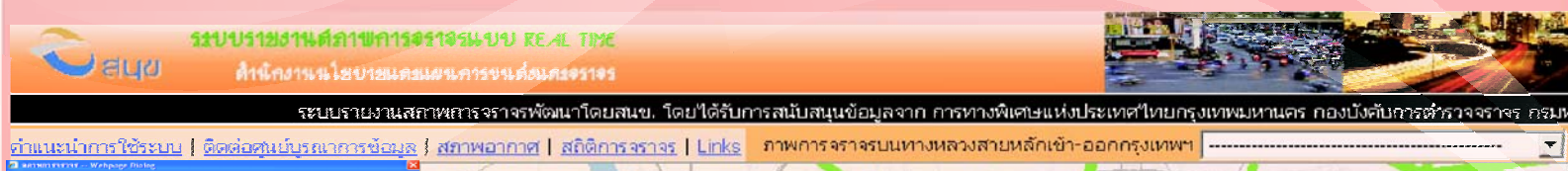
Office of Transport and Traffic Policy and Planning

Ministry of Transport



Executive Summary Report

Development of the ITS Data Integration Center, OTP : Phase II

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1. Introduction

1.1 Backgrounds

Recently, there have been several official agencies employing technologies in the Intelligent Transportation Systems (ITS). The Office of Transport and Traffic Policy and Planning (OTP) develops an integrated traffic and transportation data system Phase 1, which installed image processing cameras and loop detectors on the Bangkok traffic network. The Royal Thai Police (RTP) has two on-going projects: 1) CCTV installation phase 3 project, and 2) red light camera system project where CCTVs are installed at major intersections in Bangkok. The Bangkok Metropolitan Administration (BMA) launches an Intelligent Traffic Signs project and the CCTV installation project to promote safety. In addition, the BMA also has an ITS for the Bus Rapid Transit (BRT) system for Rajapruep-Silom line. The Expressway Authority of Thailand (EXAT) installs CCTV on expressways in Bangkok. The Department of Highways (DOH) is on a process of installing traffic detectors on major arterials. The Bangkok Mass Transit Authority (BMTA) installs devices to inspect bus operations. Private sectors also take part in installing traffic detectors that can be used to detect vehicle positions and traffic analysis such as speed on road networks.

According to the results of the meeting of the Land Transport Management Committee (LTMC) on December 27, 2007, the OTP was assigned to be the main unit for integrating traffic information and implementing the ITS in order to promote the integrity of management and to cut down the authority overlaps.

The OTP recognizes the importance of the integration of traffic information from different traffic and transport authorities in accordance to the LTMC consensus as mentioned earlier. The OTP, therefore, launches a Technology and Communication project to integrate traffic information and intelligent transportation (automatic) from different traffic and transport agencies phase 1 in 2008. In this project, traffic and transport information was collected under an open platform system so that the maximum advantages can be gained in managing, regulating, and disseminating information to general public with the aim of minimizing authority overlaps. Nonetheless, the integration is still incomplete due to the limited time frame for different agencies to develop their own systems.

In the year of 2009, the OTP hence commences the second phase 2 of the system to collect and puts together additional traffic and transport information by linking information from projects of different agencies, which are already completed, so that the system is equipped with the complete and up-to-date information. The OTP and other agencies can use the system with the maximum utility to general public.

1.2 Objectives of the Project

The main objectives of this project are:

1) To review the previous studies and projects from different agencies that are relevant to the integration of traffic and transport information for the OTP,

2) To study and suggest a platform to develop a traffic information and intelligent transportation center of the OTP under the sustainable conception,

3) To develop the second phase of traffic information and intelligent transportation integration system, which consists of:

   a. Link traffic information from detectors of relevant agencies, and develop a traffic information disseminating system to general public via internet and other available channels,
   b. Link data from a traffic flow and speed detection system of the OTP to the system under the second phase of traffic information and intelligent transportation integration system,
   c. Install additional CCTVs from the first phase of the system on a roadway network within the radius of 100 km, which are the main inbound and outbound corridors of Bangkok,
   d. Gather information relevant to traffic conditions and process the information in such a way that it can be fed to the second phase of the system. The information must be accurate and statistically significance. Information monitoring and management system is also established.

4) To enhance and maintain the database of the real-time traffic condition reporting system of the first and the second phases as well as the traffic information and intelligent transportation system phase 1 of the OTP in a workable condition.

5) To enhance efficiency of the traffic information and intelligent transportation integration center of the OTP by disseminating information to general public in various media as well as the improvement of the computer and other relevant systems in the control room of the center.

6) To promote and build up potential for personnel of the OTP and relevant agencies in development of the ITS by seminar organization and technical visits to countries with success in developing the ITS.

2. Review of Previous Operations

2.1 Office of Transport and Traffic Policy and Planning (OTP)

The OTP is responsible for planning and establishing traffic, transport and safety policies by incorporating land-transport, water-transport, air-transport, and safety plans in accordance with the key traffic and transportation plan. Currently, the OTP undergoes several projects on traffic and transport information systems, which can be outlined as:

1) The study of establishment of the main plan for reporting real-time traffic conditions,
2) The first phase of the real-time traffic condition reporting project,
3) The second phase of the real-time traffic condition reporting project.

2.2 Bangkok Metropolitan Administration (BMA)

The BMA via the traffic and transportation department, which is a bureau responsible for traffic and transportation of the Bangkok area, develops technologies in an area of ITS in various forms and projects such as:

1) Area Traffic Control (ATC) project
2) CCTV for traffic management project
3) Installation of Count-down traffic signals
4) Intelligent Taxi Parking project
5) Intelligent Pedestrian Crossing project
6) CCTV installation for security project
7) Intelligent Traffic Signs
8) Bus Rapid Transit project

2.3 Traffic Police Division

The Traffic Police Division of the Royal Thai Police (RTP), which is responsible for regulating traffic in the Bangkok area, has utilized the ITS in managing traffic and disseminating traffic information for regulating traffic in Bangkok. There are several on-going projects and operations such as:

1) Traffic information disseminating system via internet http://www.traffic police.go.th
2) Installation of the CCTV phases 1 and 2,
3) Installation of the CCTV phase 3,
4) Red Light Camera system

2.4 Highway Police Division

The Highway Police Division of the RTP, which is responsible for highway traffic, employs the ITS in overspeeding detection on highways by using automatic speed cameras. These cameras inspect traffic speeds with laser technology. Overspeeding vehicles are automatically recorded on cameras. The photographs of the overspeeding are processed and the information with date of wrongdoing is sent to the traffic regulation center of the Highway Police Division to inspect associated license plate numbers. Tickets will be issued and sent owners of the overspeeding vehicles.

2.5 Office of the Permanent Secretary of Ministry of Transport

The Office of the Permanent Secretary of Ministry of Transport undertakes the Thailand Road Network Information System project which integrates information of infrastructures and other transport facilities into a single unit in order that departments under the ministry, relevant agencies, and general public can use for their own purposes. Besides, The Office of the Permanent Secretary of Ministry of Transport also brings in the MOT Transport FGDS database to apply with other systems such as:

1) TRAM System
2) On-line Map Service system of the Ministry (http://gis.mot.go.th/Maponline/mapviewer.jsf)

2.6 Department of Highways (DOH)

Currently, the DOH has no direct ITS development projects but there are some projects that are related to application of information technologies in traffic management such as:

1) Route and shortcut guidance system during major national holidays via http://www.doh.go.th
2) Weigh-in-motion (WIM) System
3) Geographic Information System (GIS) for highway operations and research via http://www/doh.go.th/dohweb/gis/pagegis.htm

2.7 Department of Rural Highways (DOR)

Currently, the DOR has no direct ITS development projects but there are some projects that are related to application of information technologies in traffic management such as:

1) Dissemination of information in a format of geographic information system (GIS)
2) Traffic management and control system on Chiang Mai 700th anniversary Road
3) Automatic drainage control and power supply system
4) Automatic barricade and traffic signal system
5) Road lighting system

2.8 Expressway Authority of Thailand (EXAT)

The EXAT operates expressways in Bangkok and the vicinity. Currently, the EXAT brings in new technologies to promote the communication with users including traffic management such as:

1) CCTVs for monitoring traffic conditions
2) Emergency Telephone Systems (ETS)
3) Variable Message Signs (VMS)
4) Automatic Toll Collection System (EASY PASS)
5) Traffic reporting system (http://www.exat.co.th)

2.9 Mass Rapid Transit Authority of Thailand (MRTA)

Presently, the MRTA utilizes modern technologies in various forms to service MRT users and promote rider comfort and safety such as:

1) Automatic train control system
2) Automatic platform screen door system
3) CCTV system
4) Automatic fare collection system
5) Automatic gate system

2.10 State Railway of Thailand (SRT)

The SRT has a long history of evolution under the ministry of transport, which is responsible for operating railways in Thailand. The SRT brings in several modern communication systems to regulate train operations such as:

1) Train Tracking Systems (TTS)
2) Seat Monitoring System

2.11 Bangkok Mass Transit System Public Company Limited

BTS Skytrain is operated by the Bangkok Mass Transit System Public Company Limited. It is the first electric train service operating in Thailand, opened for public use in 1999. Currently, the BTS uses technology to service riders to promote comfort and safety such as:

1) Automatic train protection system
2) CCTV system
3) Automatic fare collection system

2.12 Don Muang Tollway Public Company Limited

The elevated Don Muang Tollway is operated by the Don Muang Tollway Company Limited to accommodate heavy traffic expected on Vipawadi-Rangsit Road. Currently, the Don Muang Tollway Company Limited uses the ITS in various forms such as:

1) Traveler information system via Matrix Sign
2) CCTV system
3) Emergency Telephone System

2.13 National Electronics and Computer Technology Center (NECTEC)

The NECTEC has started to develop a program for the ITS in the area of electronics and computer hardware devices under the division of the ITS in the NECTEC. Some of their relevant projects are:

1) Development of the real-time traffic reporting system (http://traffic.thai.net)
2) Evaluation and traffic reporting project in which a prototype for traffic data collection to evaluate and route planning systems was formed.
3) Development of the traffic information disseminating system (http://www.traffy.in.th/traffy10/)

2.14 Bangkok Mass Transit Authority (BMTA)

The BMTA in cooperation with the OTP develop a bus management system with an objective to improve bus operations of the BMTA, which consists of:

1) Bus Tracking System with GPS
2) Real-time Passenger Information System
3) Information Technology System related to Bus Operations
4) Software Application Development for Bus Operations

2.15 Google Maps

Google in cooperation with the ministry of transport provides a web-based service on traffic information and route planning for users in Bangkok. This service integrates public transport services and is an easy-to-use application on internet, which consists of:

1) Google maps for route planning from one area to another in Bangkok under the cooperation of the OTP and google.
2) Cooperation with the OTP to amalgamate real-time traffic information using an interface of the google maps for route planning and route selection based on travel time or other utility criteria from origins to destinations.
3) Google Maps for mobile phones. This service allows mobile phones users to search for their current locations with the function "My Location," which can be accessed at http://m/google.co.th/maps

2.16 Marine Department (MD)

The MD is responsible for regulating, inspecting, and directing water transport and safety especially transportation in the Chao Phraya River, which is the main water corridor in Bangkok and the vicinity. The relevant operations of the MD to the ITS are:

1) Installation of CCTVs along the Chao Phraya River banks to promote safety and regulate water traffic,
2) Water transport safety center links CCTV communication 24-hours constantly via internet to other official agencies. This center can transmits both pictures, streams of video, and sounds and is also capable of recording video and pictures.
3) Information disseminating system with variable message signs (LED) and sound system to communicate with ship or boat riders.

