THE ADVANCED TRAFFIC MANAGEMENT AND CONTROL SYSTEM FOR THE SECOND NATIONAL FREEWAY IN TAIWAN

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abstract: The first freeway traffic control system in Taiwan area was established in 1984, six years after the Sun Yat-sen National Freeway was open to traffic. A more advanced traffic management and control system, capable of performing all the features of traffic surveillance, traffic management, traffic control and motorist information, can be achieved in the Second National Freeway in northern Taiwan which is partially operating now.
The said system aims to effectively balance traffic volume of the northern freeway network, and to monitor traffic flow conditions of all freeway tunnels so as to maintain smooth traffic and high-level traffic safety. The entire system is scheduled for full operation in early 1996.

1. INTRODUCTION

Surrounded by sea, Taiwan is but an island 100-strong kilometers in width, 400-strong kilometers in length, and the Central Mountains run lengthwise through it. Because long-distance transportation like railroad and airway can not meet all passengers' needs, the main transportation system on the island is highway. Since the Sun Yat-sen National Freeway was open to traffic in 1978, it has produced a marked effect on mass rapid transportation. This gives roadway transportation a brand-new style and has significantly contributed to local economic development.

However, as the living standard gets higher so does the call for rapid growth of long-distance transportation. The traffic performance of the Sun Yat-sen National Freeway and three main provincial highways located in western Taiwan is close to saturation. In order to solve the problem of insufficient traffic capacity in the west corridor, the government made a strategic decision to construct the Second National Freeway (as shown in Figure 1). Its ground-breaking took place in 1985, and the construction of the affiliated traffic control system followed.

2. REVIEW OF THE CENTRAL TRAFFIC CONTROL SYSTEM OF SUN YAT-SEN NATIONAL FREEWAY

2.1 Background

The planning and design of the pioneer project, the Central Traffic Control System of Sun Yat-sen National Freeway Keelung-Yangmei section (as shown in Figure 2), began in

March 1980. The system was established in 1984, six years after the Freeway was open to traffic.

With the central system in place, It brings a new epoch of computerization and automation to the freeway traffic management of Taiwan. This central traffic control system is an "on-line real-time" integrated operation system, using computerized automatic equipment to monitor traffic conditions in order to achieve the goals set for traffic safety and to strengthen freeway functions.

2.2 System Effects

It has been more than ten years since the completion and commencement for operation of the traffic control system. Under the high attention of the authorities, the effects produced by traffic management and control system include:

(1) minimizing traffic accidents, injuries, and fatalities;
(2) elevating the service of highway police and patrol car;
(3) alleviating the traffic delay caused by traffic accidents;
(4) shortening the traffic delay caused by maintenance works;
(5) reducing the congestion of traffic flow and upgrading efficiency of rescue;
(6) diminishing the cost of vehicle's repairs and medical treatment;
(7) transferring technology, taking in latest high-tech, and cultivating the capability of domestic plan, design, and construction;
(8) urging highway towards safer and quicker so as to maintain transportation function and to advance economic development;
(9) adding the mobility of national defense.

2.3 System Weaknesses

Although its modern traffic management equipment has made great strides for Taiwan's highway traffic, since parts of the communication facilities are old or quantity insufficient, the traffic management system for the Sun Yat-sen National Freeway has some drawbacks.

A. Communication System on Cable Phone
(1) Switching system of cable phone is worn-out.
(2) Exclusive phone line is busy.
(3) Sound of extension is not good.
(4) Test of emergency phone is read by human labor.
(5) Switch of spare line is operated by human labor.

B. Communication System on Wireless Phone
(1) Switching system of wireless phone is worn-out.
(2) Channels of wireless phone are few, and too busy when accident happens.
(3) It is difficult to delete the dead angle of wireless phone communication.
(4) Man-power of maintenance is few and dispersed, so it is not easy to arrange support.

C. Traffic Control System
(1) Quantity of roadside traffic detection facilities is insufficient.

(2) Changeable message signs are without the function of local operation.
(3) Computer and communication system, toll and weighing stations both are not operated on-line.

