# 2011 EASTS Outstanding Transportation Project Award



## Journey Time Indication System in Kowloon (JTISK)


April, 2011

Autotoll
快易通

# 1. EXECUTIVE SUMMARY

Autotoll Limited (Autotoll) is pleased to submit our Journey Time Indication System in Kowloon (JTISK) Project for the 2011 EASTS Outstanding Transportation Project Award.

The objective of the implementation of Journey Time Indication System (JTIS) is to disseminate real-time journey time information to motorists via LED displays, interactive voice response system (IVRS) and internet speed map so that motorists are enabled to choose alternative routes to cross the harbor from Kowloon Peninsula to Hong Kong Island and vice versa to avoid the traffic congestion.

Autotoll, the Electronic Toll Collection (ETC) service provider in Hong Kong, collaborated with counterparts to lead a team of experts to undertake the project. The implementation enables the motorists to compose a plan which aids at shortening the driving time by choosing a less congested route to cross the harbor prior the journey. Moreover, based on the journey time information via LED displays, IVRS and speed map at the webpage of the Hong Kong Transport Department, motorists can make their route choices to cross the harbor so as to alleviate the congestion on the roads connecting cross harbor tunnels.

The challenges from design to commissioning of the JTISK are to handle numerous sites' work, coordination with different government departments and utility service companies, installation on main routes and expressways, and more crucially to satisfy the high accuracy level as required by the Hong Kong Government. The project team not only has met all these challenges and delivered the project within permitted schedule and budget, but had also maintained the quality of work. JTISK was a prize winning project of "Considerate Contractors Site Award" organized by Works Branch of the Development Bureau of the Hong Kong Government and was granted a Merit Award.

# 2. OUTLINE OF THE PROJECT

The Transport Department of the Hong Kong Government invited tenders for the implementation and operation of the Journey Time Indication System in Kowloon (JTISK) and the integration of JTISK with the Journey Time Indication System in Hong Kong (JTISHK), and Autotoll was successfully awarded the tender. JTISK was the extension of JTISHK which had been implemented in 2003. JTISHK provides the estimated journey time from Hong Kong Island to the exit of three cross-harbor tunnels in Kowloon Peninsula via three sets of on-gantry indicators. The journey time estimates are updated at five-minute intervals.

The scope of work of this project, JTISK, included (1) the installation of journey time indicators with digital display modules at six strategic locations in Kowloon Peninsula to provide real-time average journey time of vehicles crossing the harbor through the three cross-harbor tunnels; (2) the installation of the necessary vehicle detection equipment along the approach roads to the cross-harbor tunnels in Kowloon Peninsula to collect the traffic data required for computation of the estimated journey time; (3) the design and the development of computer system for computing journey time information at two-minute intervals, and for monitoring and controlling the system operation; (4) modification of vehicle detection and data communication equipment of JTISHK for integrating with the JTISK as a single system; and (5) the development of computer system to disseminate journey time information and average vehicle speeds of the combined JTISHK and JTISK on the Internet.

The JTISK has been launched to the public at the end of May 2010. The completion of the project enables the motorists to compose a plan which aids at shortening the driving time by choosing a less congested route to cross the harbor prior the journey. Moreover, providing journey time information via LED displays, IVRS and speed map at the webpage of the Hong Kong Transport Department for motorists to make route choices based on the latest traffic information at major approach roads to the cross-harbor tunnels in Kowloon Peninsula and hence alleviate the congestion on these approach roads.


**Figure 1, Coverage Areas of JTISK and JTISHK**

As a contractor and operator, Autotoll is responsible for the supply, installation, operation and maintenance of journey time indicators, vehicle detection devices and system for travel time computation and dissemination and other related hardware, software and system necessary for the implementation of the JTISK and integration with JTISHK. The project was commenced in October 2008 and lasted for 18 months. Autotoll would be responsible for 8 years' operation and maintenance upon completion of the implementation. The construction budget of the project was US$5.5 million.

## 3. IMPACT OF THE PROJECT

***Social Impact***

Hong Kong is a dynamic city, but its transportation is terrible. In urban area, such as Causeway Bay and Tsim Sha Tsui, the roads are usually fully clogged with vehicles in rush hours. There are many sources of this traffic congestion, for instance, underground repairs, too many buses, special events and traffic accidents. The bad traffic condition causes many problems, such as buses arriving late, delays in deliveries. It is difficult to estimate how much time Hong Kong residents waste in traffic congestion or the economies loss but the figures are definitely high. Yet, time is money. As such, JTIS is an influential system not only enables to alleviate the serious traffic problem facing by the public, but can also save the economies loss.

***Transportation Impact***

During rush hours, vehicles are usually not evenly distributed on the roads. If motorists select the less occupied road, they can avoid jams. An advanced traveler information system such as JTISK could provide such information to motorists. All motorists, not only the drivers who use this system, could travel more smoothly as jams would be eliminated because this system can help to redistribute the vehicles on the roads. The system creates an equilibrium system because more vehicles will travel on the less occupied road. This can help to avoid overloading roads while allowing drivers to select the best route to their destination.

Furthermore, Autotoll adopted the methodology of collecting traffic data from its corporate Automatic Vehicle Identification (AVI) tags for real-time journey time estimation has extended the application of AVI technology from ETC service to the industry of the Intelligent Transportation Systems (ITS). This gives an insight on the further utilization of available traffic raw data to deduce valuable information.

# 4. METHOD/TECHNOLOGY OF CONSTRUCTION

The overall JTISK system block diagram is illustrated in **Figure 2**. It consists of numerous sub-systems for traffic data collection and communication, journey time computation, information dissemination, central control and monitoring, etc.

