Application for 2013 EASTS Outstanding Transportation Project Award

1) Name of the Project: The Expressway Authority of Thailand ITS Center

2) Outline of the Project

- Category of the Project: Planning
- Project Cost: USD 1,678,000
- About the Project:

Expressway Authority of Thailand (EXAT) is responsible for construction and traffic management of expressway network in Bangkok Metropolitan Region, Thailand. Due to the rapidly increasing traffic demand, the effective traffic management system is urgently required to enhance level of service of EXAT. As mentioned above, Intelligent Transportation System (ITS) is one of the key systems to improve the performance of the existing infrastructure of EXAT. Therefore, the EXAT has established many projects to fulfill such objective.

The ITS Center (Phase 2.0) is the extension of the EXAT's ITS Master Plan (Phase 1.0) and the EXAT's ITS Pilot Corridor (Phase 1.5). The first project, the ITS Master Plan, is to study and define a framework of ITS development of EXAT as well as to set up ITS Master Plan. The second project, the ITS Pilot Corridor, is to design and equip some traffic sensors along a section of the Kanchanaphisek expressway to develop a pilot data processing system and study effectiveness of ITS application. The third project, ITS Center, is to design and equip traffic sensors along the Kanchanaphisek expressway and establish an ITS center. In the ITS Center project, the sensors are used to collected traffic data to be used in five modules set up at ITS center. The five modules consist of i) traffic state estimation and prediction system, ii) travel time estimation and prediction system, iii) incident detection system, iv)traffic O-D system, and v) traffic management center. The window application, web application, and mobile application are developed as user interface for the five systems. The ITS center is expected to be a control hub which facilitate EXAT personnel in managing expressway and provide information for both authority and expressway user. This is considered as one of the first fully-equipped ITS corridor in Thailand.

The project represents the best effort in academic and practitioner collaboration to deliver the successful complex ITS system. The collaboration between the two universities (The Hong Kong Polytechnic University and King Mongkut's Institute of Technology at Latkrabang) from Thailand and Hong Kong and the team of EXAT in Thailand brought out the most advanced analysis and application of ITS in this region. This project is a celebration of the application of the recent academic results in practical project at its best.

3) Impact of the Project:

- Social Impact
  - enhance level of service of the expressway
  - provide information for expressway authority in managing and control expressway
  - decrease potential incident
  - provide passengers information on travel time
- Transportation Impact
  - first full-scale ITS deployment on highway corridor in Thailand
  - increase efficiency of the expressway
  - allow for automatic management of expressway system to reduce man-power
  - best practice for ITS deployment in developing countries
  - application of the most recent academic researches on key components of ITS system (example of knowledge transfer)

4) Method/ Technology of Project:

- Project Site and Sensor Deployment

The project site is the Kanchanaphisek expressway, 22.49 km., which is a part of outer ring road of Bangkok, Thailand. Figure 1 shows the location of the project. The spots along the expressway in the figure 1 depict sensor which are installed in the project. The average sensor spacing is 1.5 km.