3. THE SECOND NATIONAL FREEWAY PROJECT AND THE AFFILIATED TRAFFIC MANAGEMENT AND CONTROL SYSTEM

3.1 Background

The Second National Freeway in northern Taiwan diverges from Hsichih system interchange of the Sun Yat-sen National Freeway and connects with it again at Hsinchu system interchange. The mainline is 90 kilometers in length, including a 6-kilometer "Taipei Connecting Road" which links Taipei downtown area and a "Second Inner Circuit", approximately 12 kilometers in length, which connects the CKS International Airport. The new traffic management and control system covers the entire line of the Second National Freeway and integrates the existing traffic control system of the Sun Yat-sen National Freeway Keelung-Yangmei Section. With its construction in place, a freeway traffic management and control system network in northern Taiwan is taking shape (as shown in Figure 2) and the standard of traffic management and services advances, too.

The planning of this system was conducted from December 1986 to July 1987. The system contains facilities of general roadside detection, display, control and rescue. It also upgrades the Taishan Traffic Control Center in Keelung-Yanmei section to cover traffic surveillance and control operation of the entire network in the northern freeway. In addition, Tunnel Control Center is set up in Mucha, which is in charge of the traffic surveillance and control between Hsintaiwu interchange to Chungho interchange of the Second National Freeway and Taipei Connecting Road, to maintain driving safety in the tunnel areas. Mucha Tunnel Control Center is also connected with Taishan Traffic Control Center and supervised by the latter. This large-scale system costs more than US$50 million. In August 1993, a portion of the facilities was ready for operation along with the opening of finished roadway in Chungho-Hsinchu Section. The remainder is expected to be completed in the beginning of 1996.

3.2 Purposes of Establishing the System

A. Alleviating serious congestion problem
Detecting facilities are installed along the freeway to grasp quickly any abnormal traffic conditions in traffic flow. Traffic information is provided to motorists by changeable message signs and broadcasting equipment to advise them diverting to other roads.

B. Expediting traffic accidents management
In order to minimize injuries and fatalities and restore traffic as soon as possible, the detecting system and roadside emergency phones make it possible to notify immediately by hot line and to respond quickly to traffic accidents.

C. Providing traffic information to motorists

Through the changeable signs and broadcasting equipment, the system can provide timely information obtained from the automated detectors along the line for road user's reference and to safeguard driving safety.

D. Solving motorists' contingent difficulties
The system provides motorists with roadside emergency phones to transmit messages and to solve their travelling difficulties.

3.3 Principles of the System Implementation

A. Introducing latest high-tech products
Each equipment is the latest high-tech product. The fiber opticals which are being devotedly developed are used on the trunk lines of transmission in this project.

B. Using as many domestic products as possible
In order to nurture capability of domestic manufacturers, products or equipment that can be produced domestically must be bought locally.

C. Conducting technology transfer
Foreign manufacturers are required to offer joint bids with qualified domestic electronics manufacturers and to engage domestic high-tech talents to participate in the project. Moreover, the international seminar on traffic control technology is held for technology transfer.

D. Coordinating with the integrated telecommunication development
After the project construction started, at the request of the Directorate General of Telecommunications, long-distance fiber optical cables were laid to meet the needs of the expansion of telecommunications.

3.4 Functions of the System

A. It can effectively balance the traffic flow in northern freeway network.
B. It can provide traffic information, assistance, and rescue to road users.
C. It can effectively manage the traffic conditions to maintain smooth traffic throughput and high-level traffic safety.
D. It can automatically collect, process, and analyze traffic data of the northern freeway in a continuous manner for freeway authorities to make proper traffic management decisions.

Major traffic management and control measures of the system are: (1) mainline closure; (2) mainline lane-use control; (3) mainline speed-limit control; (4) mainline traffic diversion; (5) on-ramp metering control; (6) off-ramp roadway signal interconnection; (7) ramp closure; (8) tunnel lane-use control; and (9) tunnel closure. The following incident types can be well-handled by the system: (1) traffic congestion; (2) traffic accidents; (3) fire disasters; (4) land-sliding; (5) vehicle broken down; (6) scattered objects; (7) roadway maintenance works; and (8) heavy wind, fog, or rain.