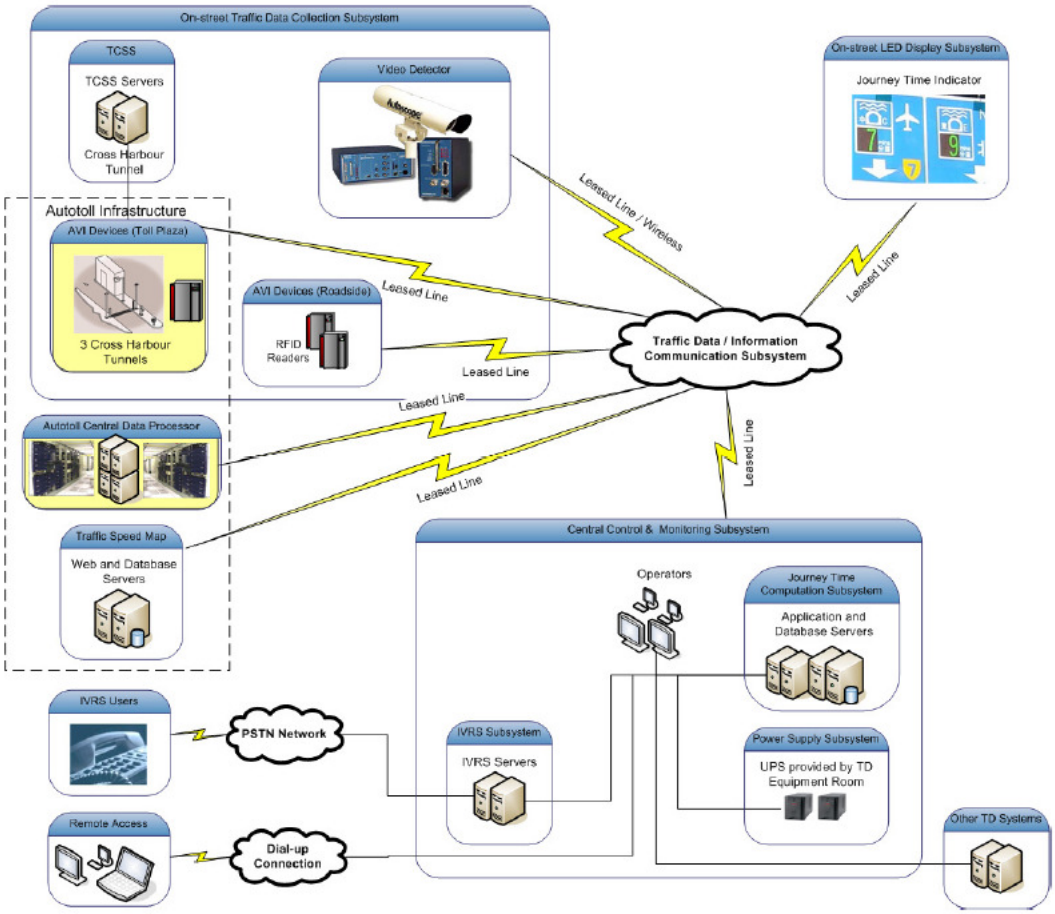



**Figure 2. JTISK System Block Diagram**

***Hybrid Data Collection Method***

The key and unique methodology adopted in JTISK was the hybrid data collection method which provided high accuracy level in capturing the data for real time journey time estimation. According to the contract of the JTISK project, the requirement of the distance between two adjacent traffic monitoring stations (TMS) should not be more than 2.5 km, except within harbor crossing tunnels. TMS refers to the front-end sensor components and any integrated or ancillary traffic data processing unit for acquisition of traffic data for the generation of journey time information. A TMS may contain more than one detector for data collection.

Two types of traffic detectors have been adopted for collection of real-time data for journey time estimation in the JTISK. These traffic detectors are the automatic vehicle identification (AVI) tag reader by radio frequency identification (RFID) technology and the video detector by video image processing (VIP) technology. AVI technology can provide robust and area-wide traffic data, even when the sample size of observed vehicles is relatively low. The performance of AVI technology is stable without any adverse effect caused by the traffic and weather conditions, and no error on ID matching with the use of the AVI tags. Worldwide application of AVI technology to journey time estimation in the prominent cities such as Houston, San Antonio and New York and Autotoll's solid experience in extensive deployment of such technology in Hong Kong, AVI should be the best suit technology for the travel time data collection. However, the capital cost of such technology is high. On the other hand, the cost of video detector using VIP technology is comparatively lower.

Thus, the cost-effective solution is a hybrid detection methodology by integrating the AVI technology with VIP technique for real-time data collection. AVI tag readers have been installed at all LED display sites, while video detectors have been installed at the strategic routes with not more than 2.5 km between them. The number of traffic detectors for JTISK and JTISHK are given in **Table 1**. AVI tag reader captures the time stamps of vehicles passing that AVI tag reader together with their identification information. By matching the identification information of the vehicles, journey times of vehicles passing between two consecutive tag readers are computed at two-minute intervals. The video detectors record the traffic counts and the spot speeds of vehicles travelled at particular locations.

| | No. of AVI tag readers | No. of video detectors |
|---|---|---|
| JTISK | 13 | 19 |
| JTISHK | 9 | 16 |

**Table 1. Number of Traffic Detectors for JTISK and JTISHK**


**Figure 3. AVI Tag Readers Installed on Gantry**


**Figure 4. Video Detector Installed on Gantry**

The conventional methods would only estimate journey times for the paths with real-time data available, such as the previous JTISHK. As such, the errors of their estimates would increase with reduction on available real-time data particularly when some of the TMS for real-time data collection were broken down. In this JTISK project, real-time traffic data captured from various traffic detectors together with the offline (historical) data are simultaneously considered in the journey time estimation algorithm.

***Computation Algorithm***

The adopted algorithm in JTISK, shown in **Figure 5**, integrates different types of available real-time traffic data and offline estimates for provision of most up-to-minute traffic information for the selected paths in Hong Kong Island and Kowloon Peninsula. In addition to the use of real-time AVI data collected from roadside tag readers and tunnel toll booths along the selected paths and VIP data for journey time computation, the offline database could be complementary to the real-time database as the availability of real-time data would be varied by time of day and day of the week etc. The offline database would be updated continuously with the real-time data collected by time of day and day of the week for improvement of the journey time estimation. Moreover, the algorithm is capable of further expansion of the coverage areas of real-time traffic information provision.

