split and assignment. To reflect changes in traffic composition and trip purposes, Planning Department has also developed a Passenger Demand Forecast Model based on various statistics and survey data.

This paper will broadly describe each forecasting step and highlight areas for further development. It also attempts to provide readers with an overview of how cross-boundary traffic is predicted scientifically in a dynamic situation that we are facing.

2. Sources of Information and Data

The models employed by the Planning Department are developed using numerous statistics and survey data. They include Cross-boundary Passenger Movement Records (PMRs), Vehicle Movement Records[2] (VMRs), Monthly Digest of Statistics[3], Monthly Traffic and Transport Digest[4], Hong Kong and Guangdong (GD) Population, Land use development, Gross Domestic Product (GDP) and other socio-economic statistics. All these data, however, do not reflect the cross-boundary travel characteristics nor provide information about the experience of Hong Kong residents living in the Mainland. As such, Planning Department has commissioned regular surveys to collect the missing information. They are the Cross-boundary Travel Survey, the survey on Hong Kong Residents' experience and Aspiration for Taking Up Residence in the Mainland and the Survey on Hong Kong People Living and Working in the Pearl River Delta Region. With the completion of the Hong Kong Shenzhen Western Corridor (HSWC) in late 2006, the additional land crossing capacity will open up opportunity for more private car usage. To have a better understanding of the likely demand, Planning Department has also commissioned the Survey on Propensity to use Private Cars to Cross the Boundary in 2005 and results will be available in 2006.

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[2] When a Hong Kong Identity (HKID) Cardholder crosses the boundary, a movement record is created, which contains useful information such as residence status, date of birth and sex, the control point, date and time of crossing and the direction of crossing. All HKID card numbers are replaced by unique serial numbers to protect privacy and based on which the records can be matched to obtain information about an individual's movement across the boundary within a certain time period. Similarly, VMRs provide information about vehicles crossing the boundary. All these information are provided by the Immigration Department and the Custom and Excises Department.

[3] Census and Statistics Department produces Monthly Digest of Statistics which provide annual statistics of cross-boundary passenger arrivals and departures.

[4] Transport Department produces Monthly Traffic and Transport Digest, summarizing different kinds of vehicle trips crossing each control point.

Both PMRs and VMRs are valuable sources of information for model development. To establish a transport model that can truly reflect people's travel behavior and characteristics, information collected in the Cross-boundary Travel Surveys is of particular importance. Three surveys were carried out separately in 1999, 2001 and 2003. Another one is scheduled in November 2006. From these surveys, information including trip purpose, origin and destination of trip and socio-economic characteristics of the trip makers are collected. Analyses of the survey findings allow us to have a better understanding of the changing characteristics of movement and pattern.

In addition to the above statistical and survey data, there is planning information that needs to be collected. They can be broadly divided into four categories, viz. transport-related, Mainland-related, planning and development information and government policies.

Transport-related information includes current major highway and railway network and their development plans in both Hong Kong and the GD Province, utilization level of the existing highway and railway systems and public transport services. The latter comprise of cross-boundary coach, shuttle bus, franchised bus and ferry services as well as domestic public transport services on both sides of the boundary.

Mainland-related information includes statistics, news and published documents. Statistics cover population, GDP and socio-economic data of different cities in the Mainland, in particular within the GD Province. News and published documents cover official and unofficial reports, papers and news. To keep track of the latest development in Mainland cities, Planning Department and the Census and Statistics Department have jointly developed since 2003an inter-departmental information database, now called "Hong Kong-Macao-Guangdong Information Database" (GD database). The GD database consists of two parts. Part I contains major socio-economic statistics of Hong Kong, Macao, the GD Province and other major Mainland economic regions and Part II assembles up-to-date information such as government announcements, news and reference materials in respect of socio-economic, urban planning, transport, infrastructure, logistics, tourism and environmental protection aspects. This database is also equipped with a Geographical Information System to display more accurate and interactive geographical information of the Mainland.