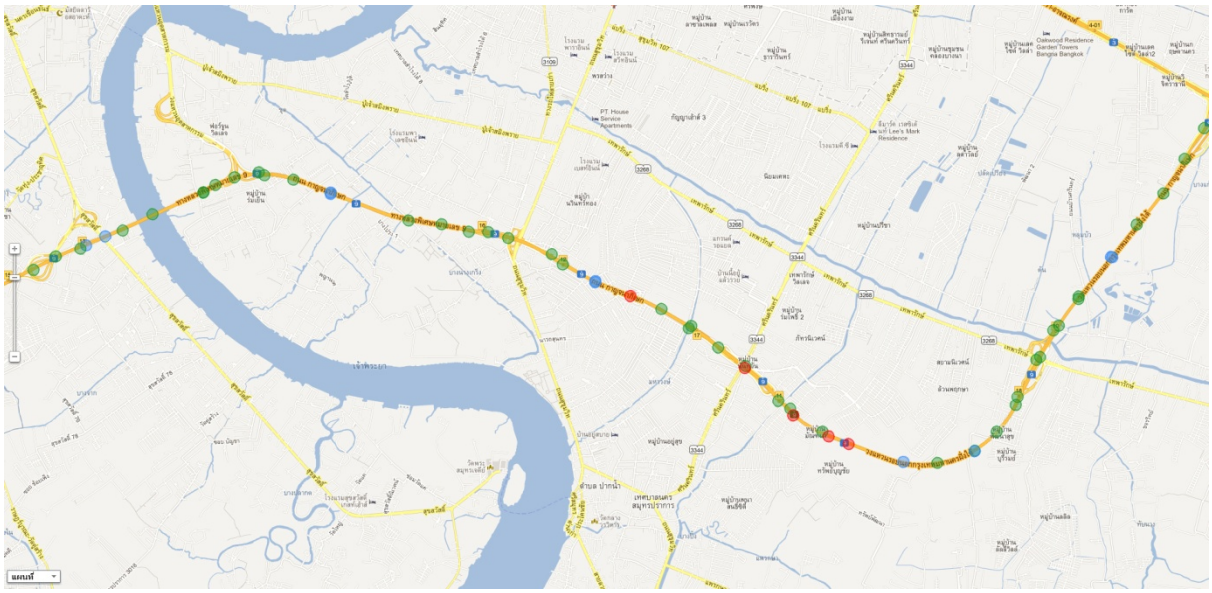
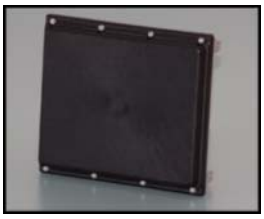


Figure 1 Project site Kanchanaphisek expressway, Bangkok, Thailand

Three kinds of traffic sensor which are IDS, Microwave sensor, and CCTV (as shown in figure 2) are combined in this project. The IDS sensor (Autoscope system) is the inheritance system from the original construction of the tolled road. The IDS sensor is

installed at every 5 kilometers along the expressway. The Microwave sensors are installed as a part of this project. The project also carried out an extensive comparison of the sensor devices. In the first stage of the project, the sensor locations were designed based on the background traffic data (e.g. queue length, merging and diverging location, backward wave speed). In total, 46 Microwaves sensors were installed on this expressway. The general design principle is that the maximum interval between sensors is 2 kilometers. More sensors are installed at the areas before the diverging and merging activities to detect the capacity drop, queue build-up, etc. The sensor (Smartmicro) can detect each vehicle trajectories in the range of 200 meters and is capable of detecting rain. The design of the ITS system fully utilizes the data obtained from both sensor types. Apart from the sensor installation, each location of microwave sensor a lower-resolution CCTV camera is also installed.



(a) IDS Sensor (b) Microwave Sensor

(c) CCTV

Figure 2 Traffic sensor installed in the project

Figure 3 Sensor Installation

- The System Development

The overall ITS Center system architecture is shown in figure 4. It consists of three main systems which are sensor group, processing server group, and user group.