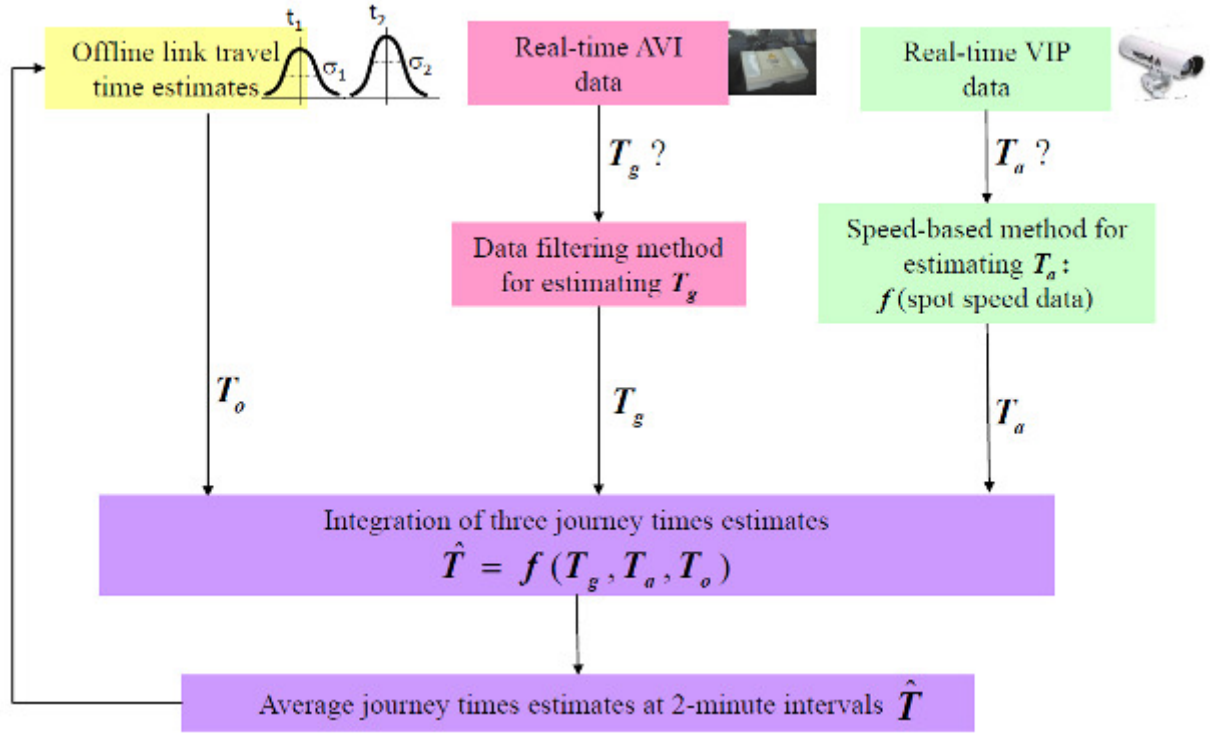



**Figure 5. Adopted Algorithm for Journey Time Computation**

The merits of the adopted algorithm are:

- Feasible for integrating other data sources and different types of real-time traffic data for journey time estimation.
- Offline database is integrated into the real-time journey time computation system. Not only mean travel time data but also spatial covariance relationships of link travel times are adopted in the algorithm for journey time estimation. The covariance can indicate some correlations between link travel times. This correlation is of particular help for link travel time estimation based on spot speed data.
- A robust data filtering method was developed for generating stochastic valid time windows. The thresholds of valid time window are dependent on various factors at previous time intervals.

***Validation Method***

According to the contract requirement of the project, the accuracy level of the journey time estimates on each of the selected paths should be within +/- 20% errors with a compliance of 95% in two survey days. To validate the journey time estimates, comprehensive floating car surveys were conducted for collection of the observed journey times. The surveys were carried out during two peak and one non-peak periods on typical weekdays and weekends (Saturday or Sunday) respectively. Each of the survey periods was scheduled with three hours. During the surveys, the test vehicles were driven at similar speeds of the surrounding traffic on the selected paths. Hence, the journey time measured on each of the selected paths can be considered as an observed average travel time of the traffic stream as a whole. The validation results for the journey time estimation on the selected paths in JTISK and JTISHK are summarized in **Table 2**. The results showed that both JTISK and JTISHK meet the requirement of the targeted accuracy level (i.e. +/- 20% errors with a compliance of 95%) for all the selected paths throughout the survey periods within the two survey days.

**Table 2. Validation Results for Journey Time Estimation in JTISK and JTISHK**

| JTISK | | | | JTISHK | | | |
|---|---|---|---|---|---|---|---|
| Path No. | Selected path | No. of samples | Accuracy* | Path No. | Selected path | No. of samples | Accuracy* |
| 1 | J1-CHT | 159 | 98.1% | 1 | JHK1-CHT | 94 | 97.9% |
| 2 | J1-WHC | 117 | 98.3% | 2 | JHK1-EHC | 91 | 98.9% |
| 3 | J2-CHT | 78 | 96.2% | 3 | JHK2-CHT | 120 | 95.0% |
| 4 | J2-EHC | 203 | 99.0% | 4 | JHK2-EHC | 102 | 97.1% |
| 5 | J3-CHT | 110 | 96.4% | 5 | JHK2-WHC | 110 | 95.5% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | J3-EHC | 137 | 100.0% | 6 | JHK3-CHT | 103 | 95.1% |
| 7 | J3-WHC | 80 | 98.8% | 7 | JHK3-WHC | 114 | 98.3% |
| 8 | J4-CHT | 86 | 95.3% | 8 | JHK11-CHT | 90 | 97.8% |
| 9 | J4-WHC | 132 | 98.5% | 9 | JHK11-EHC | 119 | 99.2% |
| 10 | J5-CHT | 187 | 97.3% | | | | |
| 11 | J5-EHC | 184 | 98.4% | | | | |
| 12 | J6-CHT | 93 | 95.7% | | | | |
| 13 | J6-WHC | 114 | 96.5% | | | | |

*Percentage of samples within ± 20% errors throughout the survey periods in the validation.

J1-J6, JHK1-JHK3 and JHK11 are the journey time indicators in Kowloon Peninsula and Hong Kong Island, respectively.

Abbreviation: CHT – Cross Harbor Tunnel; EHC – Eastern Harbor Crossing; WHC – Western Harbor Crossing.