4) Survey, study, analyze, and design a water traffic and transport system to regulate water traffic and promote the safety. This system can be used for management and regulation of water traffic as well as the communication service for ship operations.

3. Operations of the Traffic and Transport Information Centers Abroad

3.1 Main Components of the Traffic and Transport Information Centers

The main components of the traffic and transport information centers can be categorized into 4 groups:

- **Traffic Data Collection System**

The development of the traffic and transport information centers has originated from real-time traffic data collection system where traffic data are collected from traffic detectors or sensors. When there are vehicles passing on roadways equipped with detectors, traffic information is sent back to the center. These data consist of traffic flows, vehicle speeds, traffic densities in form of occupancy, and traffic queue lengths that can only be deducted from CCTVs.

- **Communication System**

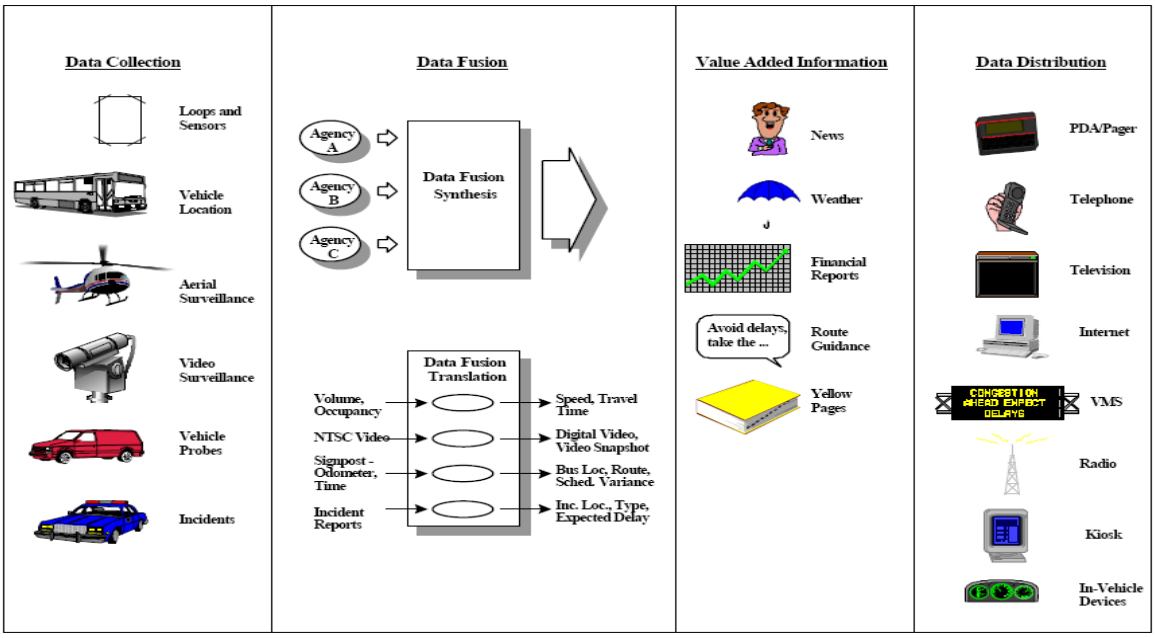
Communication system can be divided into two parts: 1) inbound communication system, which obtain information from various detection devices via communication networks; however, the most widely-used one is Virtual Private Network (VPN). Data are transmitted to the center via router, and 2) outbound communication system, which transmits processed information to illustrate on web servers or other relevant devices at destinations.

- **Traffic information processing and analysis system**

Traffic information processing and analysis system records data from the traffic data collection system via the communication system to the database system in the center. Previously, the data analysis was done using software program with a purpose of efficiency evaluation but now the data analysis part is focusing on describing or explaining the current traffic conditions close to the real conditions in the field.

- **Information Dissemination System**

Information dissemination to public is divided into 2 parts: 1) information presentation on maps with roadway networks. These maps are beautifully adjusted to represent some locations of interest, which can be easily understood by users, and 2) information dissemination to general public, which can be done via various media, particularly internet.



Source : Advances in Traffic Data collection and Management FHWA, USDOT, January 2003

Figure 1 Components of the Traffic and Transport Information Centers

3.2 System Architecture of the Traffic and Transport Information Centers

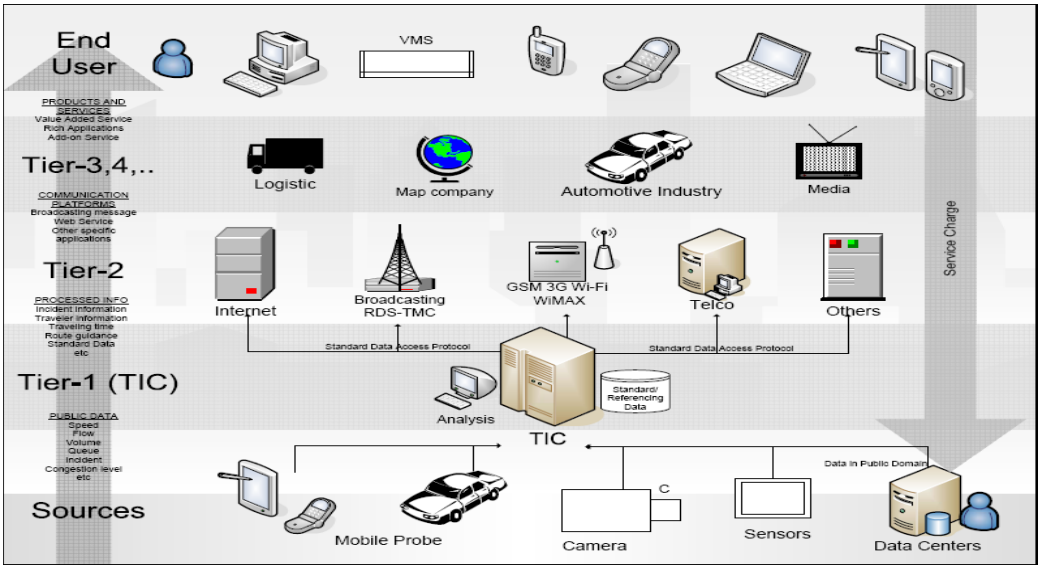
Relation of all systems that are mentioned earlier can be represented in a form of system architecture for a better understanding of the system as shown in **Figure 2**. This system architecture was established under the ITS project supported by the NECTEC, which can be explained as follows:

TIER 1 (TDC): Real-time Traffic Data Center gathers and/or collects data from detectors on roadway networks. This center will locate with server, which collects data from all sources and preliminarily processes data by fusing data for a better use.

TIER 2 (TAC): Traffic Analysis Center. This center obtains information from the TDC and then processes and analyzes the information for uses. The information will be value-added.

TIER 3 (TIC): Traffic Information Center. Values are added to the information processed by TIER 2 for specific uses of TIERs 2, 3, and 4, which are different from TIER to TIER. For instance, TIER 2 will emphasize on modifying the data obtained from different sources of TIER 1 to closely explain traffic conditions in the field while TIER 3 and 4 will focus on modify the information obtained from TIER 2.

END USER: End user means devices/equipment for receiving the information or users with capability to use the devices/equipment at destinations, which can be categorized into several groups such as general drivers or transport entrepreneurs and/or truck operation companies.



Source : Adjusted by Dr. Prasakorn Pratombutr in ITS program supported by the NECTEC
Source means sources and/or origins of data, which must be sent to servers of the center.
Main sources are loop sensors and overhead detectors such as ultrasonic or radar detectors.
Now, there is an attempt to use mobile phone as sources as well.

Figure 2 System Architecture of the Traffic and Transport Information Center

3.3 Evolution of the Traffic and Transport Information Centers Abroad

The advent of the traffic and transport information centers in the U.S. started in 1990-1995. Due to the change in traffic conditions, congestion spreading to major corridors and suburban areas, the U.S. therefore set up a central unit (the government enacted the law to let the local governments set up an organization to integrate cooperation between the central unit and the local offices) whose functions was to coordinate between the central unit and the local offices. Therefore, this resulted in more development projects that promote cooperation among the local offices, the state offices, and the federal offices.

Next, traffic management between areas function started to come into plays because traffic management must be done in area-wise. This gained a lot of benefits in several areas and led to the initiation of numerous projects related to traffic detection with efficiency or performance measures. This type of project obtained legal supports from various agencies that preferred to receive the matching fund (no matter how related functions of the agencies are). This continues to the point that traffic information can be obtained in real-time together with evaluation (especially for agencies with capability of collecting traffic and transport information in real-time). This leads to the concept of the development of the traffic and transport information centers to function as discussed.

From technology development in the ITS, the U.S. federal government in 1990-2000 widely supported an establishment of the centers for gathering, analyzing, processing, and disseminating traffic and transport information in real-time. The initial phase was the establishment of "511 Project" to service traffic and transport information to general public.

Nonetheless, the advent of the traffic and transport information centers in Europe is quite different due to the factors of sustainability of the centers according to government policies and directions of national development, which can be categorized into 2 groups such as:

- Group 1: The development of the centers in Europe is similar to those in the U.S. with an attempt to resolve traffic congestion problems by "traffic control and management." In this way, there must be real-time traffic data collection efforts. Thus, an evaluation of performance measures was conducted as well. As a result, a lot of traffic data and information are available to make use of and disseminate these to general public.

- Group 2: This group emphasizes on data collection and converts them to information. Therefore, the centers are developed with a function of real-time data collection. Though some original data are available, they are not enough to present in a format of complete information. The leaders may be private either private or public sectors but usually the public sector is the leader. One special characteristic of the group is that sometimes the public sector becomes a customer itself because of the need for data in various perspectives.

For the advent of the centers in Japan and China, they are entirely different from those in the U.S. and Europe. The key factor is the lead of the government and the cooperation between the private and public sectors, which can be summarized as follows:

- Japanese government initiated a study to develop traffic and transport information for transport entrepreneurs and general road users (1990-1995) with the cooperation among 3-4 government agencies which possessed traffic and transport information.
- The traffic and transport information center in Japan was named "Vehicle Information and Communication Systems: VICS." Revenues of VICS come from the share of VICS receiver sales.
- VICS receives no funding from the government. VICS earns a lot and is capable of subsidizing some government agencies.
- However, most Japanese auto-makers make one-step ahead by trying to develop a system that integrates all information required by markets.