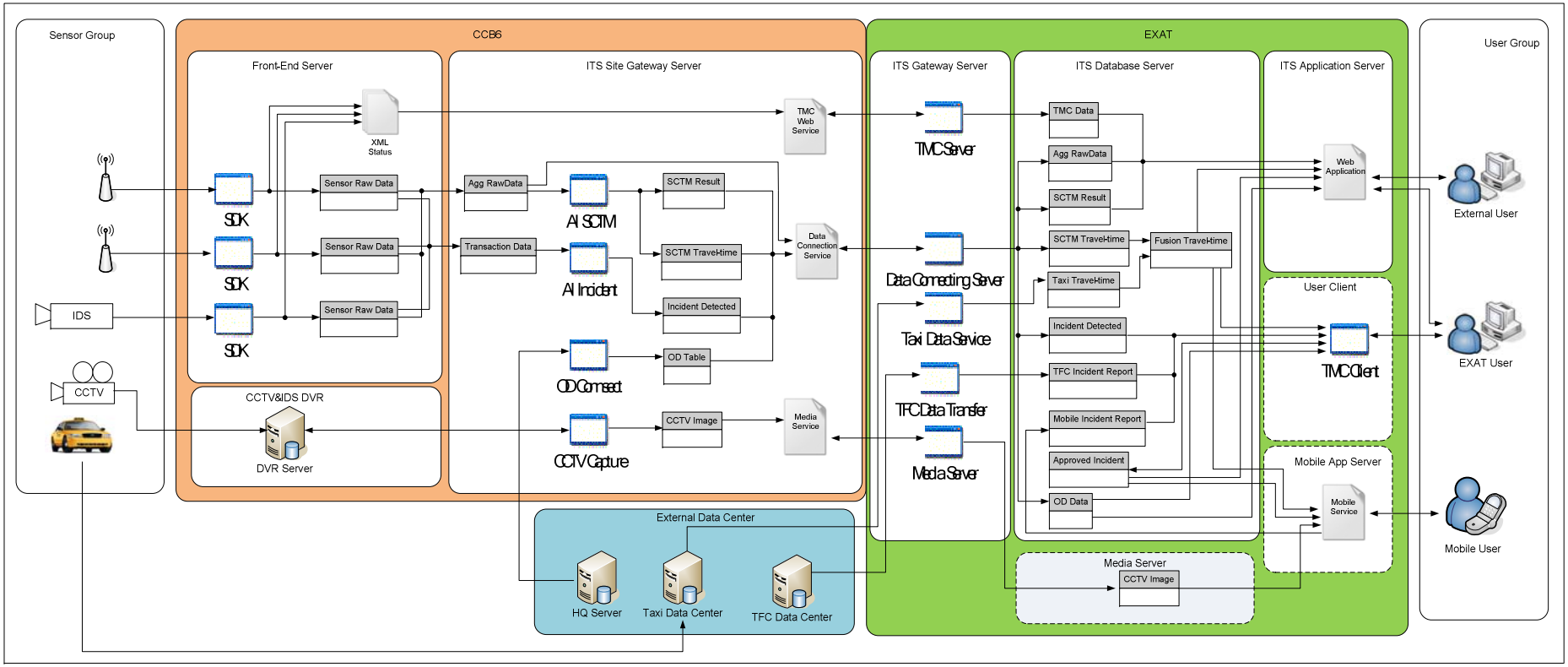


Figure 4 ITS Center system architecture

The sensor group consists of various kinds of traffic sensors which are equipped along Kanchanaphisek expressway as mentioned above. They are used to collect traffic data in terms of traffic parameter and VDO. Then, the collected data are transferred to the processing server group. Figure 5 shows server installed in the project. There are two location of server, CCB 6 and ITS Center. The servers at CCB 6 directly are connected to the sensor. The servers at ITS Center are used to process the data.

(a) Server at CCB 6

(b) Server at ITS Center

Figure 5 Server in the Project

In the server group, five sub-systems are embedded to analyze and provide result for the authorized personnel. The five sub-systems are as follows:

i) Traffic state estimation and prediction system - is to estimate traffic condition according to sensor data (point-based data). The Stochastic Transmission Model

(SCTM) (Sumalee et al, 2010[1]) is used to provide real-time and continuous traffic data along the expressway. The SCTM is also used as the basic system for data fusion of the data from different sensors sources and to resolve the data error/conflict issue. This is a very powerful system for practical implementation of on-line traffic state estimation.

ii) Travel time estimation and prediction system - is to provide traffic information in terms of travel time spend on a particular section. In this system, both travel time analyzed by SCTM (using the method developed in Sumalee et al 2013[2]) and GPS probe car are fused to provide real-time information. The GPS probe data is obtained from the Taxi-probe system which includes more than 10,000 taxis in Bangkok. The data exchange system is set up to allow for the data acquisition of the taxi probe data from the external source.

Figure 6 to 10 illustrate the result on web application from traffic state estimation and prediction system and Travel time estimation and prediction system.