3.5 System Configuration and Major Facilities

The traffic management and control system of the Second National Freeway and the Sun Yat-sen National Freeway, including data collection and information display equipment, central processing equipment in control center, and transmission and communications equipment, etc., are shown as Figure 3. Major facilities of the system is shown in Figure 4.

3.6 Features of the System Operation

A. The Enhanced Traffic Management and Safety Control in Freeway Tunnels
There are total 23 tunnels within the 15-kilometer section from Hsichih to Chungho along the Second National Freeway. For this reason, tunnel traffic management plays an important role in traffic control system. Figure 5 presents safety facilities in freeway tunnels. The functions of this system in tunnel management are as follows.

(1) Autonomous extinction of fire disasters
This system can detect and indicate fires in tunnels, report to the control center, and automatically confine the closed circuit TV cameras to urge controllers to take countermeasures. Simultaneously, relevant changeable signs display the fire alarm, and interchanges are metering controlled or closed, so as to safeguard driving safety.

(2) Verification and response of traffic incidents
When traffic incidents happened in tunnels, road users can use emergency phone for direct communication with the control center, the controllers can take countermeasures in a timely manner. Through the computer's operation, relevant equipment automatically display traffic information to road users.

(3) Mitigation and dissipation of traffic congestion
Traffic congestion in tunnels can be verified either by vehicle detector or the emergency phone calls from road users or wireless phone calls from police patrol cars, and dissipated by the control of changeable message signs.

(4) Strict control of travel quality
Because the tunnel is a closed area, natural ventilation and traffic piston action can rid the tunnel of waste gas from vehicles, and various detectors operated by computer can do so as well.

B. Traffic Diversion and Guidance on Freeway Interchange Area
To set up bigger changeable message signs 800 meters before reaching the interchange as well as to build general signs to provide information for road users on choosing their way and to guide and manage traffic flow.

C. Implementation of Ramp Control on Congested Freeway Segments
Bringing freeway transportation into full play depends on the control of exit and entrance at interchanges. In order to achieve the goal, it is necessary to put ramp control in practice and to match the guidance of local traffic signals and changeable message signs.

D. Data Collection of Traffic Diversion on Freeway Interchanges

Traffic data obtained from headway/speed vehicle detectors, then calculated by and stored in computers, are utilized as the basis of management, analysis, and application.

E. Setup of Communication Network

T he constitution of communication network is decided by the location of local and central control equipment.

F. Upgrading of Automated Traffic Management Functions in Central Computer System

The computer program adopted in the traffic control network is a distributed dual-CPU computer network, an integrated one constituted by small- and medium-sized mainframes together with micro-computer work stations, and central controller of sub-systems.

4. IMPROVEMENTS ON TRAFFIC MANAGEMENT AND CONTROL SYSTEM OF THE SECOND NATIONAL FREEWAY IN NORTHERN TAIWAN

- In respect of vehicle detectors, two inductive loops in each lane at intervals of 6 meters are installed to enhance accurate vehicle-speed measurement and vehicle classification..
- Supplementary landsliding detectors to monitor the slide of big-cut side-stratum are also in place to provide alarm in advance.
- On-ramp signal control is implemented to moderate the traffic flow entering the freeway and to maintain the service level of freeway mainline.
- Substitute solid state CCD for original tube type for CCTV elements, and SM OF for MM OF of Cable in base band video. Adopt graphic multiplexer to upgrade the using of channel, and proceed image processing and file management through the on-line operation of CCTV workstation and host traffic control computer.
- Substitute automatic tester of emergency phone for human-labor operated test.
- Substitute SM OF for FM OF of trunk cable in transmission and communication system, and dynamic network for prepared electric network of DS-1 human-labor switch so as to enhance the reliability of transmission and communication system.
- Adopt distributed dual-CPU computer network and accord with micro-computer and central controller of subsystem to constitute an integrated computer system network.