### *Construction*

The construction work of the project embraced civil, electrical and mechanical aspects. As stated aforesaid, AVI tag data collection was the key component of JTISK, therefore, the design, installation method, workmanship of the AVI tag readers were crucial factors for the accuracy, excellent deployment and implementation of the project. As such, Autotoll has derived and designed the unprecedented and unique mounting method for the AVI tag reader. Mounting frame for AVI antenna installation is shown in **Figure 6**. This mounting frame was designed to be fixed on gantry and fit for the existing gantry traffic sign structure. This mounting frame and the corresponding mounting methods have been approved by the Hong Kong Highways Department.

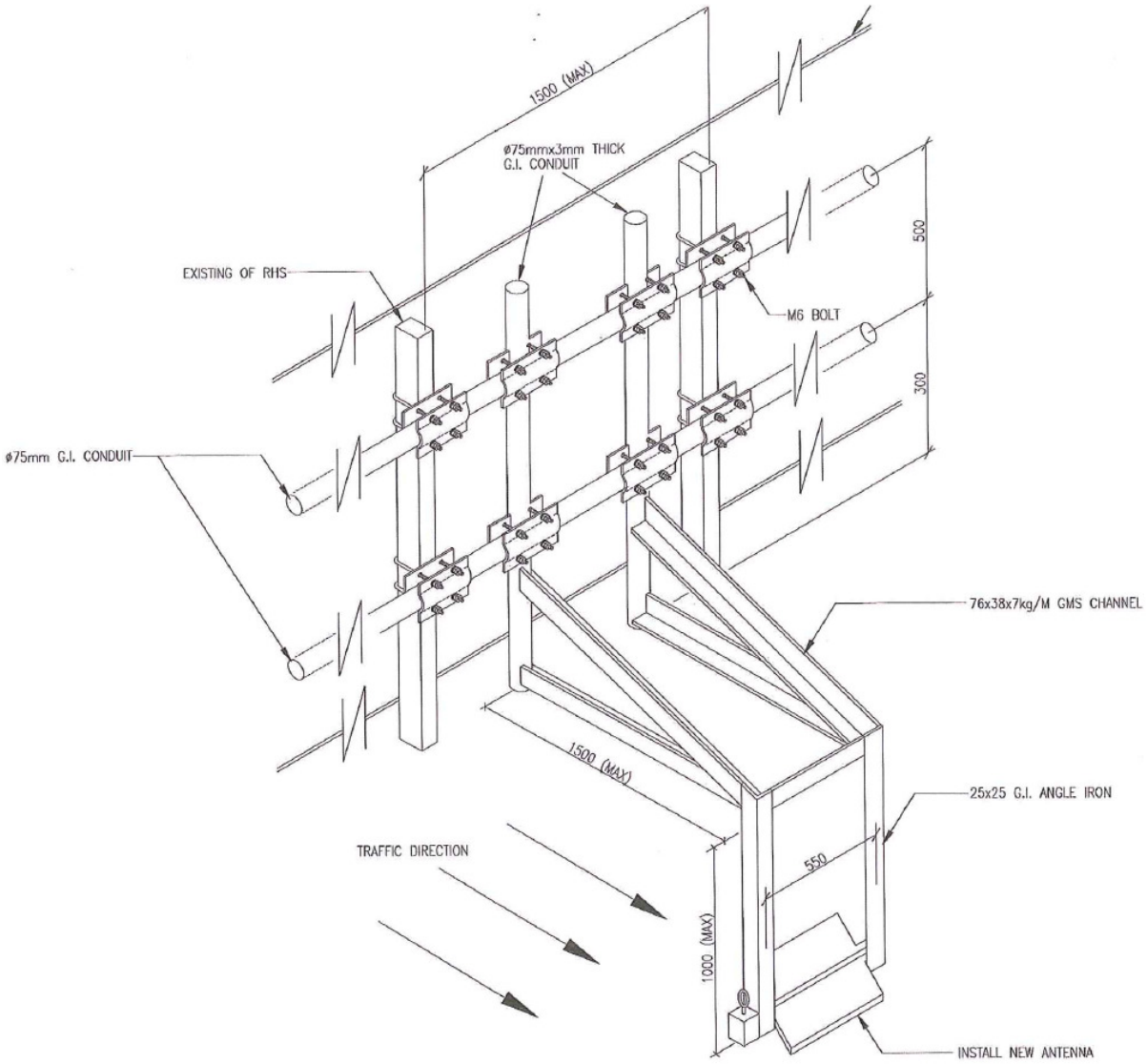



**Figure 6. AVI Antenna Mounting Frame**

Besides, crane lorry and chain blocks (or other equivalent access tool/equipment) have been used to lift up the antenna mounting frame to proper location for installation. Appropriate Temporary Traffic Management (TTM) which had been approved by the Hong Kong Transport Department has been deployed on the corresponding lane(s) with installation work.

Apart from the AVI tag readers, journey time indicators have also been installed for the journey time indication. **Figure 7** shows the layout of a journey time indictor (JTI) installed at a particular major route on Hong Kong Island.