Figure 6 The display of real-time state estimation

[1] Sumalee A., Zhong, R.X., Pan, T.L., and Szeto W.Y. (2011) Stochastic cell transmission model (SCTM): a stochastic dynamic traffic model for traffic state surveillance and assignment, Transportation Research Part B, 45(3)p 507-533

[2] Sumalee, A., Pan, T.L., Zhong, R.X., Uno. N., Indra-Payoong, N.(2013) Dynamic stochastic journey time estimation and reliability analysis using stochastic cell transmission model: Algorithm and case studies, Transportation Research Part C, In Press

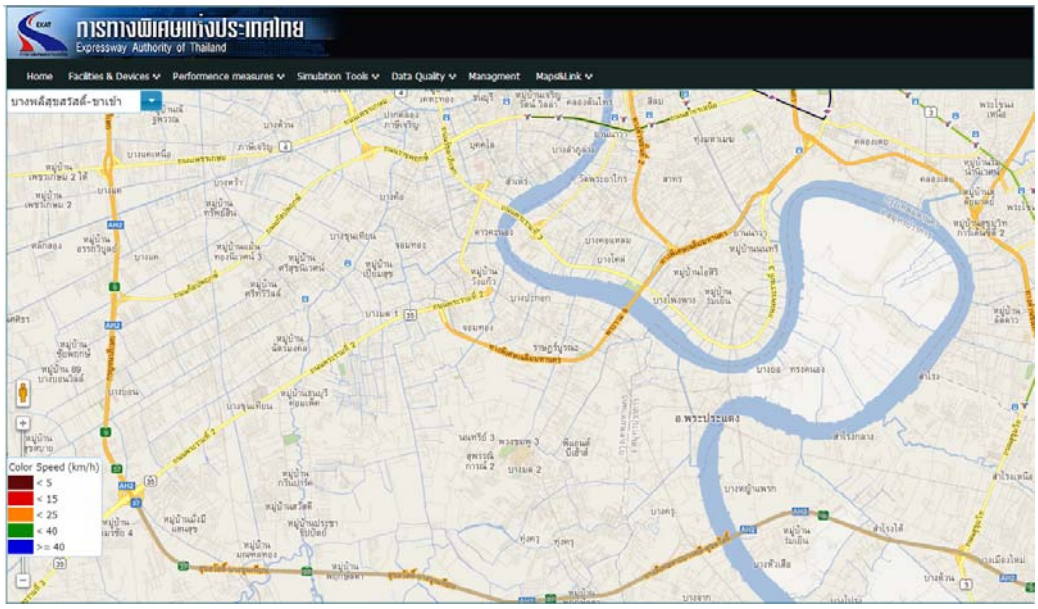


Figure 7 The display of speed map

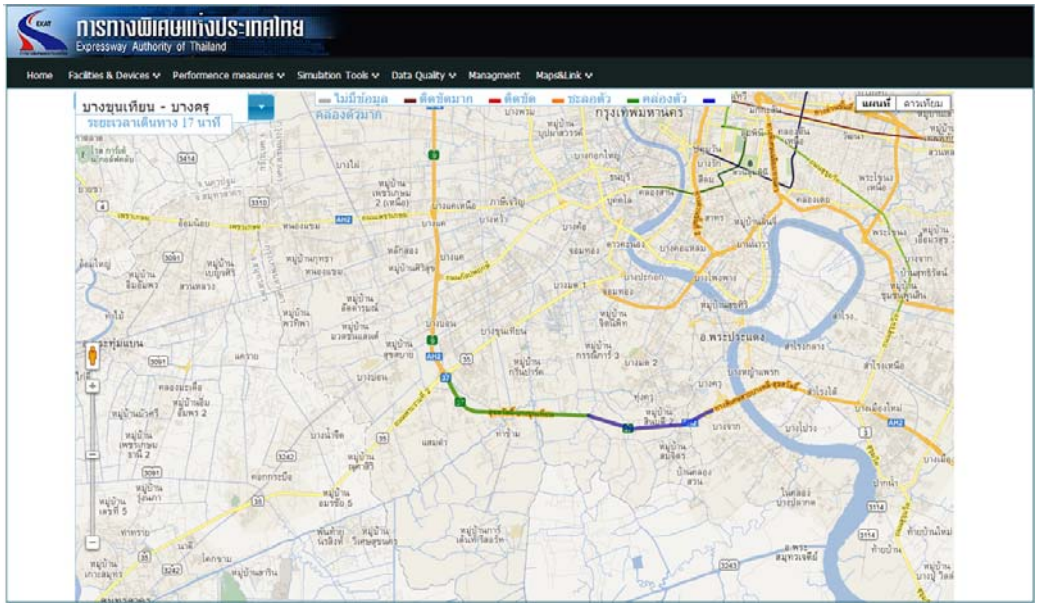
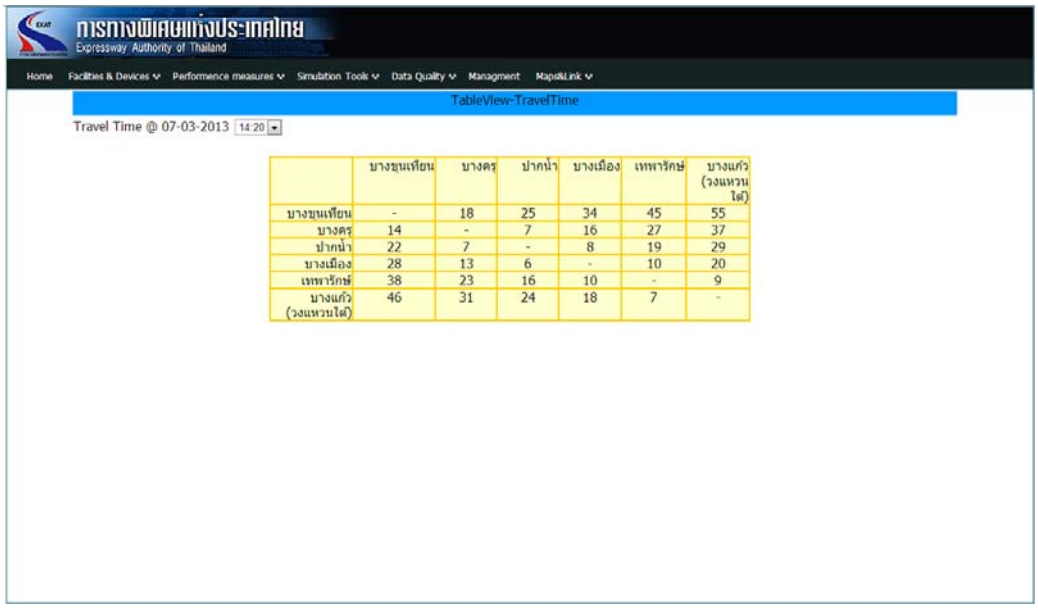


Figure 8 The display of travel time on the map



	บางขุนเทียน	บางคร	ปากน้ำ	บางเมือง	เทพารักษ์	บางแก้ว (วงแหวนใต้)
บางขุนเทียน	-	18	25	34	45	55
บางคร	14	-	7	16	27	37
ปากน้ำ	22	7	-	8	19	29
บางเมือง	28	13	6	-	10	20
เทพารักษ์	38	23	16	10	-	9
บางแก้ว (วงแหวนใต้)	46	31	24	18	7	-

Figure 9 The display of travel time on OD table

iii) Incident detection system - is to report and alert incident on the expressway. In this system, three kinds of algorithms are used to detected incident, California algorithm, McMaster algorithm, and Fuzzy Logic algorithm. The example of the result of incident detection system is shown in figure 10. Apart from the three standard algorithms mentioned, the research team also developed the anomaly trend detection algorithm for analyzing abnormal traffic trend data which may result in the incident. This is a novel approach and was applied successfully in this project with the full validation results.