5. PROSPECTS OF THE FREEWAY TRAFFIC MANAGEMENT AND CONTROL SYSTEM IN TAIWAN

- The establishment of a highly efficient motorist information system.
- The investigation of feasibility of freeway automatic guidance system.
- The introduction of image processing technology to acquire diversified traffic attribute data.
- The step-by-step upgrading into the Intelligent Vehicle/Highway System.
- The integrated operation for both traffic control system and the tunnel electro-mechanical facilities.

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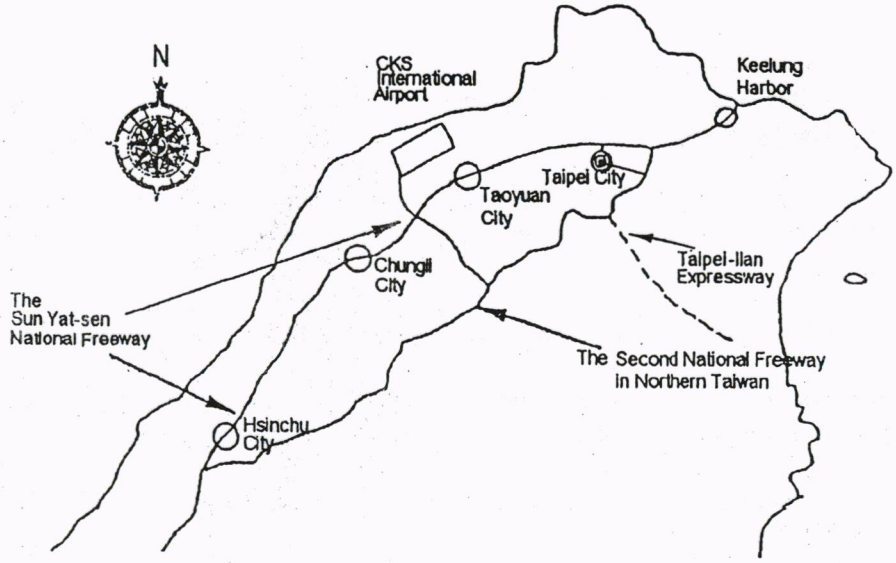