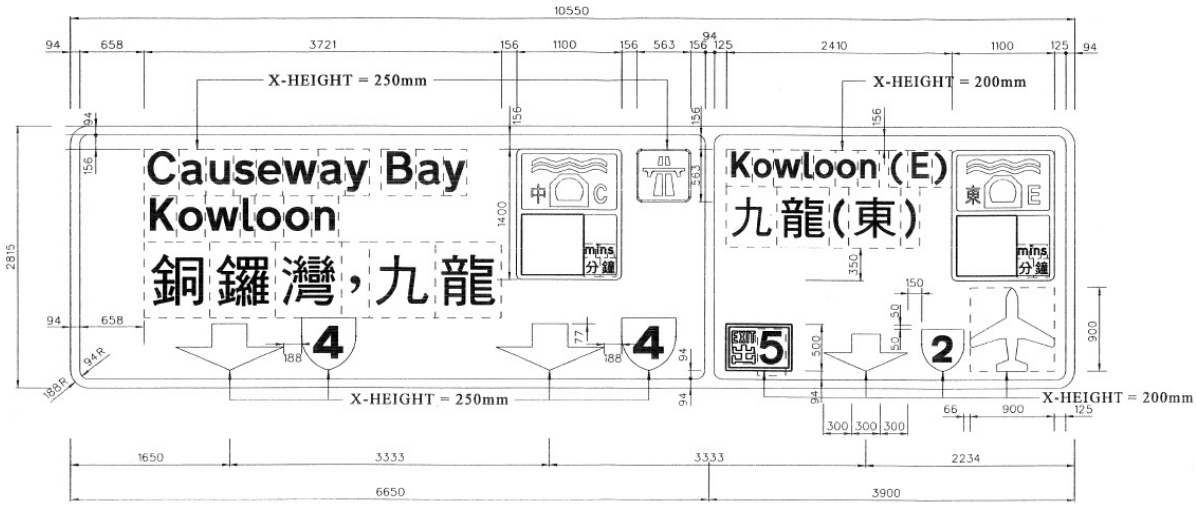



**Figure 7. Journey Time Indicator**

Traffic sign supporting frame has been modified in advance for JTI installation. Crane lorry and chain blocks (or other equivalent access tool/equipment) have been used to lift up traffic sign JTI to proper location for installation. Same as the installation of AVI tag readers, appropriate TTM which had been approved by the Hong Kong Transport Department was deployed on the corresponding lane(s) with installation work.

The video detectors were mounted on an installation pole which had to be fixed on the existing supporting frame of the gantry/ footbridge. The installation detail is illustrated in **Figure 8**. During the installation of video detector, crane lorry (or other equivalent access tool/equipment) has been used to lift up mounting pole to proper location for installation the video detector. Appropriate Temporary Traffic Management (TTM) which had been approved by the Hong Kong Transport Department also has been deployed on the corresponding lane(s) with installation work.

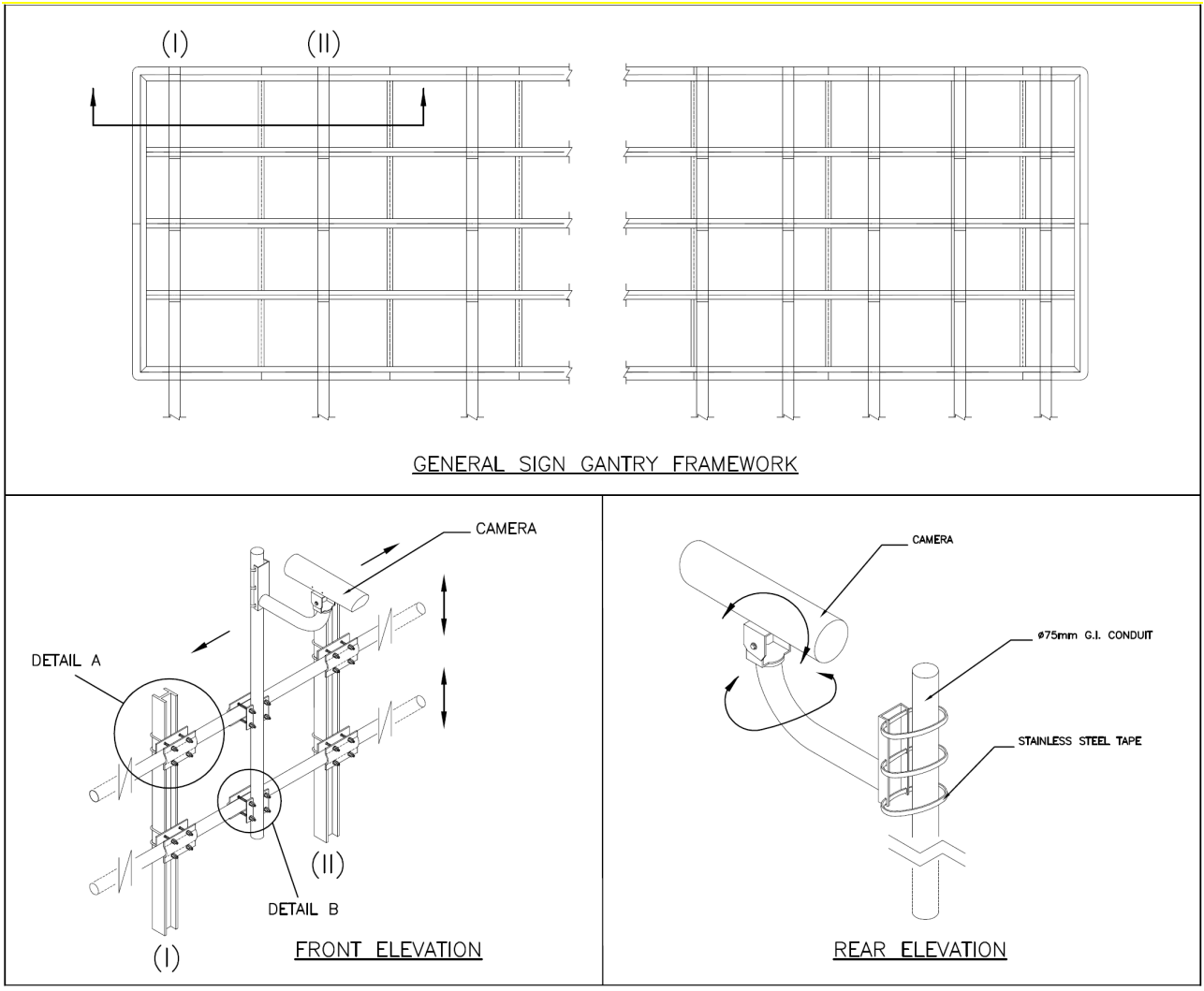



**Figure 8. Video Detector Installation Detail**

Besides the advanced algorithm and various methods adopted in the project, the tight quality control over the construction work also enhanced the efficiency and enabled the project to be completed on time and within budget. In spite of various challenges encountered, such as numerous working sites up to 28, comprehensive coordination works with different Government departments and utility service companies, risky installation on gantry on main routes and expressways and also working at height, the project could maintain high quality control and yet the site works of the project was awarded the Merit Award – Public Works (New Works) of the "Considerate Contractors Site Award Scheme 2009" as organized by the Works Branch of the Development Bureau of the Hong Kong Government.