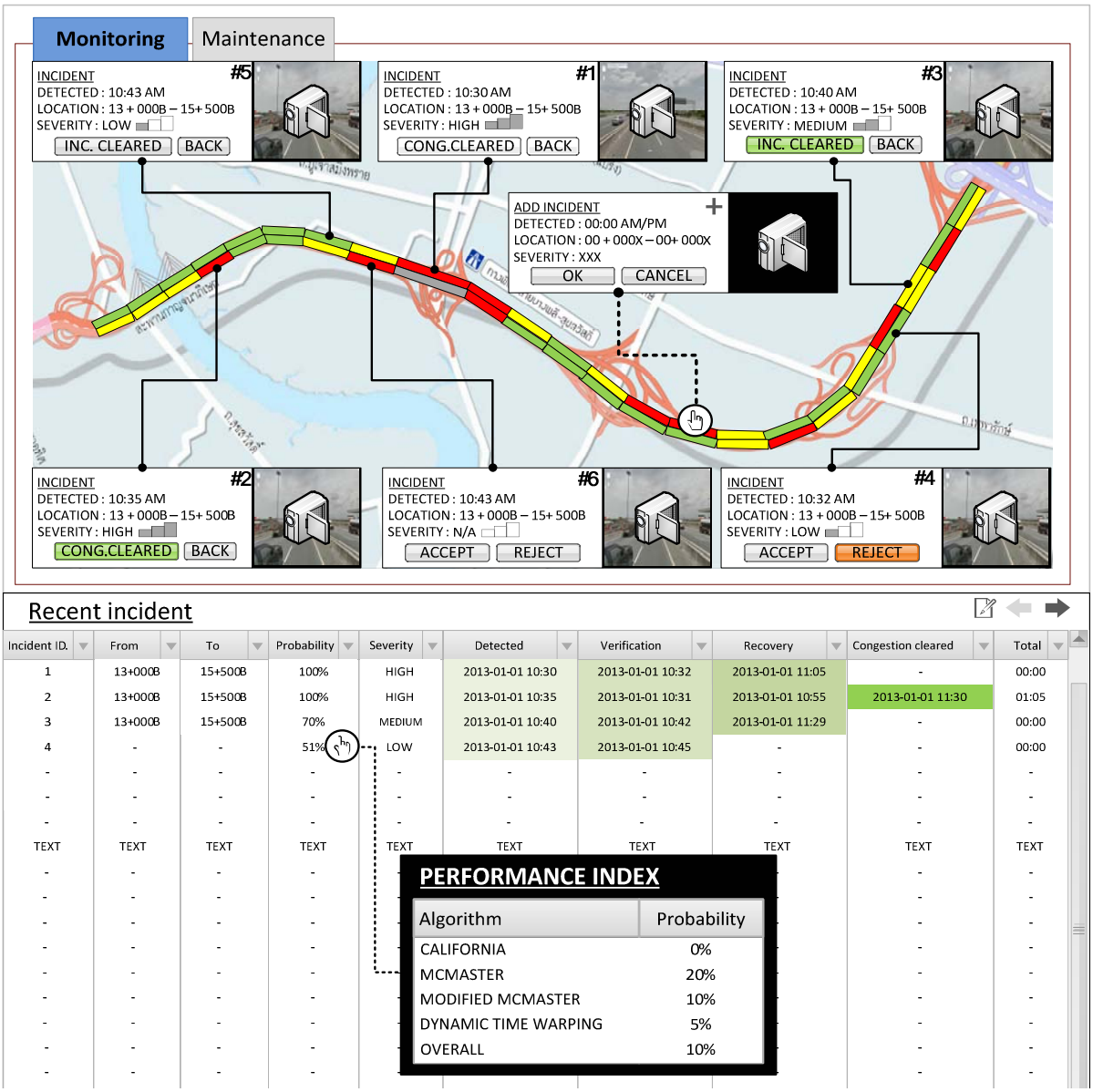


Figure 10 The display of incident detection system

iv) Traffic O-D system - is to report traffic volume between a particular O-D pair along the expressway. The project team designed an innovative data exchange architecture to link up the data from the toll payment system (through IC-card data and toll-tag data) with the ITS database. The main challenge was the security and stability issue in linking up the traffic management database and financial database. This represents one of the key obstacles in using available information on tolled road to enhance the data acquisition.

v) Traffic management center (TMC) - is the project control hub. It includes numerous components for traffic data collection and communication, traffic state estimation and prediction, travel time estimation and prediction, incident detection, O-D query, central control and monitoring, etc. Figure 12 shows the structure of TMC. Figure 11 shows the TMC which is established in the project. The TMC also contains

the VMS-logic which provides suggested messages for each VMS (variable message sign) along the expressway. The logic utilized the travel time information, incident detection information, and rainfall detection data to provides the most relevant and important message. The TMC presents the integrated center of all data obtained or analyzed from the system sensors and presented to the users in the most user-friendly format.