4. Evolution of the Traffic and Transport Information Centers in Thailand

4.1 Existing Operations of the Traffic and Transport Information Centers

Recently, there are several agencies conducting projects on applications of the Intelligent Transportation System (ITS) technologies. The OTP develops the real-time traffic condition reporting system by installing image processing cameras and inductive loop detectors on major roads. The RTP have two projects: the third phase of the CCTV installation project (installation of CCTV and image processing cameras) and the red light cameras project at 30 main intersections in Bangkok. The BMA is on its way to install CCTV at some important locations as well as intersections by focusing on the security aspects. The EXAT has installed CCTV on expressways. The DOH installs traffic detectors on major highways as well as the installation of the CCTV on the motorways. The private sector also starts to apply the ITS technology by installing GPS on taxis from which data can be used to analyzed travel speeds on sections of interest. Another interesting sample is the participation of the NECTEC by technical supports for government agencies that lack in knowledgeable personnel and technical knowledge to develop the information system, which can be outlined as follows:

- The technical support for the RTP such as the highway police division and the traffic police division to update the traffic information websites, especially during the main holidays so that road users can be alternative routes to avoid traffic congestion when travel back homes.
- The cooperation among agencies that collect traffic and transport information to unify the database.
- The support of the establishment of the ITS Thailand for its role in TIER 2, 3, and 4, particularly for TIER 3 and 4 and the cooperation with private agencies with skills on the information technology system in these activities.
- The support of research and development for TIER 3 and 4 to disseminate traffic information to road users.

However, the operations of these agencies still have some problems. There is no cooperation to link and integrate systems. The uses of data from detectors are inefficient in general. Therefore, overlaps of responsibilities and investments together with no standard of data transmission still exist. The data usage cannot gain the maximum benefits with no integrated system.

4.2 Summary of the Development and Operations of the Existing Traffic and Transport Information Centers

When considering a general view of the systems of the relevant agencies, it is found that the development and operation of the traffic and transport information centers in Thailand are quite similar to those in abroad. But there are still some differences in preliminary purposes, which can be summarized as follows:

- Agencies collect real-time traffic and transport information from roadway networks such as the DOH, the Thai Traffic Police Division, and the OTP, which operate as TIER 1. They still cannot efficiently utilize traffic information.

- Private sectors start taking part in data collection such as Genius (Forth Corporation shareholder of Genius Traffic System) takes concession to install LED to display traffic information on the Intelligent Traffic Signs in Bangkok. They also operate as TIER 1.

- These simultaneously agencies analyze and process data together with disseminate real-time traffic and transport information. Therefore, they also operate as TIERs 2, 3, and 4.

- However, there is no validation of the data analysis process. In addition, information that is disseminated is not suitable for general users and special users such as truck operators.

- The weakness of the existing conditions of the traffic and transport information centers is at TIER 2, which must emphasize the analysis and processing procedures.

- Establishment of TIER 3 and 4 can be a partnership with private sectors. Public sectors should investigate how to cooperate with private sectors and the strengths and weaknesses of this cooperation.

The consultant also considers the possibilities and the platforms of the real-time ITS data integration centers in future, which can be summarized in **Figure 3**.

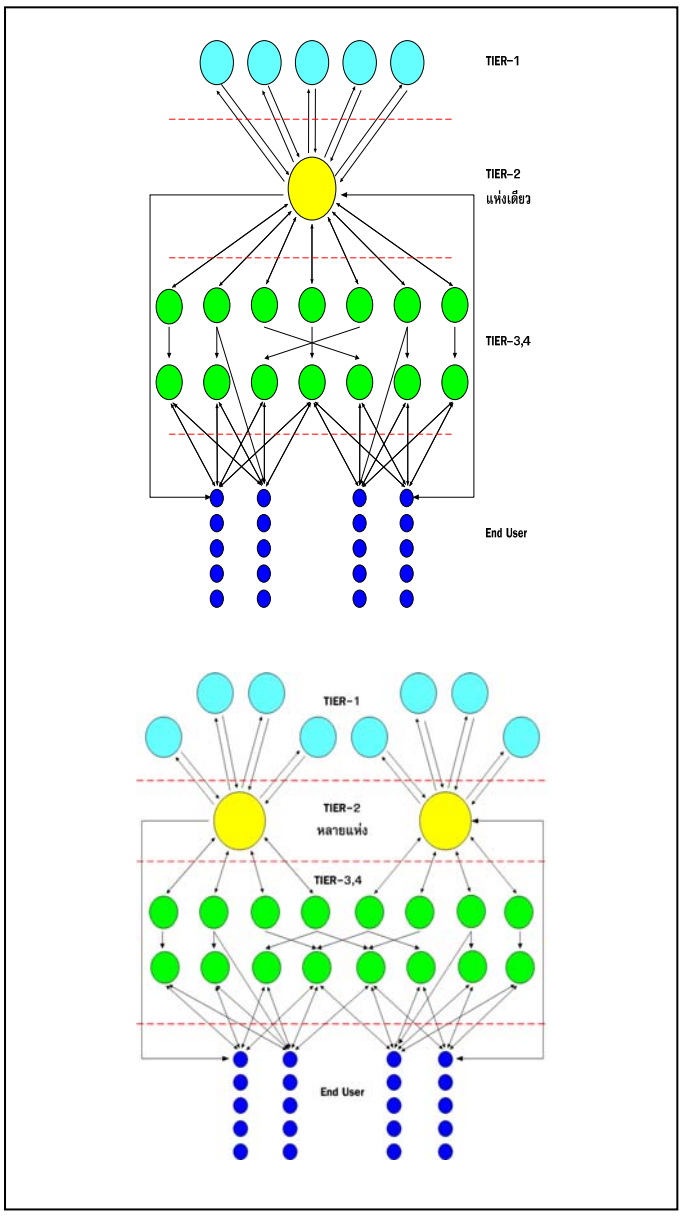


Figure 3 Platforms of the Development of TIER 1-4 in Future

From the preliminary evaluation of the conditions in future, the following summaries can be drawn:

- There can be many TIER 1s, each of which is under the direction of its own agency. For instance, the DOH and the DOR can collect real-time traffic and transport information on their own roadway networks.

- The number of TIER 2, which can be one or more, must be carefully evaluated for both advantages and disadvantages. TIER 1 operating under different agencies link information to TIER 2 in time of demanding. The development of TIER 2 should be carefully considered because the possibility of the TIER 2 development is not easy due to high capital costs and the requirements of high accuracy of data in use.

- Should TIERs 3 and 4 currently operating under different agencies be improved? Because there are already a lot of government agencies functioning as TIERs 3 and 4, the private sectors might be no longer interested in developing or might be able to make use of information directly without extra costs. Currently, TIER 3 and 4 in abroad are operated by private agencies.

- Finally, disseminating system to general public should be ready with accurate information. Private agencies can perform this function.

5. Developing a Sustainable ITS Data Integration Center of the OTP in Future

5.1 Suggestions Developing a Sustainable ITS Data Integration Center of the OTP in Future

In order to develop a sustainable ITS data integration center, it must be enhanced in two general approaches: 1) technical approach, and 2) management and operational approach, which are detailed as follows:

- Technical suggestion approach should emphasize on improvements of processes in TIERs 1, 2, and 3. TIER 4 is already in good technical condition. TIER 1 should entirely improve an infrastructure part of data collection. This includes both software and hardware parts. For the software part, types of data, intervals of data collection and reporting, and etc. should be clearly redefined. For the hardware part, server system for sending and receiving data from field should be improved. TIER 2 and 3 should improve software to be able to gather and collect information obtained from the center, and analyze/process and evaluate traffic conditions appropriately and accurately to obtain information guidance to road users or general public.

- Management and operational approach should place an emphasis on public and private partnership and improve an operational format into business model so that it can fully operate as a business unit. Operational formats should be categorized from skills and capabilities of each unit. For example, the private sectors mostly have better management capability and marketing skills than the public sectors while the public sectors have capability of collecting and analyzing data. Operating the center should emphasize on outcomes that can be used by different agencies especially TIER 3 and 4 (emphasize on collecting/analyzing data and value-add to data and disseminate to general public), which can make use of modifying data for uses and disseminating to general public. This will induce more use of real-time traffic and transport information (The private sectors can study market and have a better understanding of markets than the public sectors) and save the government spending on development. However, there might be some private agencies taking part in developing TIER 1 and 2 if they can make profits in forms of money such as advertisements.

5.2 Appropriate Platform of the Organization and Operation of the ITS Data Integration Center in Future

The Appropriate Platform of the organization and operation of the ITS data integration center in future as suggested by the consultant is shown in **Figure 4**, which is organized by functioning and emphasizes on developing TIERs 3 & 4 that are operated by the private sectors. The OTP still functions as a fundamental (TIERs 3 & 4) operator (to stimulate markets and maintain the basic level of service for general public). However, the operation of the ITS data integration center in future should focus on functioning of TIER 2. There can be more one TIER 2 (for the case of private operators but there is only one operator under the direction of the matching fund). TIER 2 operated by the government office should emphasize on receiving data from TIER 1, which is mainly operated by the government agencies. In case of necessity, purchasing or exchanging information with TIER 1, operated by the private sectors, is also possible (for instance, data obtained from probe vehicles or data from private companies operating under concession permission of the government such as the BMA). In the initial phase, the center should function as TIER 3 and 4 in order to disseminate information to general public (road users) without any charge or fee. The important point is to ensure that real-time traffic and transport information will be widely used and accessed by the general public, which can be promoted by freely distribution of information. This can help traffic management and also promote cooperation with the private agencies so that the private organizations in business can add values to information (in TIER 3) and disseminate information to road users (TIER 4). This information can be value-added and be sold otherwise the private organization might distribute information in a form of promotions.