## 5. FINANCING AND MANAGEMENT

The project was financed by the Hong Kong Government as it was a tender contract. The project was managed by Autotoll who has more than 15 years' experience in ETC service operation and is a leading Intelligent Transportation Systems (ITS) service provider in Hong Kong. The project team worked tightly with its strategic counterparts including university, consultancy firm, as well as operations counterparts such as subcontractors, different government departments and utility service companies, from the beginning till the completion, which was critical for the outstanding performance of the project. The project was completed within budget and the programme with a safety record far above the industrial average as proven by the award attained.

## 6. UNIQUENESS OF THE PROJECT

The uniqueness of the JTISK can be summarized as follows:

- Normally, the raw traffic data collected from corporate AVI tag holders in ETC is merely useful in the operation of the service. JTISK is the first project that makes use of AVI tag data and transforms the data into journey time indication index shown to the public. Autotoll is the only company in the region capable of making use its existing AVI devices at the cross-harbor tunnels in the collection of raw traffic data.

- AVI tag data is an ideal source to deduce accurate real time traffic information as previous studies concluded AVI is best suit for traffic data acquisition as its performance is not subject to traffic and weather conditions, and there is no error in tag ID matching. The reliability of the other technologies, such as License Plate Recognition System is not comparable to that of AVI technology because the quality of the captured image is subject to vehicle speed, traffic condition, weather condition, such as rain and fog, and there is error on license plate matching.

- Autotoll has built up 10 traffic monitoring station (TMS) equipped with AVI tag readers at various strategic locations in both Kowloon Peninsula and Hong Kong Island as the origin of the selected routes. In order to optimize the system performance, Autotoll also set up another 18 TMSs which equipped with vehicle detectors to capture the vehicle spot speed and traffic flow. Therefore, there are total 28 TMSs are equipped with image processing vehicle detectors, and capture the traffic flow and spot speed of individual vehicle for journey time calculation. Autotoll is the pioneer in Hong Kong to install the

AVI tag readers on footbridges and gantries in order to implement the AVI tag readers for real-time traffic data collection.

- A novel solution algorithm was developed for real-time journey time estimation. The algorithm integrates the real-time traffic data collected by AVI and VIP technologies, together with the offline (historical) travel time estimates. It was proved from the validation results that the journey time estimates are highly accurate.

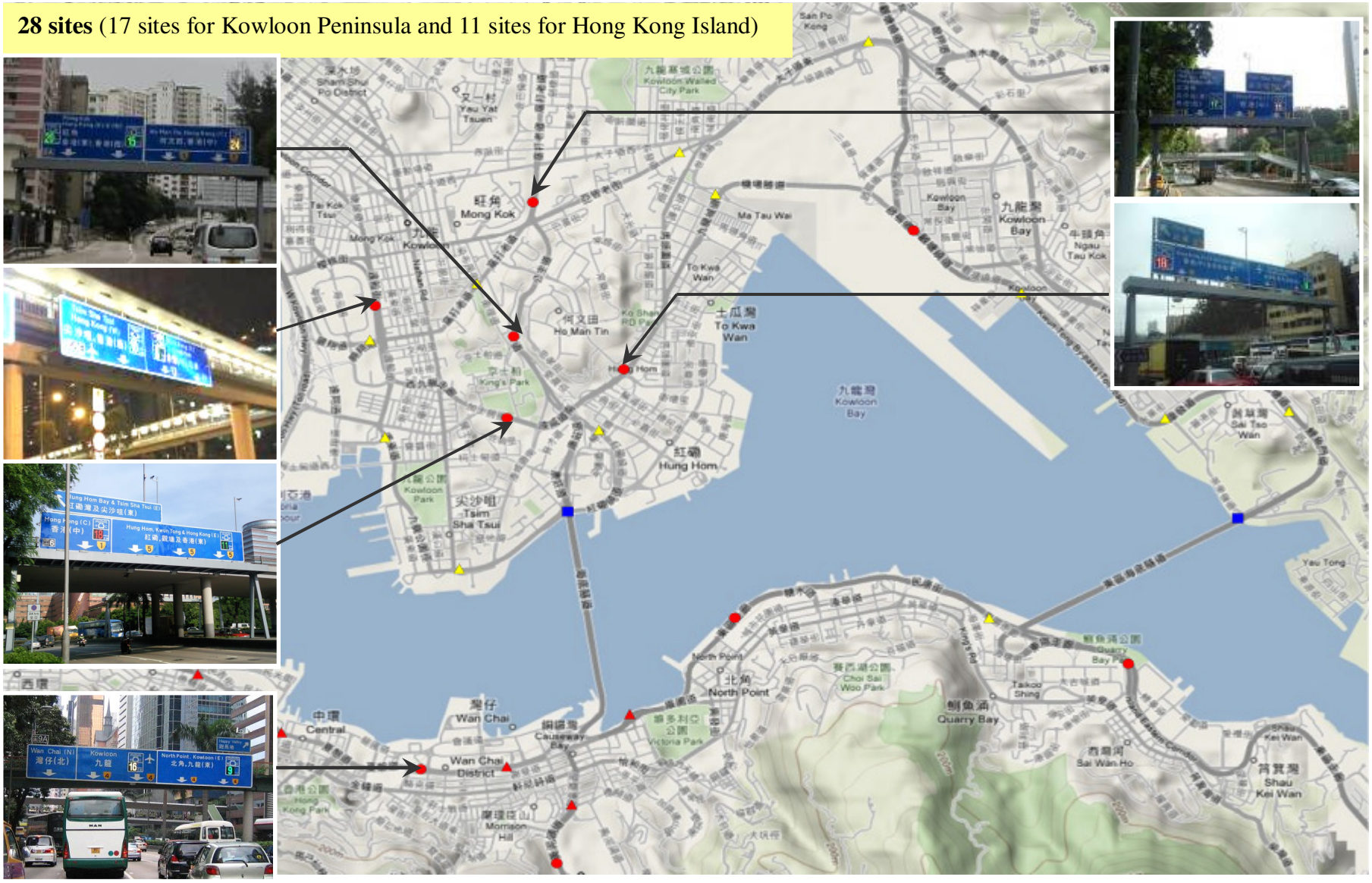
- The project had not only developed a new journey time indication system for Kowloon Peninsula but also taken-over the previous system in Hong Kong Island. Obviously, there were many challenges of modifying the previous JTISHK including both hardware and software so as to integrate with the JTISK as a single system.