Besides historical data, we need to know all relevant planning and development information such as forecasts of Mainland and foreign visitor arrivals, population and economic growth projections, land use and transport infrastructure plans and construction programme of both sides, Hong Kong Port Cargo forecasts, Hong Kong Port Master Plan as well as measures to improve the hardware and software provision at each control point. All these information are important inputs to the forecasting models.

Cross-boundary traffic demand is greatly affected by cross-boundary policies imposed by either the Mainland authorities or the Hong Kong Government. For example, since the implementation of the Individual Visitor Scheme (IVS) by the Mainland authorities in late 2003, the Mainland visitor arrivals have increased significantly from 6.8 million in 2002 to 12.4 million in 2005. By the end of 2005, IVS covers a total population of 200 million Mainland residents in 38 cities and at present, about 90% of IVS endorsement comes from the GD Province. Another example is the removal of regulatory constraints for road

cargo by the Mainland authorities, including the "4-Up-4-down" rule and "1-truck-1-driver" rule in Jan 2005 and September 2005 respectively. Cross-boundary goods vehicle and container truck trips are being monitored to see if there is any increase in multiple truck trips and reduction of empty goods vehicles. As such, before any forecasting exercise, we need to be clear about the existing policies and the likely changes in order to minimize criticism to any of the predicted flow.

3. The Forecasting Tools

To forecast the total cross-boundary passenger and vehicle trips, Planning Department employs basically two models, viz. the Total Passenger Demand Model (TPDM) and the Cross-boundary Transport Model (CBTM). The model structure of CBTM is shown in ***Annex A*** and the traffic prediction process is simplified in ***Annex B*** for easy reference.

The TPDM is made up of two models, viz. the demand model for the total cross-boundary trips made by Hong Kong residents and the visitor arrivals model for the total cross-boundary trips made by visitors, including both Mainland and foreign visitors. The TPDM is derived, calibrated[5] and validated mainly by using PMR received by Planning Department since 1997, Monthly Digest of Statistics since 1972 and the Cross-boundary Travel Survey results in 1999, 2001 and 2003.

Historical data indicated that cross-boundary trips by air representing less than 3% of the total demand. The CBTM is designed to focus on non-air passenger demand forecast and analysis of the interaction between the passenger demand and the land and sea-based public transport services provision. The CBTM comprises a Highway Model (HM) and a Public Transport Model (PTM). The HM predicts the cross-boundary flow of goods vehicles, container trucks as well as private cars and coaches by crossing point. The PTM estimates the cross-boundary flow of people by transport mode and by crossing point. The CBTM was originally developed under the "Crosslinks Further Study – Stage 1 Investigations on Traffic Demand" commissioned by the Planning Department in 1997. It was calibrated using survey data collected in 1996/97. With more information collected in the Cross-boundary Travel Surveys[6] and updated statistics, Planning Department has regularly enhanced and recalibrated the model structure. Improvements have also been made to the passenger zonal trip end function and trip distribution function.

4. How Total Passenger Demand is Predicted?

All passenger trips are classified by place of residence of Hong Kong Residents (HKR) living in HKSAR or the Mainland. They are further classified by three trip purposes, viz. leisure, business and commuting. The trips made by Mainland and foreign visitors are collectively treated as one class. Such classification is considered appropriate as majority of cross-boundary trips were made by HKR whilst Mainland and foreign visitors only account for about 12% of all cross-boundary movement in 2003. As such, the TPDM is divided into the following seven data series to represent these seven categories of passenger trips:-

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[5] Calibration is the process of determining the "best fit". This may not be a good fit. Hence it is often useful to use some of the statistical measures (R^2, χ^2 for instance) to measure whether the fit is good, having calibrated using some other method. It is always useful to validate the model by checking that the modeled values resemble the real values.

[6] Planning Department has commissioned three Cross-boundary Travel Surveys in 1999, 2001 and 2003. Another one is being scheduled in 2006.

1. Commuting trips made by HKR usually living in HKSAR
2. Business trips made by HKR usually living in HKSAR
3. Leisure trips made by HKR usually living in HKSAR
4. Commuting trips made by HKR usually living in Mainland
5. Business trips made by HKR usually living in Mainland
6. Leisure trips made by HKR usually living in Mainland
7. Trips made by Mainland and foreign visitors.