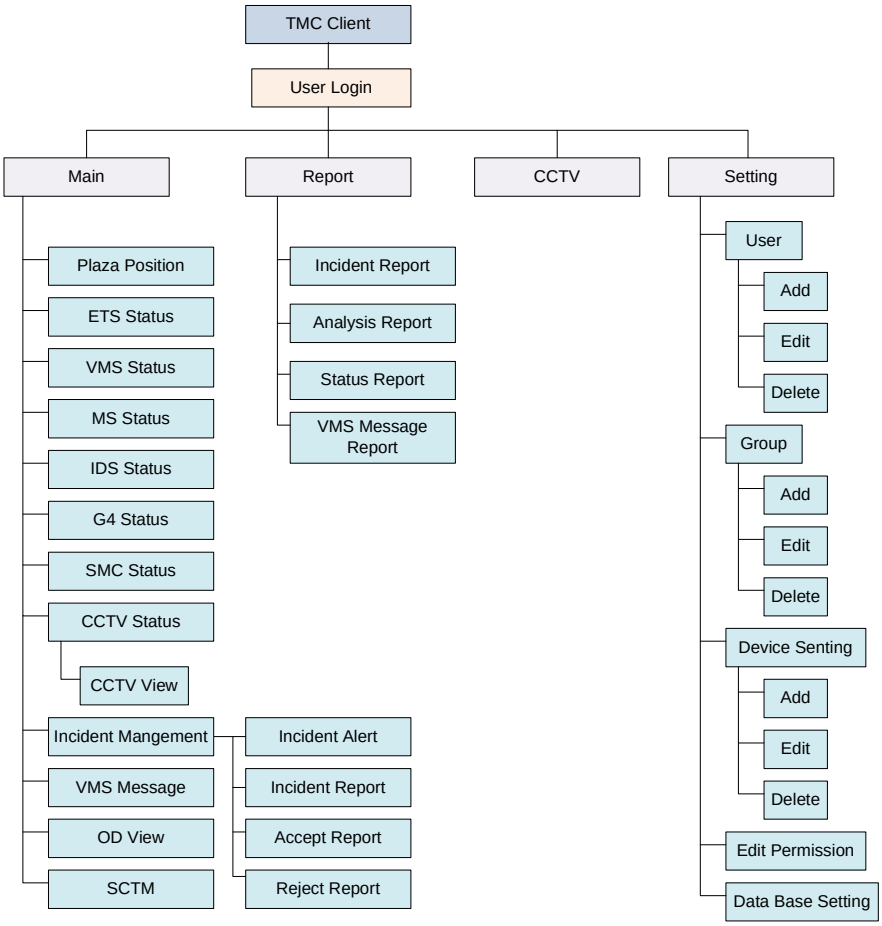
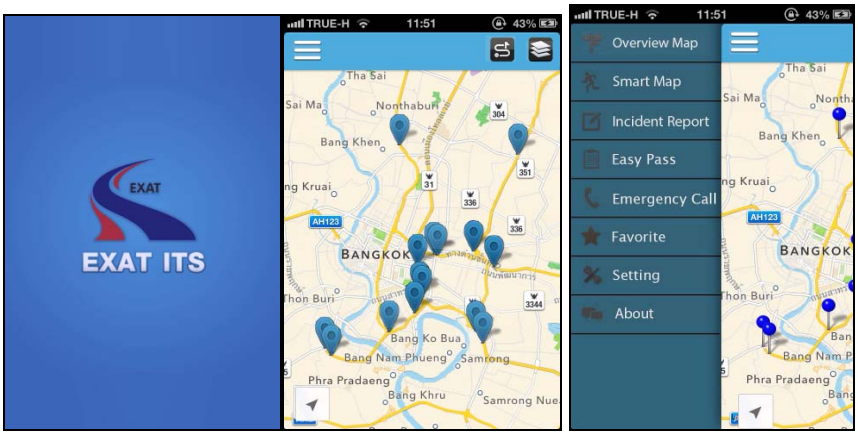