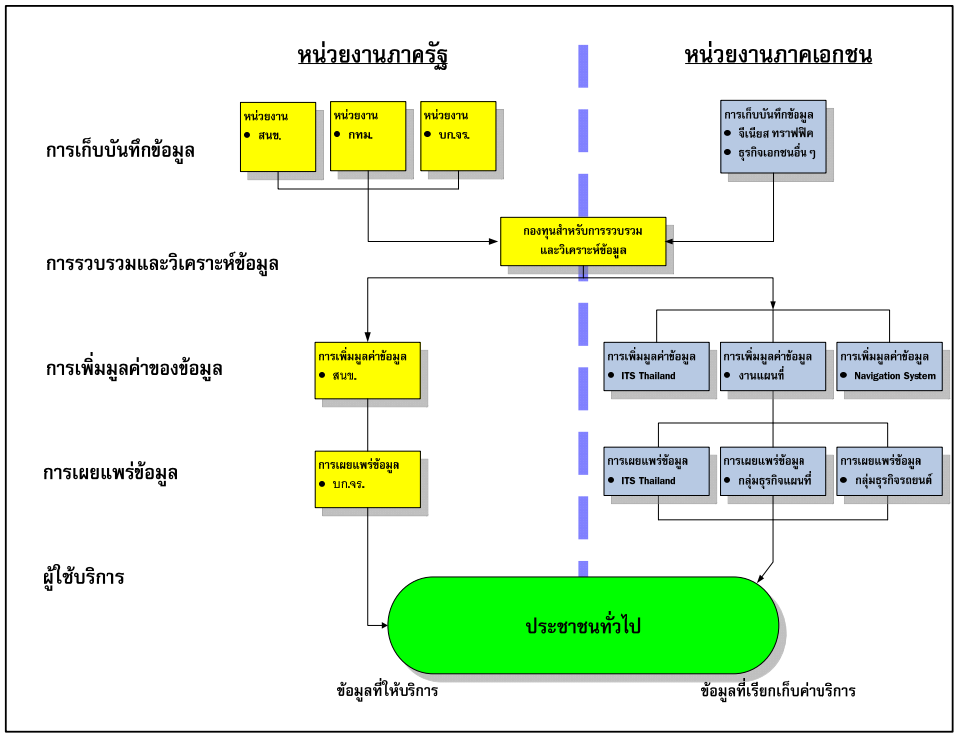


Figure 4 Organization Platform by Function in Format 2

5.3 Policy and Operational Plan for the Government to Promote the Center Establishment

Approaches (in form of policy) to operate the center in a sustainable way in future consist of 6 matters:

1) Establishment of the agency to operate as TIER 2 in form of Institutional Arrangement to link among various TIER 1 and emphasize on accurate real-time traffic and transport data analysis. Cooperation with the private agencies operating as TIER 3 and 4 is also important together with flexibility to work and make benefits from the outcomes in a suitable level. This can save budgets in future. Information can be disseminated to general public with low costs.

2) Cooperation and mutual understanding among TIER 1 agencies should focus on encourage TIER 1 agencies to operate as TIER 1 (Allocation of responsibility) without wasting time to develop one own real-time ITS data integration centers. With the operation, every agency will understand their roles. Matching fund (institutional arrangement) will be a center to coordinate TIER 1 agencies and private agencies as well.

3) Promotion of private participation in every function from real-time traffic and transport data collection or TIER 1 (by suggesting on appropriate types of data and data collection methods to support the existing data collection system and not to involve with the privacy issues). The cooperation (this should be clearly defined because the duty of TIER 2 is educationally related, which requires some expense, and the government sector can better take this responsibility) to develop TIER 2, 3 and 4 should support the private sector to operate such as data usage permission without any charge or fee.

4) Committee from different agencies for directing, and managing the matching fund to meet the goals and objectives of the center. This committee can help promote the cooperation among various agencies and protect the abuse of the matching fund. Committee with good knowledge and ability will lead the operation of the center into the right direction and gain benefits from the usage of the real-time traffic and transport information. This includes the development of information to suggest road users and public transport users this information cannot be directly sold. Therefore, the private agencies may not want to develop but the matching fund should develop in order to provide benefits to all user groups and it can be developed to gain benefits in a form of transportation management in future to minimize the loss on economy and environment.

5) In the initial phase, the expense of the center should come from the government spending (this includes receiving support from other funds in the ministry of transport). Later, revenues from the business units from TIER 1 to TIER 4, particularly TIER 3 and 4, should be enough to run the matching fund with the minimum dependence on the government budget.

6) To promote the business development in TIER 3 and 4, the initiation should start from the subsidy for system research and development in both software and hardware. The most important point is the permission to use the real-time traffic and transport information from TIER 2 without charge for at least 24 months so that the information dissemination system can be made available to public soon.

6. Development of the Data Linkage System from Different Agencies

6.1 Data Linkage from Traffic Monitoring System of the Traffic Safety Bureau of the DOH

The traffic safety bureau of the DOH is on the process of installing traffic detectors on major highways, which consists of image processing cameras and loop sensors where data transmitted back to the traffic safety bureau are:

1) Data from image processing cameras
2) Data from inductive loop detectors

In the development of the data linkage system from the traffic safety bureau, the consultant has installed computers functioning as Gateway Server at the DOH to link data via GPRS to the processing server at the ITS data integration center at the OTP. Also, an application program is developed to function as a control system to send and receive those traffic data as shown in **Figure 5**.

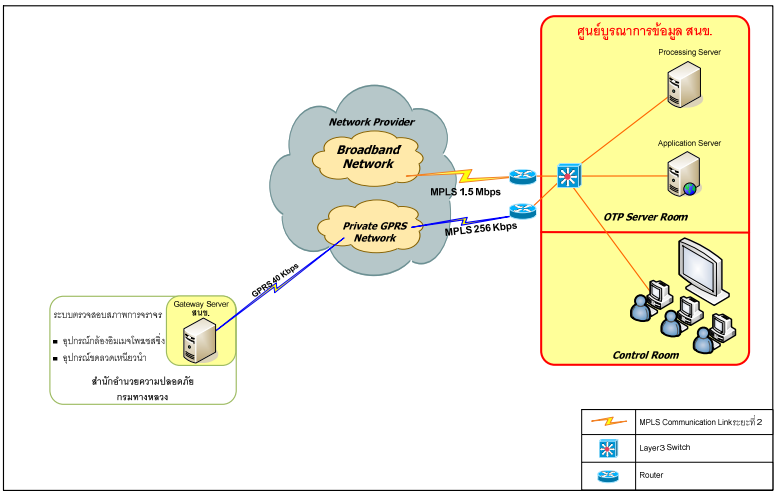


Figure 5 Layout of the Data Linkage between the DOH and the Center

6.2 Data Linkage from CCTV System of the EXAT

Currently, the EXAT sets up an expressway traffic control center with designated personnel to communicate with emergency units, expressway police, and street police to continuously service users 24 hour-a-day by using a CCTV system.

In the first phase of the project, the OTP links picture data from CCTV of the EXAT to the ITS data integration center at the OTP using computers as gateway servers. Picture signal from the system is transmitted via a communication system MPLS (Multi Protocol Label Switching) to the processing server of the center at the OTP by developing an application program to control data sending and receiving as shown in **Figure 6**.

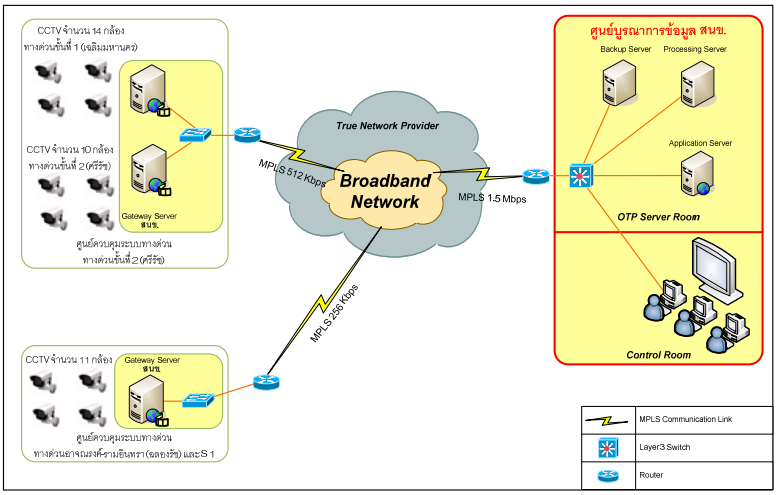


Figure 6 Layout of the Data Linkage between the EXAT and the Center at OTP in the First Phase

For the data linkage system in the second phase, the consultant has inspected signal cables of the communication system used for transmitting CCTV picture signal from the EXAT to the center at the OTP. It is found that this is enough for 35 additional cameras, counted in total of 70 cameras, from the expressway 2 traffic control center (Srirath) and the expressway traffic control center at (Aanarong-RamIndra: Chalongrath) as shown in **Figure 7**.

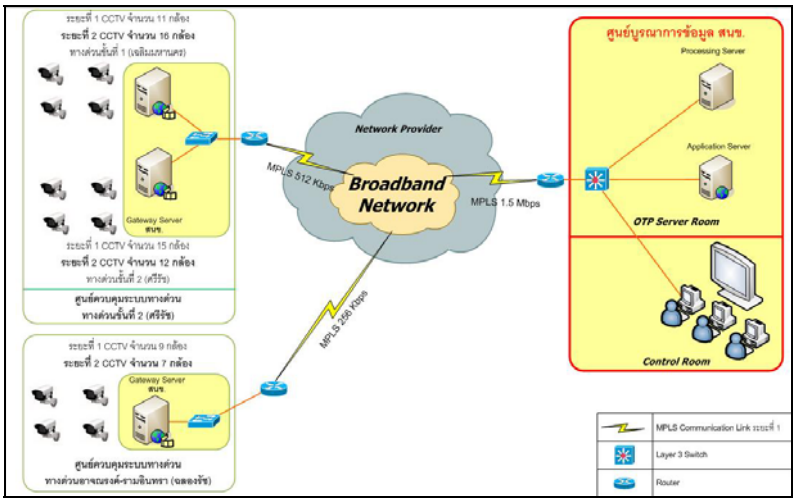


Figure 7 Layout of the Data Linkage from the EXAT in the Seconds Phase

6.3 Data Linkage from the GPS Bus Tracking System and the Real-Time Information Dissemination System of the BMTA

Currently, the OTP conducts the bus development project in Bangkok and the vicinity. In this project, there must be a pilot project, a real experiment, consisting of two parts: 1) the development and test of bus time table, and 2) bus management system.

For the second phase of the project, the consultant has linked information from the GPS bus tracking system of the BMTA. The bus operational information is processed in real-time such as average speeds of buses, and locations of buses. Besides, the consultants also link data from the real-time information service system via LED signs.

In the development of the data linkage system of the two mentioned systems of the BMTA back to the OTP, the consultant has installed Gateway Servers at the bus control center 5 to transmit data via the communication system MPLS (Multi Protocol Label Switching) back to the processing servers at the ITS data integration center of the OTP. Also, an application program is developed to function as a control system to send and receive those traffic data as shown in **Figure 8**.