Cross-boundary Travel Survey data are distinguished by person type in accordance with the above categories. Two models using discriminant analysis[7] technique are developed based on the trip makers' characteristics. They define the classification criteria in estimating the possible trip purpose of every cross-boundary trip made by HKR. By applying these models, every cross-boundary trip in the PMR can be classified into any one of the above categories. To improve the accuracy of this process, two additional assumptions were made. In classifying each trip, we assume business trips will only be made by travelers aged between 20 and 69 and the traveling frequency of a traveler who generates commuting trips cannot be less than one round trip per week.

Due to the lack of PMR information prior to 1997, we have adopted an event-based analysis to separate trips between 1972 and 1996. In doing so, we have made four assumptions in response to the observed policy changes as follows:-

1. Negligible passenger trips generated by Mainland or foreign visitors before 1978 (Open Door Policy in China);
2. Negligible business trips generated by HKR before 1983 (Setting up of Shenzhen Economic Zone)
3. Negligible commuting trips generated by HKR before 1990 (June 4th incident)
4. Negligible passenger trips generated by HKR usually living in Mainland before 1990 (June 4th incident)

Using the above four assumptions and the PMR categorized trips, regression analysis and interpolations are performed to postulate the percentage change in proportion of different categories of trips. Visitor trips are first separated using visitor data back to 1990. For trips made by HKR, they are first classified into two groups by residency, then by the three trip purposes.

A Demand forecast model is developed to estimate future demand through projection of the annual 2-way trip rate per capita for each category of cross-boundary movement made by HKR. To derive the trip rate, the projections of resident population prepared by the C&SD are used. Various trend-based time series models are assessed to define the best-fit model for each movement category. Assuming the growth in trip rate will slow down in the medium term and approach a steady stage in the long term, forecast model with S-shape, either Gompertz[8] or Sinuous model is applied to set a ceiling to the trip rate in the remote future.

Trips made by Mainland and foreign visitors are forecasted using the Visitor

[7] Discriminant Analysis is a multivariate statistical technique concerning with separating distinct sets of objects and allocating new objects to previously defined groups.

[8] Gompertz Model is a kind of growth model with S-shape. The growth rate increases rapidly at the very beginning and slows down after certain time period. This shape is very common for economic growth, population growth or biological studies.

Arrivals Model. The estimation approach adopted univariate autoregressive integrated moving average (ARIMA) analytical technique. Separate ARIMA[9] models are identified for the estimation of visitor arrivals from Mainland and from places other than the Mainland.

For visitor arrivals from Mainland, it is found that a mixed non-seasonal and seasonal autoregressive moving average model is the most appropriate process to generate the time series for the purpose. This basic model form is augmented by a step intervention model to capture the impact of quota relaxation for Hong Kong Group Tour scheme by the Mainland authorities since January 2002 and by a transfer function model to capture the impact of the SARS outbreak in March 2003. The impact of Individual Visit Scheme (IVS) introduced since 28 July 2003 have not been singled out in the estimation model as its impact has been subsumed in the impact of group tour relaxation. However, as the IVS is still expanding to cover more cities in the Mainland, its impact will need to be monitored and data collected to enhance the validity of the forecasting model.

For visitor arrivals from places other than the Mainland, a mixed non-seasonal and seasonal moving average model, both of the first order, with the original data consecutively and seasonally differenced. This basic model form is augmented by a transfer function model to capture the impact of the SARS outbreak.

The impact of the opening of the Hong Kong Disneyland is a separate exercise carried out by the Government Economist and is added to the above estimations to obtain the total number of visitor arrivals. The total cross-boundary passenger trip is therefore, the summation of the above estimations of trips made by HKR and visitors.

5. Cross-boundary Transport Model

The CBTM consists of two models, viz. PTM and HM. PTM is used to predict passenger flow at different crossing point by transport mode and the HM is used to predict vehicle flow by vehicle type by crossing point. Both models adopt a unified zoning system of 105 zones, of which, Hong Kong is represented by 40 zones, Macao as a single zone, Pearl River Delta region by 21 zones and the remaining areas in the GD Province by 29 zones. To cater for movements outside the GD Province, 5 zones are allocated and 9 other zones are reserved for future model applications to cover possible developments of new crossing point and network expansion.

