Deployment of A CVO Pilot Project for Specialized Trucks in Taiwan

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Abstract—High accident rate, overloading, speeding, illegal dumping, driving on restricted routes, and over-time driving are the critical issues in managing specialized trucks in Taiwan. The specialized trucks are used for hauling aggregate materials mainly for construction. The current management system is unable to perform real-time management, such as illegal driver behavior monitoring, dynamic dispatching and emergency support. In order to solve these problems, this project is in an attempt to improve the safety of the aggregate material transportation and its operation performance by means of real-time vehicle tracking, road information monitoring, and relevant application development. Moreover, tests of advanced equipments will be conducted to analyze the software and hardware requirements and system integration interface of intelligent transportation management system, as well as the feasibility of incorporating intelligent transportation system (ITS) into management system. The pilot project includes 150 on-board units equipped with GPS, GIS and communication devices, together with vehicle data recorders. There are totally 150 trucks from northern, central and southern regions of Taiwan in the 8-month pilot project and 60 of them go into the second phase, which is another ten-months operation period.

Index Terms—Commercial Vehicle Operation (CVO), Intelligent Transportation System (ITS), Global Positioning System (GPS), Real-time monitoring.

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I. INTRODUCTION

THIS trial project is one of the two-years action plan—"Taiwan ITS Development and System Architecture" sponsored by Ministry of Transportation and Communications. The purpose is to develop pilot CVO transportation management system combining with GPS, GIS and telecommunication technologies.

For high accident rate and frequent fatal accidents caused by aggregate material trucks, it is necessary to effectively manage this type of truck in order to decrease accidents. Meanwhile, the project aims to develop management system to assist carriers supervising their fleets.

In the project, it has in depth study of feasibility about employing related intelligent technologies. In addition, it proposes a deployment plan and builds a pilot system according to needs of carriers. It was expected that feedbacks from various players and system development experience can be an important reference for full scale implementation of ITS/CVO systems.

II. PROJECT SCOPE AND CONTENT

A. Project Scope

The project focuses on carriers shipping aggregate materials and sands. All carriers can be divided into three categories based on geographic characteristics, i.e., northern area (County Keelung, Taipei, Taoyuan, and Hsinchu), central area (County Taichung, Changhua, Yunlin), and southern area (County Chiayi, Tainan, Kaohsiung, and Pingtung). The implementation involves 50 trucks in each area and the number of total participated truck is 150.

To be more specific, the project includes scope of project includes following tasks :

1. Planning for system function and requirements.
2. Evaluation and test of applied technologies and products.
3. Proposing and execution of pilot project.
4. Implementation and operation test of pilot system.
5. Assessment of system performance and system function.
6. Drafting of regulation and related measurement.
7. Proposing a post-project for system operation and maintenance for following ten months. In addition, 20 vehicles in each area will continue to be in operation, based on function improvement obtained.

In addition, demonstration of pilot system and a proactive project will be included in the future.

III. REVIEW OF CURRENT MANAGEMENT

A. Existing industry

Aggregate transportation industry, in other words, is to ship sandstone and aggregate materials from suppliers to demanders. First of all, it is necessary for demanders (construction sites or pre-processed aggregate materials) to sign contracts with suppliers. Aggregate carriers are responsible for shipment, and it is charged by number of cubic of sandstone. Due to specific tank shape of trucks, those trucks are not capable for shipping common goods but aggregate materials; therefore, the industry

is significantly affected by prosperity of local construction business.

Aggregate material truck (AMT) can be divided into three types according to vehicle ownership. The first type is that vehicles are fully owned by carriers, and carriers hire drivers. In the situation, carriers have to be fully responsible for business. The second type is that carriers are partially possession of vehicles and some vehicles belong to drivers. The third type is that drivers are fully own vehicles but they are registered under carriers, and in this condition, drivers are responsible for all business. Basic attributes of the three types are summarized in TABLE 1.

TABLE 1. Three types of business of specialized trucks

TYPE I	Vehicles are fully owned by carriers, and carriers hire drivers; carriers have to be fully responsible for business.
TYPE II	Carriers are partially possession of vehicles and some vehicles belong to drivers.
TYPE III	Drivers are fully own vehicles but they are registered under carriers; drivers are responsible for all business.