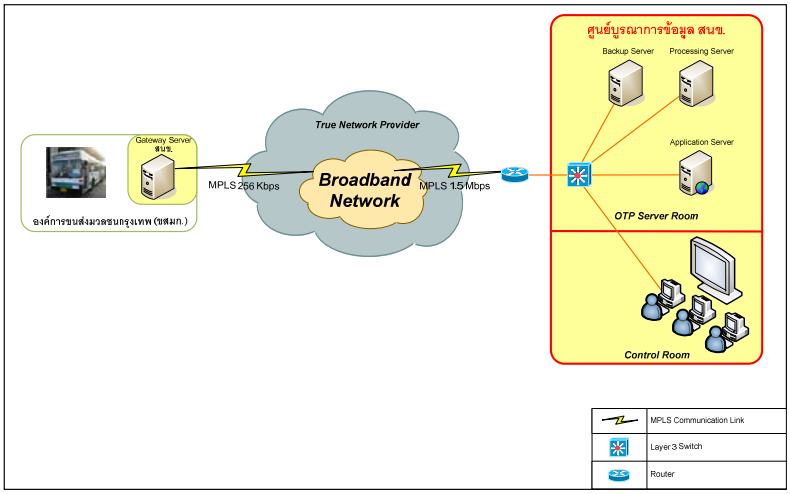


Figure 8 Layout of the Data Linkage System
from the Bus Control Center 5 and the Center at the OTP

6.4 Data Linkage from Traffic Monitoring System of the OTP

Traffic monitoring system at the OTP is developed and traffic detectors are of radar-wave type, which can detect traffic flows, speeds, and occupancies. Detector installation locations are the main roads in Bangkok and the vicinity area. There are totally 29 locations (30 sets) as shown in **Figure 9**. In the second phase, the consultant has set up the linkage system via Local Area Network (LAN) of the OTP, which is connected to the signal transmitting devices with two systems. This results in a better linkage system as shown in **Figure 10**.

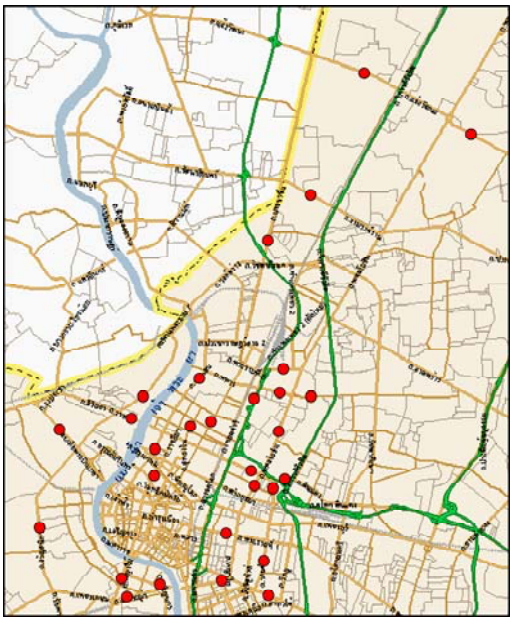


Figure 9 Locations of Microwave-Radar Traffic Monitoring Devices

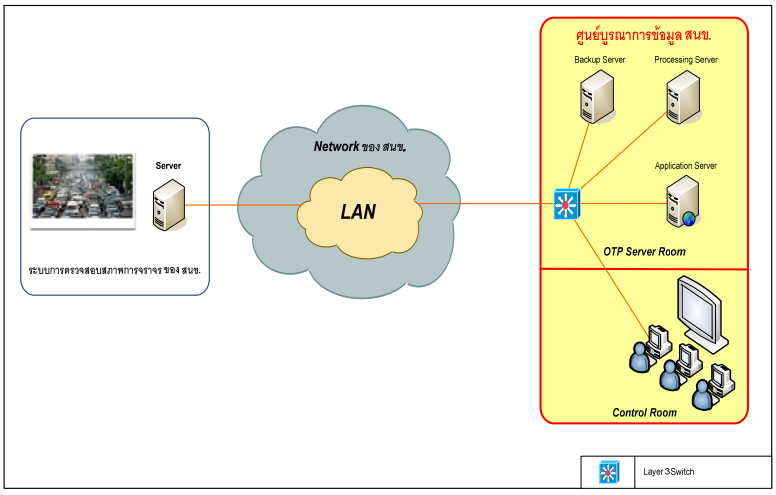


Figure 10 Layout of the Data Linkage System between the Traffic Monitoring System and the ITS Data Integration Center at the OTP

6.5 Data Linkage from CCTV of the Don Muang Tollway System

In the development of the data linkage transmitting picture signals from CCTV of the Don Muang Tollway to the ITS data integration center at the OTP, the consultant has installed computers serving as Gateway Servers at the Don Muang Tollway to transmit picture signals from CCTV of the Don Muang Tollway system. The Gateway Servers have direct connection via MPLS (Multi Protocol Label Switching) at the speed of 128 kbps to the processing servers at the ITS data integration center at the OTP. Also, an application program is developed to function as a control system to send and receive those traffic data as shown in **Figure 11**.

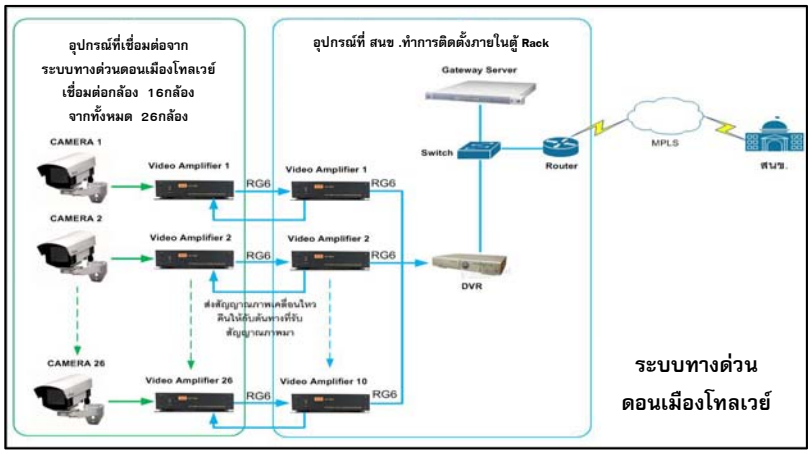


Figure 11 Data Linkage between the Don Muang Tollway System and the ITS Data Integration Center

7. Installation of CCTV System on Highway Network

7.1 CCTV Installation

In the second phase of the project, the consultant has additionally installed CCTV on major highways between Bangkok and the southern and the western regions. The detail of the installation locations of the second phase are shown in **Figure 12**.

Figure 12 Map Shows Locations of the CCTV Installation in the Second Phase

CCTVs are mounted in the four-meter poles, where poles are installed on the pedestrian flyovers. One set of the control box is installed on the flyover pier. The data communication system is of the General Packet Radio Service (GPRS) type, which is the wireless. Communication system to transmit data to the ITS data integration center at the OTP. Images will be transmitted every 5-minute interval. Lay of the data linkage is shown in **Figure 13**.

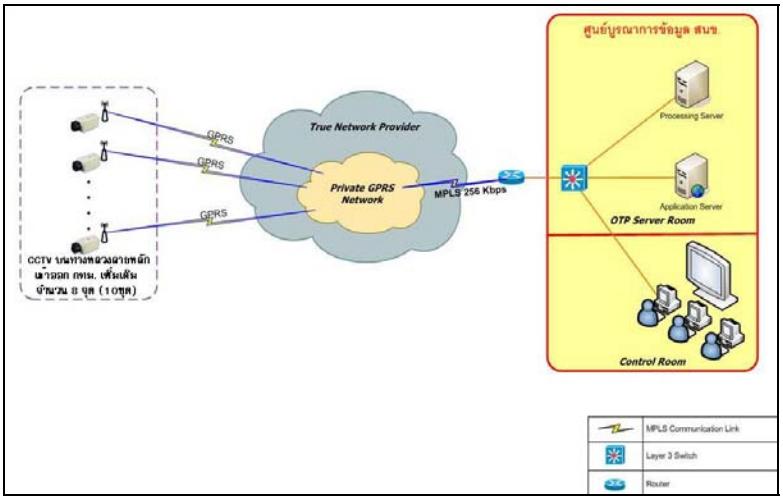


Figure 13 Layout of the Data Linkage System
between the CCTV Installed on Highways and the Center

7.2 Development of the Information Dissemination System Connected from CTTV on Highways

Picture information linked from the CCTV system installed in the second phase of the project will be presented to disseminate in a format of still pictures as in the first phase of the project as shown in **Figure 14**.

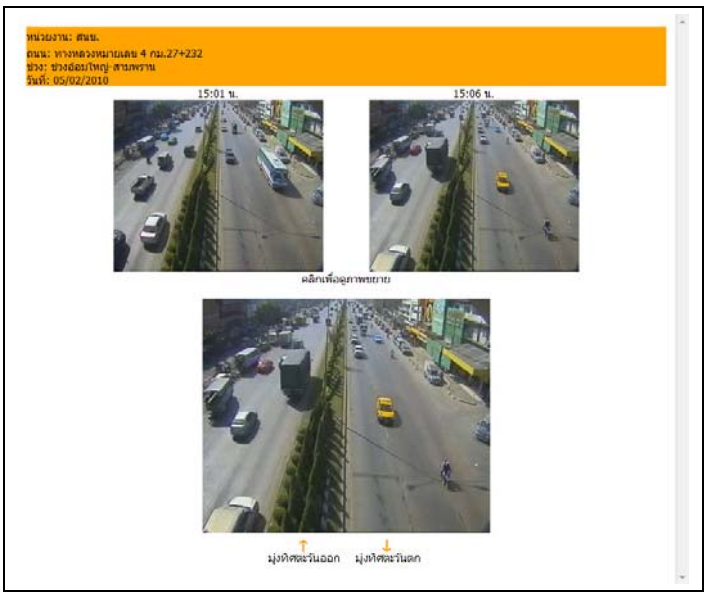


Figure 14 Sample of Information Dissemination System
Connected from CCTV Installed on Highways in a Format of Still Picture

8. Acquisition of Traffic Condition Information Fed to the ITS Data Integration System

8.1 Data Sources with RFID Devices

Data sources that can automatically inspect traffic conditions with the potential to be connected to traffic reporting systems are the sources from public transport with RFID (Radio Frequency Identification) devices. For an application of RFID to report traffic conditions, RFID tags must be installed on probe vehicles such as buses. RFID readers must be installed along the route that probe vehicles will pass on such as public telephone boxes. RFID tags and readers can be alternately installed. For instance, RFID readers are installed on probe vehicles while the tags are installed at other locations along the route. In Hong Kong, there is an application of RFID technology to collect vehicle speeds at toll booths.

Figure 15 RFID Tags Installed in Bus and the Transmission of Data between RFID and Readers

From the evaluation of the existing traffic data sources, it is found that the RFID sources are the readiest sources even though there are some disadvantages on the fact that in some intervals data must be inferred from historical data due to the limited number of probe vehicles. In the second phase of the project, the consultant provides the traffic information from the RFID sources, where data, apart from average speeds displayed in a form of color strips to represent the congestion levels, are:

- Average travel times on road sections
- Travel times on section road sections according to different thirteen vehicle classification:
  - (K) Trailer
  - (k) Semi-trailer
  - (H) 10-wheel truck
  - (h) 6-wheel truck
  - (B) Bus
  - (b) Mini-bus
  - (P) Big passenger car
  - (p) Small passenger car
  - (L) Van or pickups
  - (T) Taxi
  - (V) Public van
  - (A) Passenger car
  - (M) Motorcycle
- Spot speed sources
- Data transmitted to the center at the OTP are updated 5 minute.