The CBTM is a multi-modal model that can reflect choices of route and transport mode. The highway network includes both the highway network in Mainland and Hong Kong. For Mainland network, it covers expressway and major trunk roads and the information are updated regularly with the latest construction programme. Hong Kong network are prepared based on the latest transport infrastructure development program prepared by the Environmental, Transport and Works Bureau. Railway links and ferry routes are then added to the highway network to form a complete public transport base network. Once completed, all major cross-boundary and domestic public transport services information are incorporated. On Mainland side, domestic public transport services cover the Guangzhou and Shenzhen Metro services and those bus and coach services provided near the

[9] An ARIMA process is made up of sums of autoregressive and moving-average components, and may not be stationary. Autoregressive describes a stochastic process that can be described by a weighted sum of its previous values and a white noise error. Its process is a first-order one process, meaning that only the immediately previous value has a direct effect on the current value.

boundary crossing points. Service details such as service frequency, fare, routing, journey speed and distance between stops are coded collectively for similar type of services.

The following paragraphs describe how passenger and vehicle trips are estimated by using the PTM and HM.

Passenger Trips

The PTM comprises of a Zonal Trip Ends Model, Trip Distribution Model, Modal Split Model and Assignment Model. The Zonal Trip Ends Model employs twelve regression equations to derive a relative zonal trip end pattern for each category of passenger trip as mentioned in section 5 above except for the category of visitor trips. The zonal trip end pattern of visitor trips is obtained by growth factor technique, making reference to relevant information collected from the Hong Kong Tourism Board and surveys. Since the sum of each zonal trip end is controlled by the respective trip total by residency by trip purpose, the actual amount of trip assigned to each zone is distributed on a pro-rata basis in accordance with the relative zonal trip end pattern derived from the respective regression equation. Applying the future planning and economic data in the model, we can obtain the estimated number of passenger trips generated from and attracted to each zone in a particular design year.

The Trip Distribution Model is used to estimate the number of trips made between pairs of zones. The model has adopted the Gravity modeling technique[10]. As each trip category has unique characteristics, seven individual sets of cost deterrence functions were established to obtain the trip matrices of each trip category. By applying the future network assumptions, the future year Origin and Destination trip matrices[11] are obtained. The summation of these trip matrices is the total demand matrix ready for the next step of estimation process – modal split.

Modal split is the process of determining which transport mode is used by the passenger trips between each pair of zones. The choice of transport mode is affected by many factors, including individual trip end factors such as income, car ownership and availability; zonal trip end factors such as distance from city centre and accessibility to public transport; characteristics of the journey such as trip purpose and the characteristics of the spatial separation of the trip ends such as cost of travel, in-vehicle time, walking and waiting time and parking cost and availability. Based on statistics, the proportion of cross-boundary trips by air is first compiled and deducted. Cross-boundary private cars are subject to quota control[12]. A quota allows a private car to be driven across the boundary via a specified crossing point without any limit on the number of crossings. Hong Kong citizen who have made investments or donations up to a certain amount or are holding certain political offices on the Mainland are eligible for applying for the quotas. In order to determine the passenger trips by private car in each prediction exercise, we need to make some assumptions on the

[10] Gravity Model derives its name and basic premise from Newton's law of gravity. Newton's law states that the attractive force between two bodies is directly related to their size and inversely related to the distance between them. Thus in the "gravity model" the number of trips between traffic zones is directly related to the level of land development within each traffic zone and inversely related to the distance between them. A separate "gravity model" is developed for each trip type as each trip purpose exhibits different trip distribution characteristics.

[11] The result of trip distribution is a table, or matrix, identifying trip productions and attractions from each zone to all other zones which is generally referred to as the “Origin/Destination (OD) Trip Matrix”.

[12] A quota system for cross-boundary vehicles was introduced in 1982 in response to increasing cross-boundary vehicular traffic. It is jointly administered by the Hong Kong and GD/Shenzhen authorities. All cross-boundary private vehicles are subject to quota restrictions.