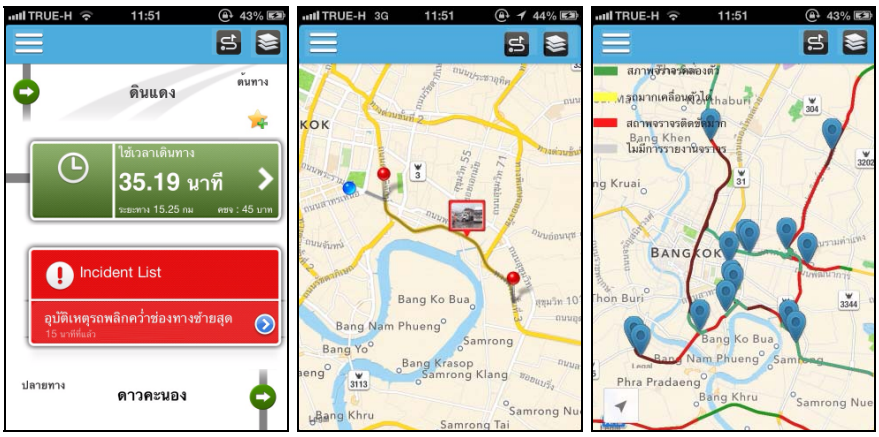
Figure 11 The structure of TMC

- Mobile Application

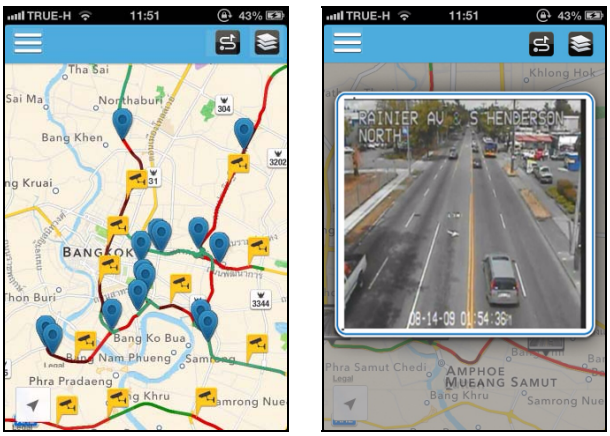
In order to facilitate expressway authority and user, a mobile application is developed. The main objective of the application is to provide real-time information for the user in terms of expressway traffic condition, travel time, incident report, capture of CCTV, and etc. Moreover, authorized persons are able to report incident happened on the expressway as soon as they confront. The examples of mobile application are shown in figure 12. The mobile application is available in both i-OS and Android systems.



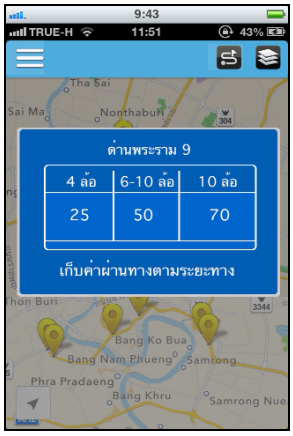
(a) The main page of the mobile application



(b) Travel time report, incident report, and traffic condition report



(c) A capture of CCTV



(d) Toll fee

Figure 12 The example of mobile application

5) Financing and Management:

The project is financed by the Expressway Authority of Thailand (EXAT). It is also supported by the MOU on ITS research collaboration by EXAT, The Hong Kong Polytechnic University, and King Mongkut's Institute of Technology at Latkrabang.

6) Uniqueness of the Project:

The uniqueness of the ITS Center could be summarizes as follows:

- First full deployment of integrated ITS in Thailand along an expressway corridor
- Application of the most recent research results in the real project deployment
- Full collaboration between academic researchers and practitioners from different countries in East Asia (Hong Kong and Thailand)
- Overcoming the organization barriers in most public institutions in development to encourage the adoption of the new technology and tool
- Full integration of different data sources as well as full range of ITS applications (state estimation, travel time estimation, incident detection, traffic management control, traveler information system)
- Flexible information dissemination at different levels (for expert operators: TMC system; for regular users: web-application; for users: mobile application)

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