Data are processed on-line and off-line (historical data) when there is no available real-time data at the moment or no vehicle with RFID passes the road section. The data processing consists of: outliers, local link parameters, basic data filtering & fusion. Speeds are calculated using the weighted vehicle type method. Traffic condition information covers at least 150 road sections with the frequency of 3 probe vehicles per 5 minutes per station. Information must be correct and accurate up to 85 percentage statistical confidence. Road sections where the RFID data are available are segmented differently from the road section where traffic conditions are reported. Therefore, speeds of the reported road sections must be converted using the weight distance average speed method before they can be made available to public.

8.2 Development of Data Linkage System

Data linkage from RFID sources in this project consists of traffic conditions on the road network in Bangkok and the vicinity. The consultant has established the connection via web service (www.siamtraffic.net).

In general, traffic information service on this web comprises two parts: services providers and service users. The service provider (www.siamtraffic.net) will send traffic information on roadways that data can be collected to the service users as requested such as:

- Route information on road segments (Link)
- Station information which is an origin or a destination of each link
- Details of each point along the route

This information will be received in the first-time-use and will later be updated in consistence with the correct information. Link information is also road information that the route originates and ends at certain locations. This includes information the construction time of link and link status. For details of each link, data will be in a vector format: latitude, and longitude, which determine the location of each link on the road and direction.

Information regarding the status of each link can be requested via the submission of link and time of information request to URL (www.siamtraffic.net). The traffic condition will be received (travel time, and speed in color) in a format of XML. Information can be received in forms of Single Links, Multi Links, and Multi Time depending on the URL format of request and time of request.

Details of the linked information consist of:

1) Traffic condition information (Link speed and travel time)

   - Single Link, Single time
   - Single Link, Multi Time
   - Multi Link, Single Time
   - Multi Link, Multi Time

2) Date and Time of data update (Basic information)

3) Basic information (Link, Station, Point to update and make consistent to the service providers)

Layout of the Data Linkage between the RFID Sources and the ITS data integration Sources can be shown in **Figure 16**.

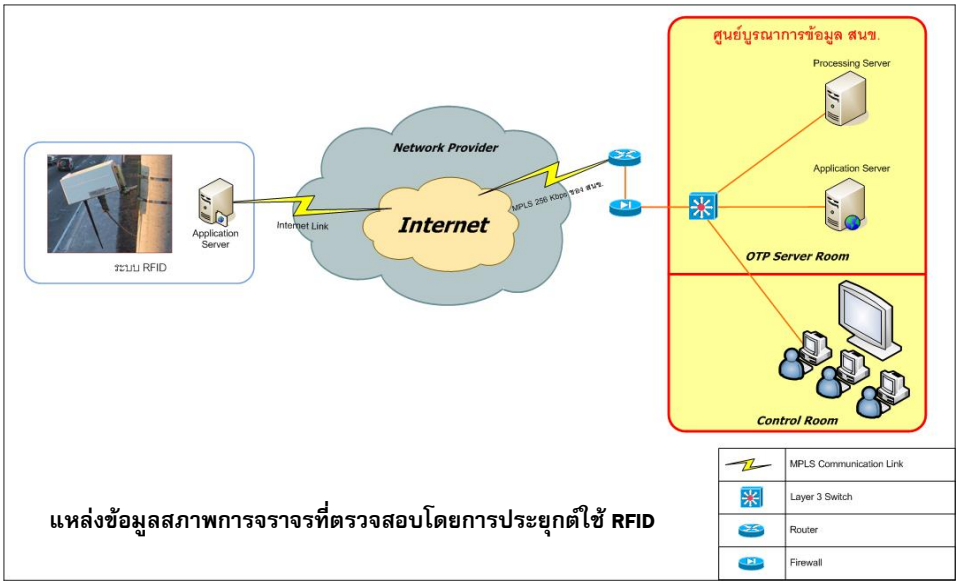


Figure 16 Layout of the Data Linkage between the RFID Sources and the ITS Data Integration Sources

9. Development of the Traffic Information Dissemination System on Internet

9.1 Improvement of the Current Web Service

In this second phase of the project, the consultant has made an improvement to the web to be more beautiful and up-to-date as shown in **Figure 17** to **Figure 20**.

Figure 17 The Homepage of the Real-Time Traffic Reporting System

Figure 18 The Mainpage of the Real-Time Traffic Reporting System

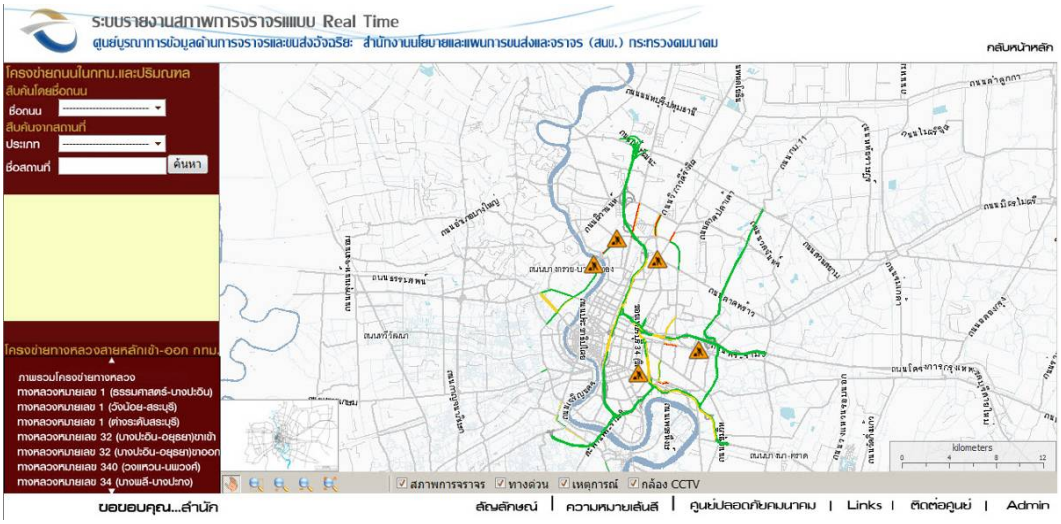
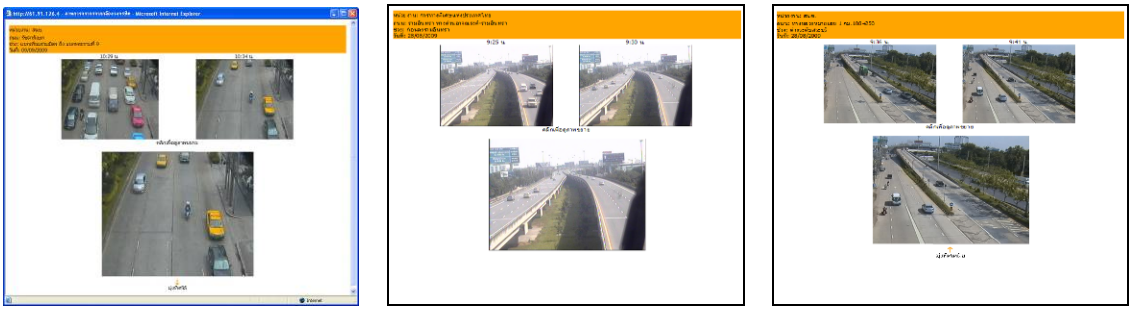


Figure 19 Color Strips Representing Traffic Conditions



Major Corridors | Expressway | Major inbound and outbound highways from Bkk

Figure 20 Still Pictures from CCTV of Traffic Conditions

9.2 Development of the Information Dissemination System Linked from the Bureau of Traffic Safety of the DOH

Data linked from the bureau of traffic safety of the DOH consists of two parts: 1) data from image processing cameras, and 2) data from inductive loop detectors. The data from image processing cameras is traffic condition information on major highways. The consultant has developed the information dissemination system using color strips representing congestion levels on roadway network maps in real-time as shown in section 9.1.

While the data from inductive loop detectors are in real-time format, they cannot be used to represent on the real-time traffic information dissemination system. The consultant has developed the dissemination system in format of statistics and historical data. General public can search information back in time for one month and can also select output formats.

9.3 Development of the Information Dissemination System Linked from the EXAT

Data linked from the EXAT in the second phase of this project is from CCTV as in the first phase. The consultant has developed the traffic information dissemination system in form of still pictures as follows:

- On traffic reporting maps, users can select whether to show locations of the CCTV by checking on check box,
- When users clicks in Icon CCTV, the system will open up a window showing two still images: 1) picture at the current time, and 2) picture at 5-minute in the past. Both pictures can be enlarged. This is displayed in section 9.1

9.4 Development of the Information Dissemination System Linked from the BMTA

In the second phase of this project, the data linked from the BTMA are bus operation schedules and average speeds of buses in four lines that participate in the pilot project. The consultant has developed the information dissemination system as follows:

- Users selects "การเดินทางด้วยระบบรถโดยสารประจำทาง", the system will open up a new window that shows information regarding bus transport systems with search functions and controls of data from this linkage as shown in **Figure 21**.

Figure 21 A Window Displaying Bus Transport System Linked from the BMTA

- Users can assign bus number of the need bus. The system will display the corresponding bus route both directions together with the current location of each bus on that route as shown in **Figure 22**.

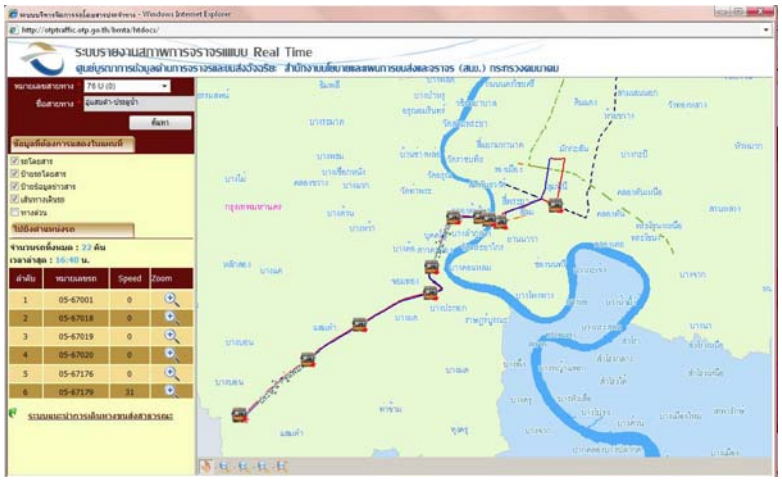


Figure 22 A Window Displaying Bus Route and Location of Bus on that Route

- Users can also select to display an expressway network on the map as shown in **Figure 23**.