Private Car Quota Policy in future. Based on the assumptions and the relationship obtained from statistics between number of quota and private car trips, the proportion of passenger trips using private car is calculated.

The next step is to use the Multiple Logit Model to compute the proportion of the rest of the trips between each origin and destination that use a particular transport mode. The transport modes include boundary train, through train, cross-boundary coach/bus and ferry. The final route assignment step is to allocate trips between an origin and destination by a particular mode to a route. Unlike private cars, public transport is confined to the services that the various ferry, bus and train companies run. On public transport, one can only go between the places served by public transport, at the time and places they serve. To do this, we need to code the public transport route as well as fare and movements between origins and destinations, all are disaggregated by mode. Once we have obtained the number of passenger trips by transport mode by control point, we need to convert the passenger trips by cross-boundary coach, bus and private car into numbers of vehicle trip by using different occupancy rates derived from surveys. The occupancy rate for private car ranges from 1.6 to 2.3 (excluding driver), and for coach/bus, it is assumed to be 30 (excluding driver).

The resulting vehicle flow will be added to the estimated vehicle flow obtained from the HM to form the total cross-boundary vehicle flow at individual control point. Up to this point, the passenger trips are presented as annual figures. For planning purpose, the annual passenger trip is converted to average weekday daily passenger trip by dividing it with an annualization factor of 397.8. This annualization factor is derived from statistics.

The CBTM implicitly assumes sufficient public transport services to serve the predicted passenger demand and very small changes to the overall accessibility, which means that the estimated demand is not service dependent. In order to study the effect of any major changes to cross-boundary public transport services to the demand, an Elasticity Model is developed which takes into account changes in generalized cost. The cost comprises waiting time, access and egress time, interchange time, in-vehicle time, immigration time and fares. For each OD pair, the generalized costs of the case with and without the major public transport service are compared in order to estimate the volume of additional demand.

Vehicle Trips

In 2005, the cross-boundary vehicle trips are made up of 29.7% container trucks, 37.1% goods vehicles, 8.9% coach/bus and 24.3% private cars. The key determinant factor in assessing the cross-boundary vehicle flow is the prediction of the total cargo volume between Hong Kong and the Mainland, in particular the Pearl River Delta region. The cross-boundary freight volume is projected based on the estimation from the Port Master Plan 2020. All air cargo is excluded, as they do not contribute to freight volume across land crossings. Crude materials such as aggregates and liquid bulk are also removed from the total tonnages of cargo for analysis as their transport would unlikely be transferred from river to road.

After deducting the volume of air cargo, crude materials and liquid bulk from the total Hong Kong cargo, the rest of the tonnage is classified as road eligible cargo, which can be sub-divided into road-based cargo, river-based container cargo and river-based break bulk. The HM employs a freight modal split function to separate the road eligible cargo demand into modes of road and river based on the respective transport networks and travel costs. This model is developed using the total tonnage of freight by county and municipality in GD

to Hong Kong. The tonnage is based on estimates prepared by the Port Cargo Forecast disaggregated by sub-region, essentially at municipality level in the Pearl River Delta area and more globally in the outer areas of GD Province.

The split of road eligible cargo by road between goods vehicles and container trucks is based on the existing pattern obtained from surveys and statistics. It is also assumed that the degree of containerization will increase slightly with time to reflect higher operational efficiency. The road freight in tonnage derived from the above mode split function is then converted to goods vehicle and container truck trips using average loading factors obtained from statistics and surveys.

According to the Cross-boundary Travel Survey in 2003, the proportion of empty goods vehicle trips leaving and arriving Hong Kong was 57.8% and 26% respectively. To estimate the total freight vehicle trips crossing the boundary, the model has adopted a slightly decreasing proportion of empty vehicle trips. By applying a gravity model, taking into account operating cost, journey time, toll charges and the capacity of each control point, the goods vehicles and container trucks are distributed between Mainland and Hong Kong zones to produce corresponding daily vehicle matrices.