Figure 1 Map of Taiwan North Area Freeway Systems

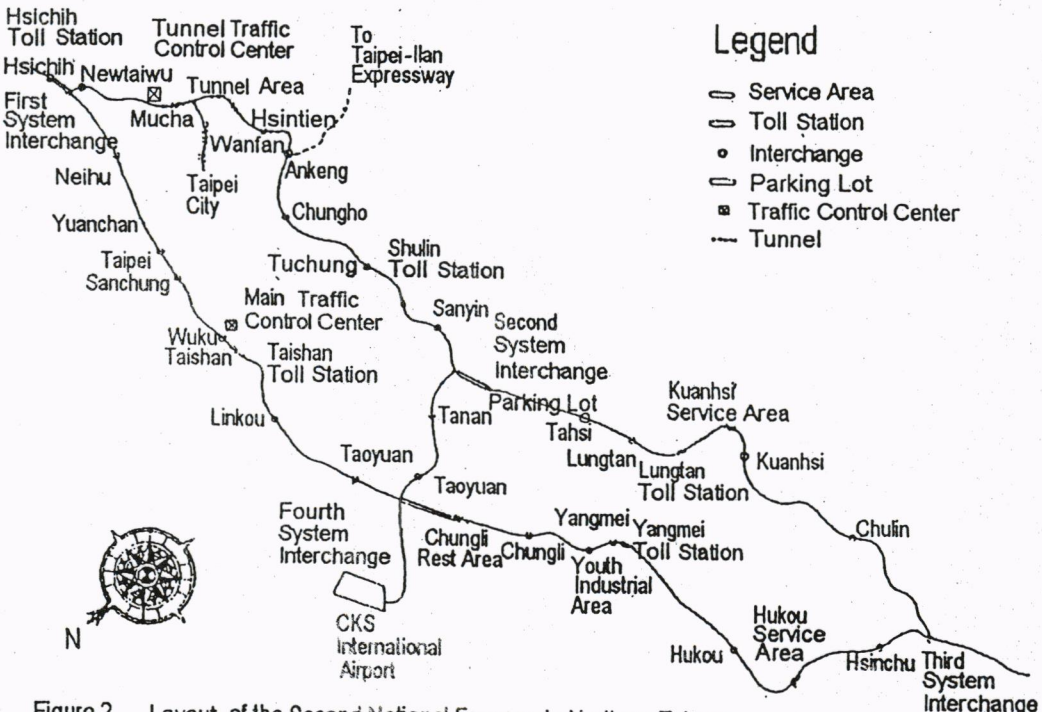

Figure 2 Layout of the Second National Freeway in Northern Taiwan

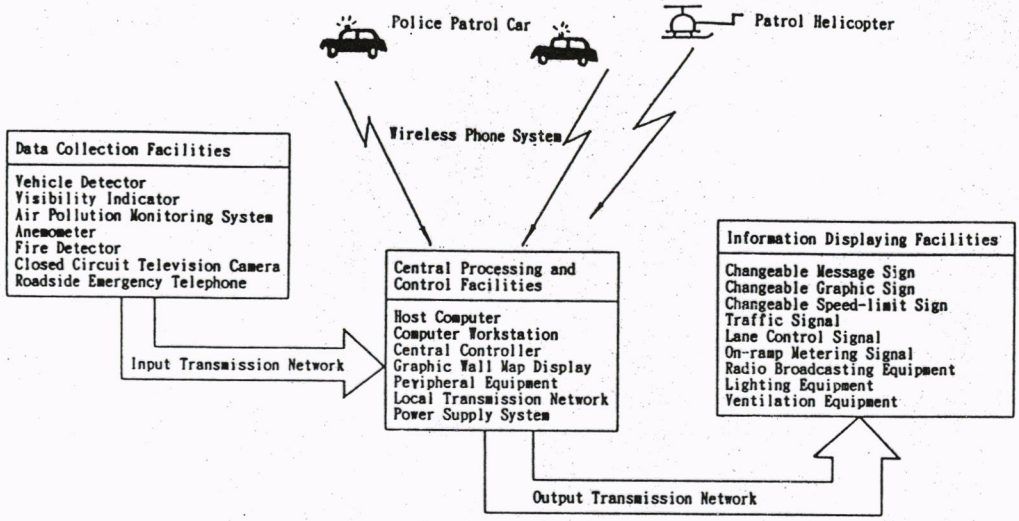