## 7. CONCLUSION

The JTISK is a unique ITS project that provides significant transport and social benefits to Hong Kong. Meeting the challenges in implementing, operation and maintenance of the project and also made a successful example for future ITS projects in Hong Kong.

## 8. PICTURES AND DRAWINGS ON THE PROJECT

**28 sites** (17 sites for Kowloon Peninsula and 11 sites for Hong Kong Island)




Tsim Sha Tsui
Hong Kong (W)
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Hong Kong (C)
Hong Hom
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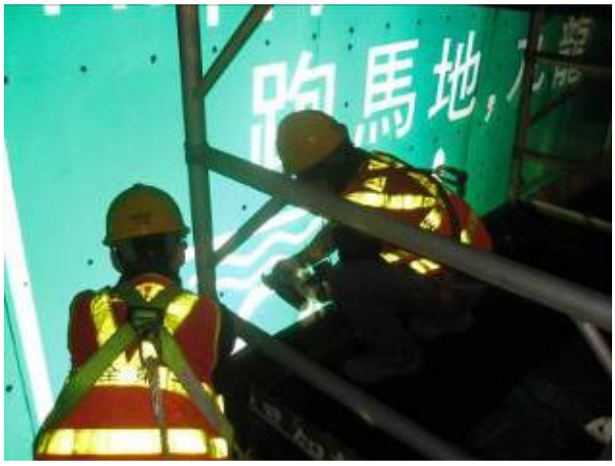
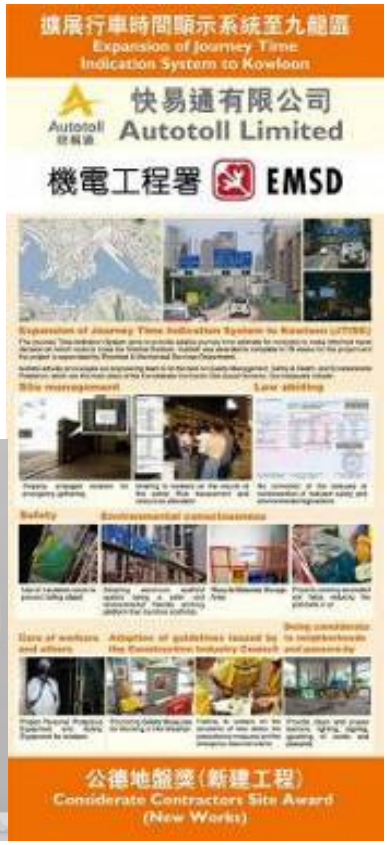
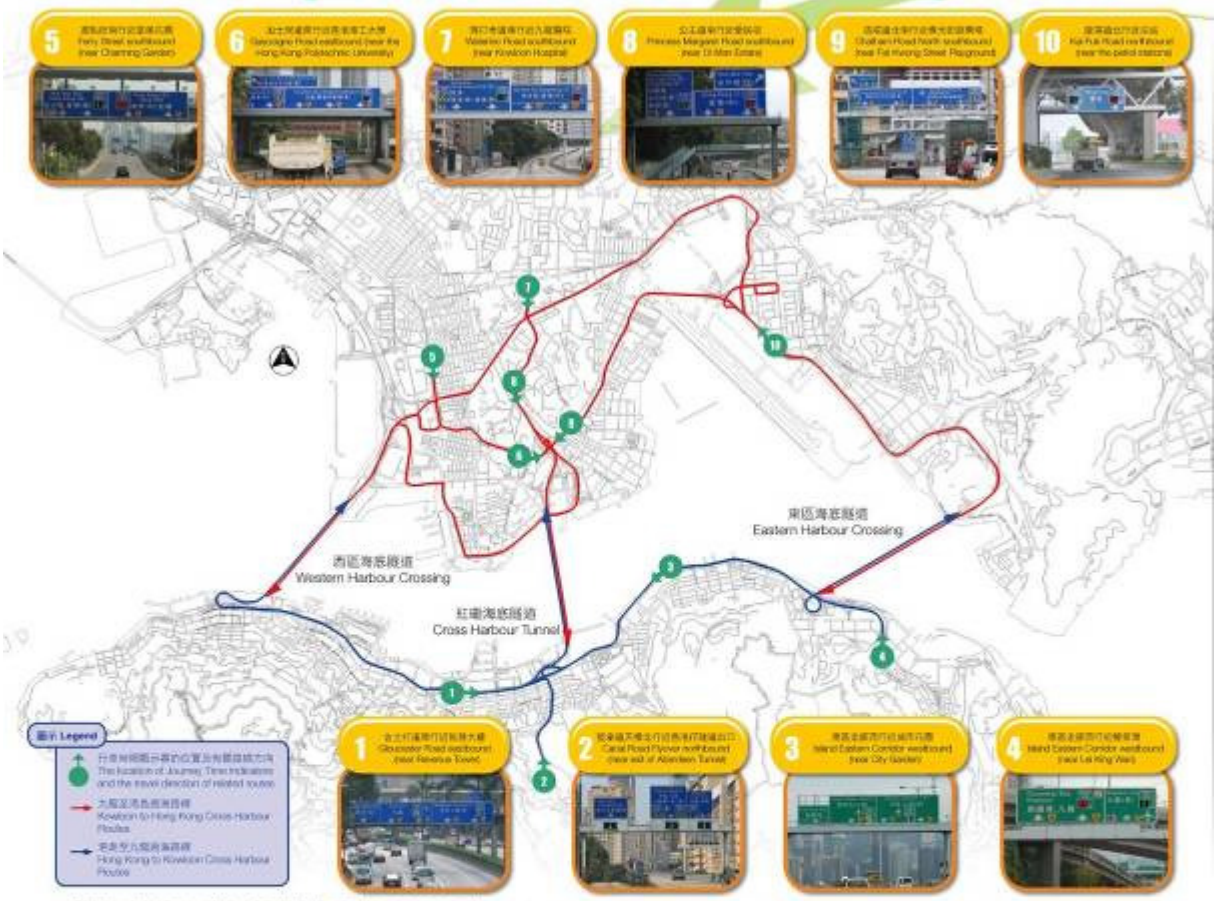