Finally, the various vehicle matrices, together with the private car and coach/bus trip matrices estimated from the PTM, are assigned to the highway network using generalized cost and the 'minimum path' rule. The output of the CBTM is the total vehicle flow, including private cars, coach/bus, goods vehicles and container trucks by control point by direction and by design year.

6. Model Applications

The CBTM is used by the Planning Department to estimate passenger and vehicle flows at each crossing point. The model is frequently used to estimate the impact of changes in population, economic growth and land use assumptions on both sides of the boundary. For example, in the ongoing Hong Kong 2030 Planning Vision and Strategy Study undertaken by Planning Department, the model is applied in the evaluation process of various development scenarios and options.

The model is also frequently used to test the impact of major transport infrastructure, whether being constructed or under planning, on cross-boundary traffic pattern and demand. Recent examples include the testing of the Lok Ma Chau Spur Line, Hong Kong-Shenzhen Western Corridor, Guangzhou-Shenzhen-Hong Kong Express Rail Link, Hong Kong-Zhuhai-Macao Bridge, new crossing point at Liantang and the Pearl River Delta Rapid Transit System. The changes in cross-boundary policy such as private car quota or tolling strategy of various highway networks on either side of the boundary will also have impact on the traffic pattern and demand. The model outputs provide a good reference and scientific analysis of the subject issue to facilitate planning work of the administration. The model is also used to explore the complex interactions between all competing and/or new transportation modes from either a demand or system performance perspective with relatively reliable and available aggregate data.

There are always criticisms of the accuracy of the modeled flows, in particular under the current rapid changing environment with increasing economic and social interaction between Hong Kong and the Mainland. The growing intimacy between Hong Kong and

Shenzhen has major implication on the cross-boundary traffic demand. To maximize the applicability of the predicted flows, realistic model input assumptions and good quality of data are essential. However, there are difficulties to collect reliable Mainland data. Most of the official data are not up-to-date and their record format is usually different from ours. It is also difficult to collect Mainland historical data with greater detail which is essential for model development. To forecast the future traffic condition, we need to know the future development plan of the Mainland cities. However, it is Mainland's practice to only have their five year plans in greater detail. For longer term planing, they have either development direction or vision. Without more concrete planning data, the forecast figures are vulnerable to criticism.

To ensure the modelled flows represent the current and future traffic situation, the prediction tools are regularly calibrated and validated using the latest available statistics and survey results collected from time to time. Whenever there are major changes in land use development, economic growth, transport network or cross-boundary policy, traffic prediction exercise is performed to examine the consequential effect. Planning Department carries out frequent prediction exercises to catch up with the development.

The CBTM needs constant enhancement to reflect the rapid changes in traffic demand and pattern and ascertain its applicability for traffic demand prediction. The imminent areas for researches cover the appropriateness to use time series modeling techniques to produce long-term visitor arrivals forecasts, refinement to the TPDM with more statistics and new cross-boundary travel survey findings, review the prediction process on the proportion of passenger trips by private car with the survey findings of the Survey on Propensity to Use Private Car to Cross the Boundary and to explore the possibility to extend the network coverage to Pan-Pearl River Delta region. The continuously increasing number of Mainland visitor trips will impose higher pressure on the modeling work as their travel behavior and characteristics are quite different from the Hong Kong people. Cross-boundary Travel Characteristic Survey may need to be modified to collect more information on Mainland visitors' trips, from which the trip purposes, ODs and socio-economic characteristics of trip makers can be correlated.

7. Conclusion

This paper outlines the methodologies adopted by the Planning Department to predict the cross-boundary traffic flow at each crossing point. The prediction process is scientific and the transport model development process has taken full advantage of the large in-house information database covering statistical data, survey information, development planning information and official and unofficial publications and reports. The Planning Department has also adopted a dynamic approach to predict the traffic volume in response to changes in development plan, transport network and services, economic growth and policy. All these forecasts will form the basis for various planning work. To ascertain high quality traffic prediction output, the Planning Department will continue with the enhancement and development of transport models that fit for the purpose and undertake up-to-date traffic forecast in response to changes. Readers of this paper will have a better understanding of how cross-boundary traffic is predicted and its limitations and will certainly appreciate the efforts made by the department in supporting the planning of smooth passenger and cargo flows across the boundary.