Figure 3 Traffic Surveillance and Control System Configuration

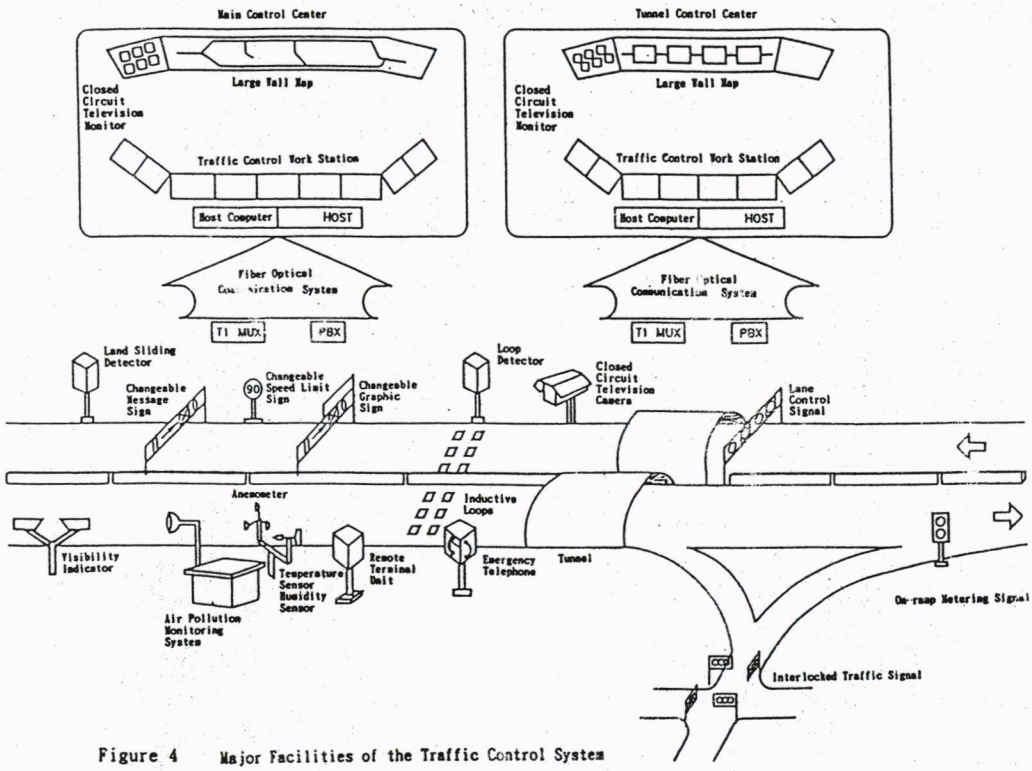

Figure 4 Major Facilities of the Traffic Control System

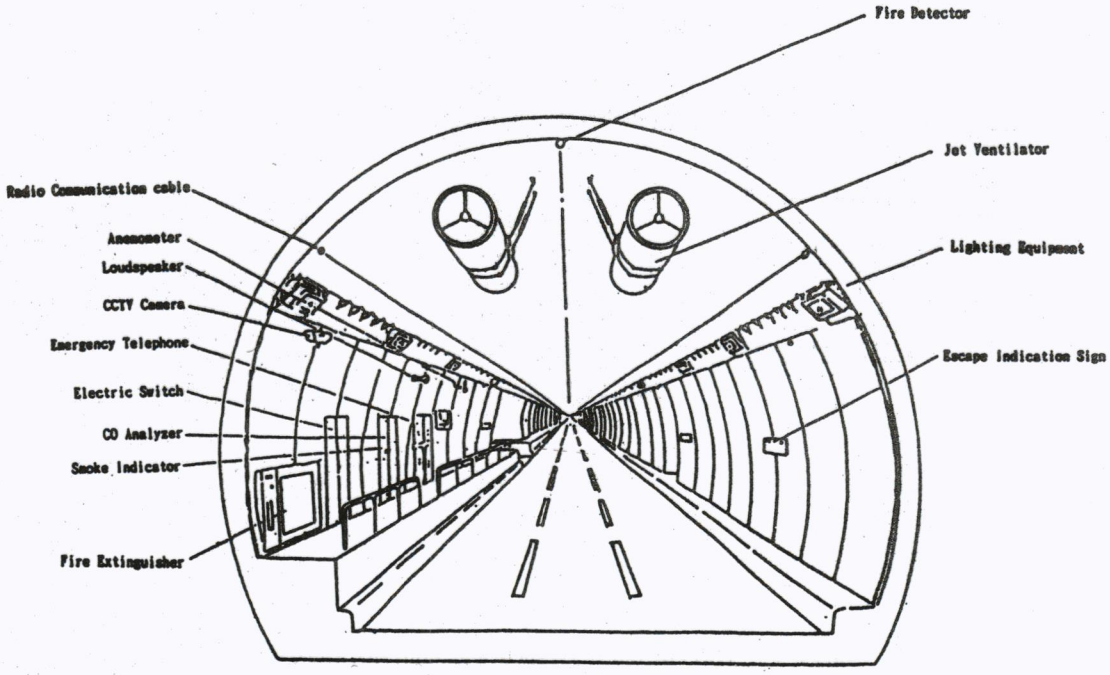

Figure 5 Safety Facilities in Tunnel