North Point, Kowloon
北角，九龍東


發展局
DEVELOPMENT BUREAU
新建工程
New Works
優異獎
MERIT AWARD
快易通有限公司
Autotoll Limited
合約編號
Contract No. : 1037/EM/2006
把行車時間顯示系統擴展至九龍區
Expansion of Journey Time Indication System to Kowloon
機電工程署
Electrical and Mechanical Services Department
公德地盤嘉許計劃 2009
CONSIDERATE CONTRACTORS SITE
AWARD SCHEME 2009
10 May 2010


擴展行車時間顯示系統至九龍區
Expansion of Journey Time
Indication System to Kowloon
快易通有限公司
Autotoll Limited
機電工程署 EMSD
公德地盤獎(新建工程)
Considerate Contractors Site Award
(New Works)

# 行車時間顯示系統
# Journey Time Indication System




「行車時間顯示系統」提供由行車時間顯示器至各條過海隧道出口的估計行車時間，協助駕駛人士選定合適的過海路線。運輸署現擴展此系統至九龍及東區，為駕駛人士提供更多的過海行車時間資訊。

The Journey Time Indication System (JTIS) assists motorists to make an informed route choice to cross the harbour by providing the estimated journey time from the journey time indicators to the exit of respective harbour crossing tunnels. The Transport Department has expanded the JTIS to Kowloon and Eastern District to provide motorists with more journey time information to cross the harbour.

## 行車時間顯示器的展示內容

顯示器展示的行車時間以分鐘為單位，展示的數值以三種顏色顯示不同的行車狀況：紅色代表交通擠塞，黃色代表行車緩慢，綠色代表交通暢順。

## Journey Time Indicator Displays


The indicator displays the travel time in minutes and the displayed digits are shown in three colours for different traffic conditions: Red represents congested traffic, Amber represents slow traffic and Green represents smooth traffic.

## 網上行車速度圖

系統內的行車時間資訊和香港、九龍及新界南主要道路的估算行車速度經已上載至運輸署的網頁(www.td.gov.hk)及PDA版網頁(pda.td.gov.hk)。

## Internet Traffic Speed Map

The journey time information of the JTIS and deduced traffic speed of main roads in Hong Kong, Kowloon and the New Territories South have been uploaded to Transport Department's homepage (www.td.gov.hk) and PDA homepage (pda.td.gov.hk).

## 行車時間顯示系統熱線

市民可致電2804 2655，收聽系統內各行車時間顯示器的最新行車時間資訊，從而計劃合適的路線。

## Journey Time Indication System Hotline

The public can dial 2804 2655 to listen to the latest journey time information of each journey time indicator of the JTIS to plan for their route.

運輸署
Transport Department

## 時間顯示屏的展示內容
## Journey Time Indicator Displays


- 顯示屏以分鐘為單位，展示由該位置到達各條隧道九龍出口的大約行車時間。
- 展示的數值會用三種顏色顯示不同的行車時間，分別是綠色、黃色和紅色。
- 時間顯示系統將會24小時運作。屏上展示的時間每五分鐘更新一次。

| 顏色 Colour | 行車時間 Journey Time | |
|---|---|---|
| | 經紅隧 Via CHT | 經東隧或西隧 Via EHC or WHC |
| 綠Green | 10分鐘或以下 10 min or below | 20分鐘或以下 20 min or below |
| 黃Amber | 11至20分鐘 11 to 20 min | 21至40分鐘 21 to 40 min |
| 紅Red | 20分鐘以上 Above 20 min | 40分鐘以上 Above 40 min |

- The indicator displays the estimated travel times, in minutes, from its location to the Kowloon exit of the respective tunnels.
- The displayed digits will be shown in three colours viz. Green, Amber and Red for different journey times.
- The JTIS will operate on a 24-hour basis. The displayed times are refreshed every five minutes.

當有過海路線處於嚴重擠塞的情況，顯示屏就會展示出一個路線嚴重擠塞的標誌。

When a cross harbour route is seriously congested, the indicator will show a "Very Serious Congestion" sign.

"路線嚴重擠塞"
"Very Serious Congestion"

遇有隧道封閉的情況，顯示屏會展示出隧道封閉標誌。

In case of emergency requiring complete tunnel closure, the indicator will show a "Tunnel Closed" sign.

"隧道封閉"
"Tunnel Closed"

當系統不能正常運作或出現故障時，顯示屏會被關閉。

When the system is not operating properly or a fault is detected, the indicator will be left blank.

"系統故障"
"System Fault"


# 行車時間顯示系統
# Journey Time Indication System

運輸署 Transport Department

## 簡介 Introduction

設立顯示系統的目的，是幫助駕車人士選擇由港島至九龍的過海路線。在抵達各主要分流點前，他們可經過顯示屏知道各條過海路線所需的時間，從而選定合適的路線。

The System serves to assist motorists to choose amongst the cross harbour routes from Hong Kong Island to Kowloon. Before they arrive at the critical diversion points, the journey time indicators will provide the journey times for the different cross harbour routes such that they could make an informed choice.


1 告士打道東行線 (近怡和大廈)
Gloucester Road Eastbound (outside Jardine House)

2 運河道天橋北行線 (近香港仔隧道口)
Canal Road Flyover Northbound (after North Portal of Aberdeen Tunnel)

3 東區走廊西行線 (近維多利亞公園)
Inland Eastern Corridor Westbound (outside City Garden)

## 投入服務時間表
## Commissioning Programme

The indicator at Gloucester Road is scheduled for commissioning in June. The commissioning of the remaining two indicators at Canal Road Flyover and Inland Eastern Corridor will follow shortly.

The Journey Time Indication System is the first of its kind in Hong Kong. You are invited to provide your views so that we can make the system operation more effective. Members of the public can forward their enquiries and feedback on the system via 1) Government Hotline 1823, 2) e-mail to jtis@td.gov.hk, 3) by fax to No. 2845 7489 or 4) by mail to 39/F Immigration Tower Wanchai for the attention of Intelligent Transport Division, Transport Department.

## 9. POINT OF CONTACT PERSON

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