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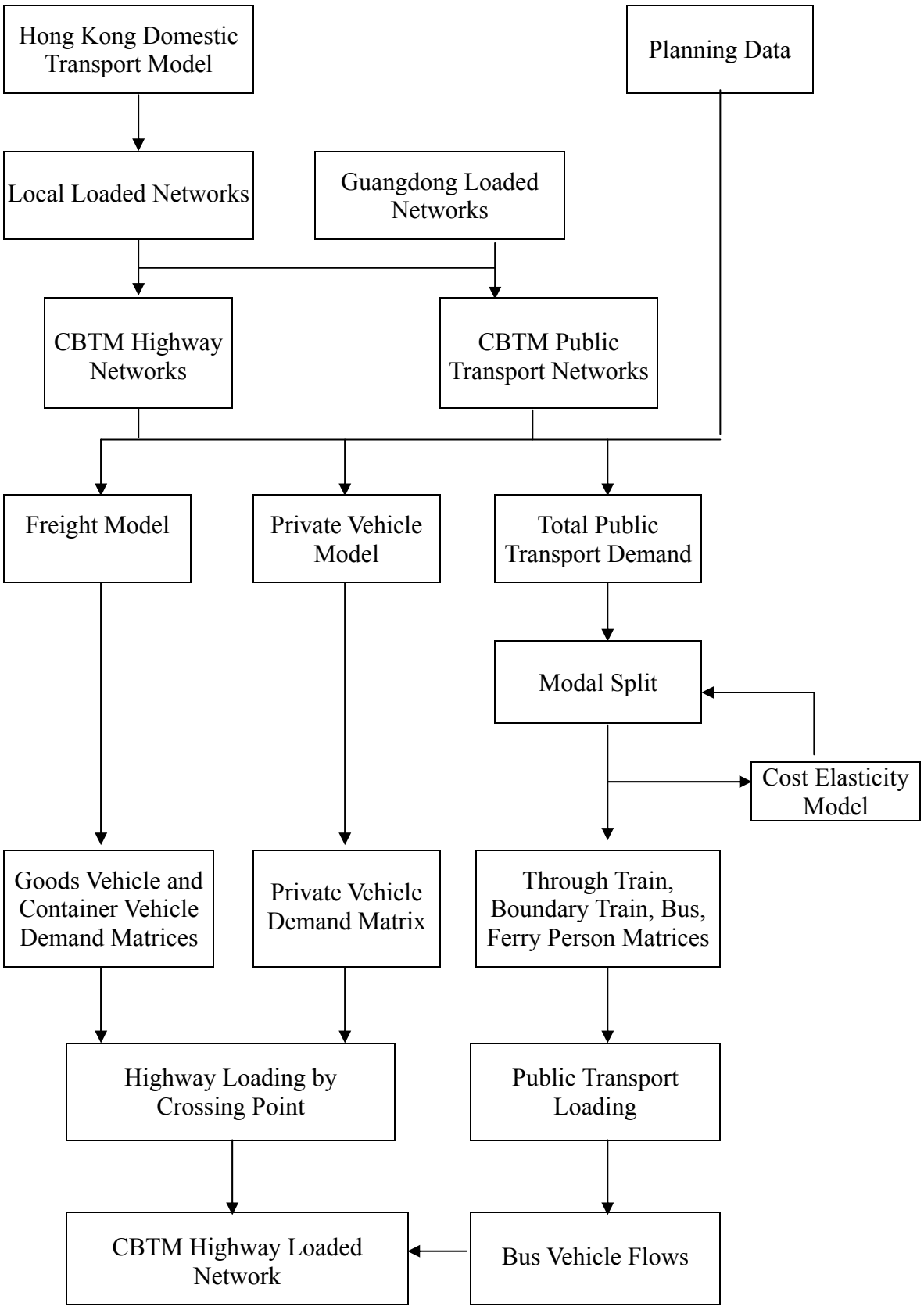
ANNEX A

Cross Boundary Transport Model (CBTM) Structure



跨界運輸模型
Cross Boundary Transport Model