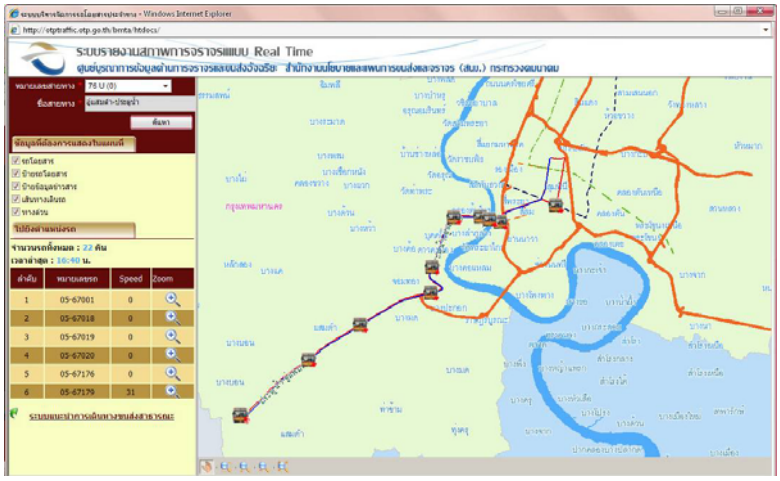


Figure 23 A Window Displaying Road and Expressway
Networks together with Bus Route and Location of Bus

- The system will show the locations of bus stops with their names along the bus route for the selected bus line as shown in **Figure 24**.

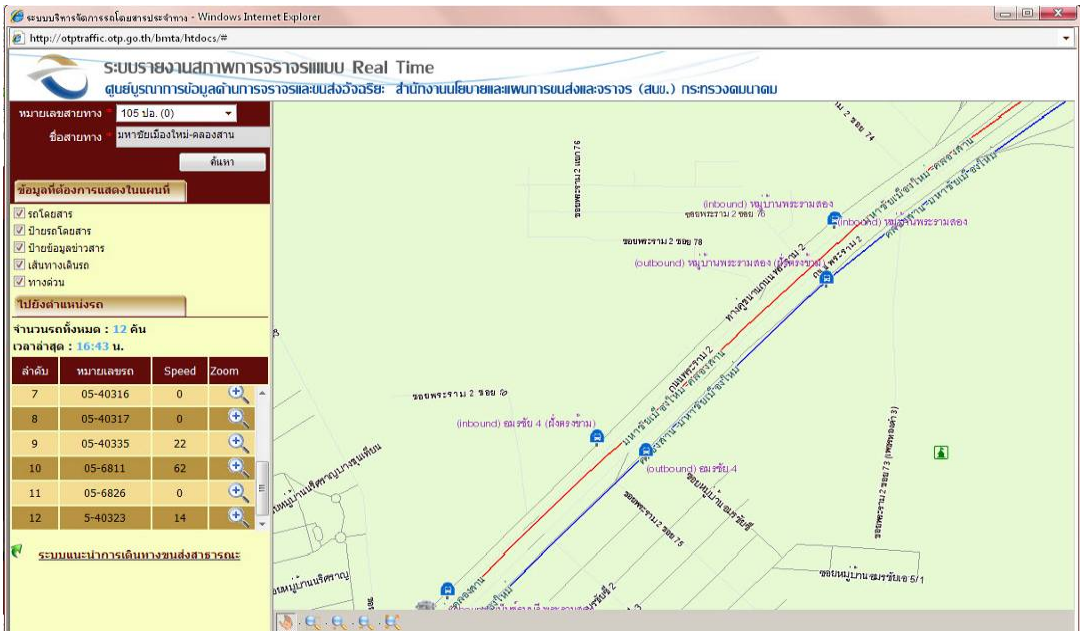


Figure 24 A Window Displaying Bus Stop Locations along Bus Route

- The system will display icon together with the locations of information signs installed at the 20 bus stops in Bangkok and the vicinity (pilot project). When users select to displaying information on the signs, the system will display information on the three current buses that are approaching.

- In addition, the system links with the route guidance system of the public transport system which the OTP, Google, and KMITNB have developed.

9.5 Development of the Information Dissemination System Linked from the Traffic Monitoring System of the OTP

Data linked from the traffic monitoring system of the OTP will be information on traffic conditions on roadways in Bangkok and the surrounding area where the OTP has installed traffic detectors. The consultant has developed the information dissemination system that represents congestion levels in forms of color strips on roadway network map in the real-time traffic reporting system. This is displayed in section 9.1.

9.6 Development of the Information Dissemination System Linked from the CCTV System Additionally Installed on Highways

Traffic condition information linked from the CCTV system additionally installed in highways in the second phase will be presented in a form of still images as in the first phase with details as follows:

- On the traffic condition reporting map of the project, there will be an icon displaying the locations of each CCTV. Users select whether to display the locations by clicking on Check Box at the bottom of the map.

- When users click on icon CCTV, the system will open up a window with two still images: the current image and the image from 5-minute ago. This is displayed in section 9.1.

9.7 Development of the Information Dissemination System Linked from RFID Sources

For traffic information linked from RFID sources consists of traffic conditions on roadways in Bangkok and the vicinity, the consultant has developed the information dissemination system in forms of color strips to represent congestion levels on roadway network map in the real-time traffic reporting system. This is displayed in section 9.1.

9.8 Development of the Information Dissemination System Linked from Don Muang Tollways

For traffic information linked from the CCTV system on the Don Muang Tollway, the consultant has developed the information dissemination system in forms of still images of traffic with details as follows:

- On traffic condition reporting map of the project, there will be an icon showing the locations of each CCTV. Users can select whether to display the CCTV locations by clicking on check box at the bottom of the map.

- When users click on icon CCTV, the system will open up a window with two still images: the current image and the image from 5-minute ago. This is displayed in section 9.1.

10. Development of the Traffic Information Dissemination System Via Mobile Phones/Pocket PC

The traffic information dissemination system via mobile phones is developed in this project to present reports and traffic conditions in 4 formats as follows:

1) **Traffic mobile:** traffic report for general users which can be used to inspect traffic conditions on maps and CCTV installed on roadways in Bangkok and the vicinity, major inbound and outbound highways, and expressways.
2) **Traffic member:** traffic report for subscribed members. Membership can be subscribed to select traffic reports such as maps or traffic images from CCTV in the common used routes, which can be recorded for repeated uses without wasting to select again.
3) **Traffic map:** report on maps on which traffic conditions are shown in forms of color strips on real maps. Sizes of maps are automatically adjusted to best suit screens of mobile phones. Users can pan maps up below right left zoom-in, and zoom-out as demanded.
4) **TrafficMe:** Report traffic conditions by centering the surrounding where the users are located.

In order to use this service, users must sign up for GPRS service with the mobile phone network providers. Then, users can be go to URL: m.trafficinfo.net.

11. System Testing

For the system testing of the data linkages from different agencies and the development of the information dissemination system in the second phase of the project, the consultant has tested the system to investigate outcomes of the system performance. The test is intended to examine the system accuracy and completeness as designed and developed, which can be outlined as follows.

11.1 Data Linkage from Traffic Monitoring System of the Bureau of Traffic Safety, the DOH

Details of the outcomes of the system testing in the second phase of the project can be shown in **Figure 25** to **figure 34**.

Figure 25 Display of Traffic Conditions Linked
from Image Processing Device in form of Color Strips

Image at the moment of testing	Image after the moment of testing
	

Figure 26 Testing of the Data Linkage from the CCTV System of the EXAT

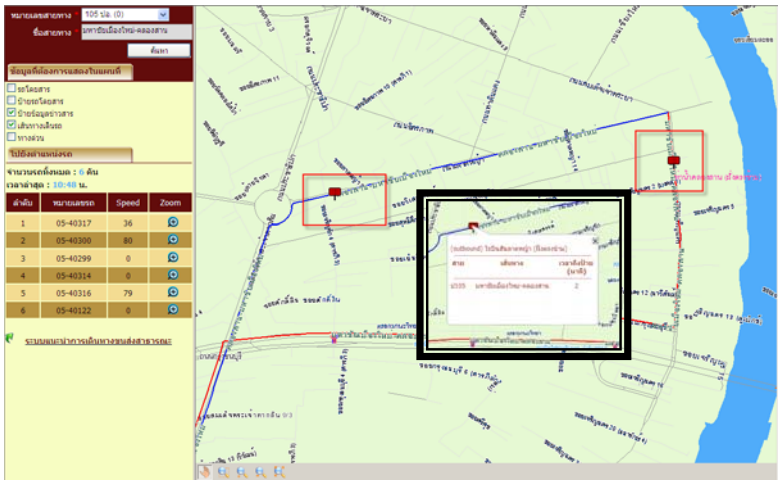


Figure 27 Display of LED Variable Message Signs Linked from the BMTA

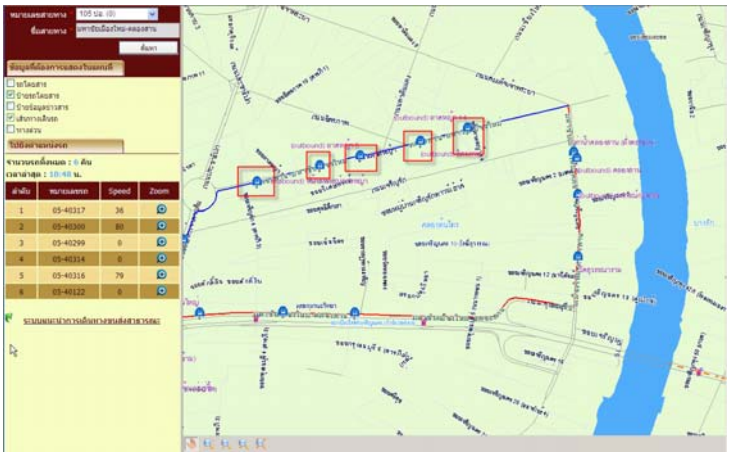


Figure 28 Bus Stop Information Display

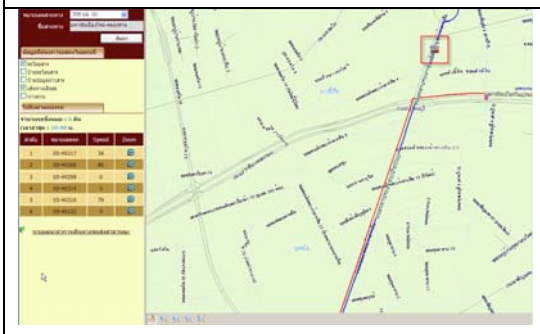
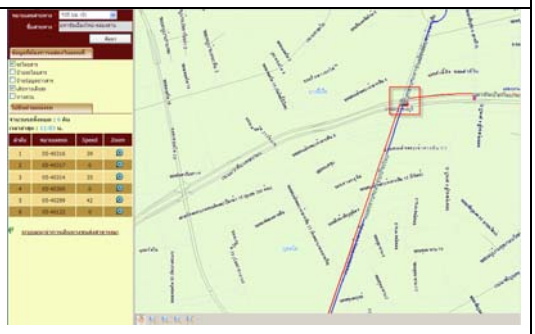
Image at the moment of testing	Image after the moment of testing
	

Figure 29 Bus Location Information Display

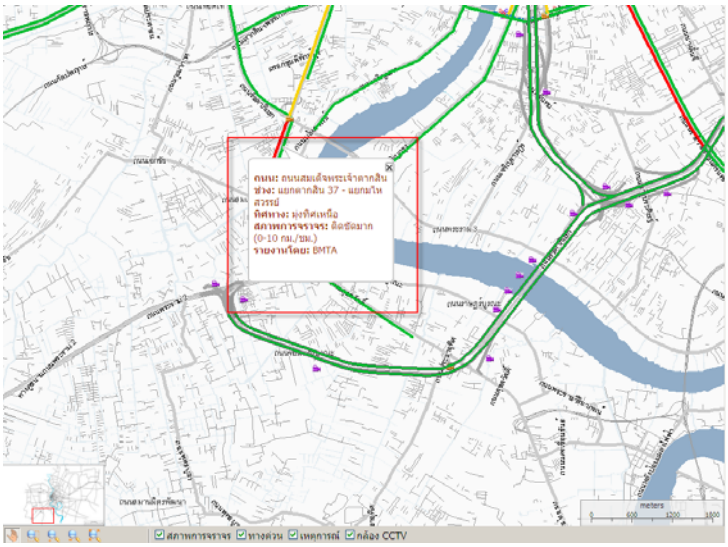


Figure 30 Traffic Speed Information along Bus Route
in a form on Color Strips on Maps Display

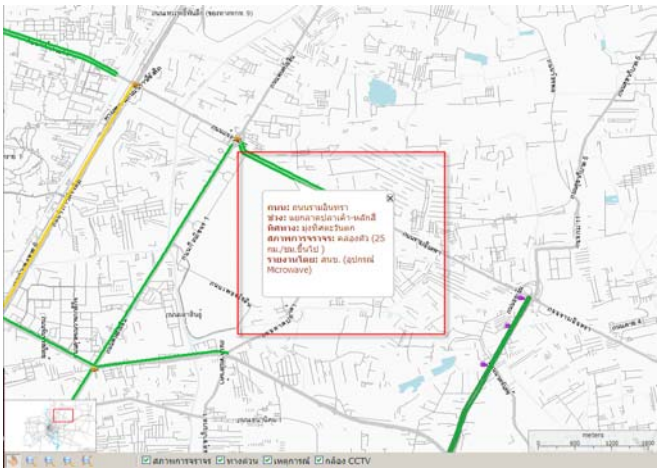


Figure 31 Display of the Traffic Condition Information
from the Traffic Monitoring System of the OTP in a form of Color Strips

Image at the moment of testing	Image after the moment of testing
	

Figure 32 Display of Traffic Condition Information Linked from the CCTV
Additionally Installed on Highways System of the OTP in a form of Still Image

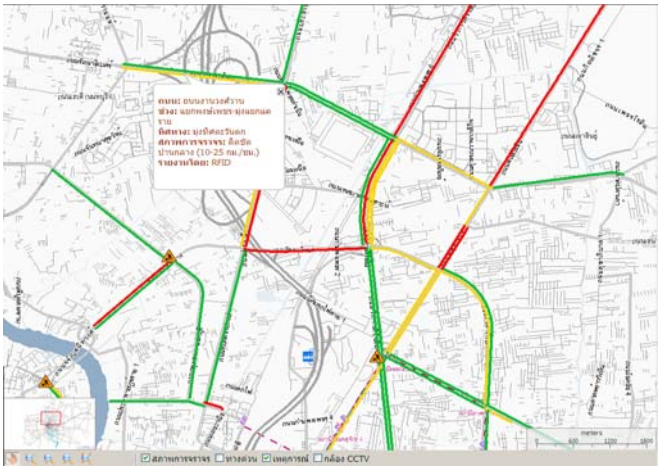


Figure 33 Display of Traffic Condition Information Linked
from RFID Sources in a form of Color Strips on Maps

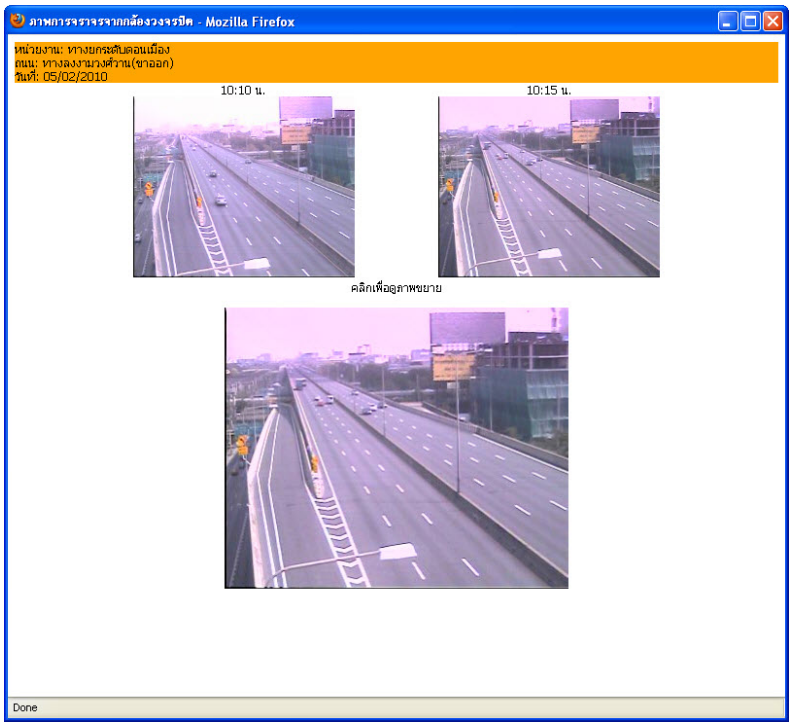


Figure 34 Display of Traffic Condition Linked from
the CCTV System of the Don-Muang Tollway in a form Still Image

11.2 Summary of System Testing

In the development of the integrated ITS traffic and transport information of the OTP in the second phase of this project, the consultant has continuously developed in the data linkage systems from different agencies, the installation of the CCTVs on southern and western highway corridors, and the data acquisition from different traffic data sources to feed into the developed system as well as the development of the information dissemination system via web and mobile phone services.

In order to efficiently operate the developed system, the consultant has tested the performance of the system and related devices to identify and rectify any shortcomings to meet the satisfied outcomes. The test includes: 1) devices used data linkage system, which are examined in the office before the actual installation at different agencies, 2) signal testing for the communication system, 3) the development of the application software for data linkage, 4) the testing of the data processing and analyzing system during the course of the project by simulating information streams to examine the system accuracy, and finally 5) the testing of the entire system from the initial to ending phases to ensure the correct system performance.

In summary, all systems developed in the second phase of this project are efficiently functioning with good integration among subsystems and procedures. No mistakes and/errors have been found. The system can function with stability. Data linkage and data processing units can accurately performance as designed algorithms. Therefore, the OTP, other agencies, and the general public can confidently use the developed system for route planning.

12. Public Announcement of the Operation of the ITS Data Integration Center

It is necessary for the operation of the ITS data integration center to have public announcement in various forms of media so that the center will be known to public. This can result in higher number of users and also frequencies of using the service. Public announcements in this project consist of several activities such as:

1) The official opening ceremony of the ITS data integration center

Figure 35 Decoration at the Opening Ceremony of the Center

Figure 36 The Opening Ceremony of the Center on September 10, 2009

2) Media preparation for the public announcement

- Prepare video clips for the public announcement of the website of the real-time traffic condition reporting system (**Figure 37**).

Figure 37 Still Image of the Video Clips for the Public Announcement of the Website

- Prepare pocket-sized cards for the public announcement of the website of the real-time traffic condition reporting system (**Figure 38**).

Figure 38 Pocket-Sized Cards for the Public Announcement of the Website

- Prepare pocket-sized calendars of the year 2010 (**Figure 39**).

Figure 39 Pocket-Sized Calendar of the Year 2010

3) The public announcement of the real-time traffic condition reporting system on advertisement boards which the consultant rented for this purpose at two locations: 1) Ngamwongwan Inbound expressway, and 2) Sukhumvit 63 road. The boards will be in display from December 1, 2009 till January 1, 2010: 2 months period as shown in **Figure 40**.

Ngamwongwan Inbound expressway

Sukhumvit 63 road

Figure 40 Advertisement Boards of the Real-Time Traffic Condition Reporting System

13. Conclusions and Recommendations

13.1 Conclusions

The implementations of the second phase of the project can be summarized as follows:

1) The ITS data integration center of the OTP should be established in a form of the matching fund under the management and direction of the committee whose members of which come from different agencies in order that cooperation among relevant agencies can effectively be promoted. This can also help protect abuse of the matching fund. At the initiation, expenses of the fund can be obtained from the federal subsidy (this includes an application for subsidy from other funds in the ministry of transport). However, in the long-run, revenues from operations of the business units from TIER 1 till TIER 4, particularly TIERs 3 and 4, will be adequate to finance the fund with the minimum dependence of the federal spending.

2) In the seconds phase of the project, the consultant has established the data linkages and developed the information dissemination systems via a website as follows:

- Traffic monitoring system of the Bureau of Traffic Safety, the DOH
- CCTV system of the EXAT
- Bus tracking system and real-time information dissemination system of the BMTA
- CCTV system additionally installed at major inbound-outbound highways of Bangkok of OTP
- RFID traffic data sources provided in the project, and
- CCTV system of the Don Muang Tollway

With the completion of the development of the data linkage systems from different agencies and the development of the information dissemination system via a website in the second phase of the project, the ITS data integration system of the OTP is equipped with more transport and traffic data and general public can gain more benefits from utilizing those data as well.

3) The consultant has enhanced and developed the information dissemination system via mobile phones in both quantity and quality aspects of information dissemination: 1) Still images from CCTVs, 2) maps with roadway networks in graphic modes, and 3) Maps with color strips representing traffic congestion levels. This also includes the subscription service, which will help users become familiar with the service by selecting and/or recording traffic routes that are commonly used to track traffic conditions.

13.2 Recommendations

To completely develop the information dissemination system of the ITS in future, the consultant recommends the followings for operations:

1) For the real-time traffic reporting system, the key component of the future system should be able to collect more information and has wider roadway network coverage. This traffic information should be obtained from traffic detectors such as traffic flows and speeds. This type of information is more relevant than images obtained from CCTV systems because not only it can be distributed to general public for reporting traffic condition, but also can be used for traffic and transportation planning.

2) In addition to collecting and developing the ITS data integration system in form of traffic condition reporting, future operations of the system should emphasize on gathering and developing the related system for public transportation in Bangkok and the surrounding areas as well. The future system should integrate public transportation to cover multi-modal transportation such as bus, mass transit, ferry, and public van. This will promote ridership of public transport and will on the other hand help alleviate traffic congestion.

3) An important piece of information for route planning such as road construction and maintenance timelines of roads on provincial highways and expressways should be incorporated to the system. The developed system in future should allow agencies to key-in construction site information under responsibilities and an access to database should be designed based on authority levels. The system will automatically update this information at the OTP center via internet to process and disseminate to general public later on.