B. Statistics of accidents and violations

According to number of accidents since 1994, the average number of fatal accident caused by AMTs is 180 persons per year. The number reaches historical high in 1994 and retained 70 to 80 in the following years. However, it had no significant change in number of accidents and number of injuries. The historical trends are illustrated in TABLE 2:

TABLE 2. Yearly number of accident occurred

	1994	1995	1996	1997	1998	1999	Average
No. of accident	189	145	131	222	245	146	179.7
No. of death	162	80	60	109	70	81	93.7
No. of injuries	127	99	53	85	96	74	89

Source: MOTC, 2nd Quarter, 1999.

Regarding the study of accidents caused by gravel trucks, the death rate was calculated by Tsai[1] as 2.10×10^{-6} person per kilometer that trucks travel. It is 15 times higher than freight vehicles, which is 1.41×10^{-7} . In addition, injury rate of gravel truck is 0.98×10^{-6} person per kilometer, and is 13 times higher than freight vehicles, which is 0.73×10^{-7} . It indicates that accident rate caused by gravel truck is much higher than that caused by freight vehicles. FIGURE 2 also provides factors resulting in accidents of gravel trucks.

C. Managing issues of gravel trucks

Several behaviors and operation environment that may cause difficulty in truck management have been observed as follows.

1) Improper working conditions for drivers:

- Unreasonable pricing mechanism: in Taiwan, the third type of carriers is in majority so that this type of drivers are responsible for finding business by their own. Drivers often work overtime and tend to have trucks overloaded in order

to gain extra profit.

- Avoidance of roadside inspection: since regulation of "Gravel Truck Safety Management" was effected in 1994, carriers were ticketed more frequently and felt great pressure. Therefore, some carriers took local highways to avoid inspection on national highways on which they normally use.
- Poor traffic conditions: for that duty of drivers have to accomplish certain trips of shipment every day, they have to work overtime when there are traffic congestion, and it may cause high accident rate.
- Negative social impression: although responsibility of accidents needs professional judgments, general public and media often blame drivers. Therefore, drivers usually have great pressure from the public and their professional image is suffered.

2) Long distance of shipment: the distribution of sandstone fields is primarily located in southern, central, and eastern region of Taiwan. It has only few located in northern region while this region has most of the demands. Sandstone has to be shipped from every other region into north. This generates more trips and the long distance shipment causes higher accident rate.

3) Difficulty of supervising: carrier manager lacks of proper equipment to have real-time monitoring of their fleets. Also, because drivers are not employees of carriers, carriers have loose control on drivers.

4) Difficulty of enforcement: in addition to high accident rate, gravel trucks might have problems such as overloading, speeding, and moving on restricted routes. Also, drivers tend to work overtime in order to ship more volumes. However, it is difficult to enforce these types of violation with existing enforcement manpower, equipments, and roadside inspection locations.

FIGURE 1 Assessing safety issues of specialized trucks[2]

IV. PILOT SYSTEM AND APPLICATION

A. System function

Primary function of the pilot system is as follow.

- 1) Gravel truck moving path monitoring and comparison.
- 2) Road traffic information collection and delivery.
- 3) Fleet monitoring and arrangement
- 4) Management of accidents and specific events.
- 5) Vehicle speed and route supervising.
- 6) Build of prototype of supervising system and dynamic inspection system.
- 7) Incident database construction and inquiry.
- 8) Statistics and analysis of monitoring data collected.

B. Management strategies and applied function

1) Shipment quantity control of sandstone of sandstone fields, screening/processing sites and construction sites. Once these vehicles have been weighted before leaving the origins, the weight information is delivered to control center or supervising authorization. It further studies the feasibility of one-time weight inspection for these trucks having non-stop shipments.

2) The pilot project of gravel trucks can be further applied to heavy transport vehicles in its route planning, real-time location monitoring of certain roads in metropolitans, and control measurements for heavy vehicle in metropolitans.

3) Apply monitoring function of pilot system to roadside inspection location planning, frequent abnormal conditions analysis and heavy vehicle moving path planning.

4) Through connection between enforcement authorization and fleet monitoring center, it is able to understand feasibility of transport route application. That is, by combining dynamic monitoring system, transport routes and shipping time of heavy vehicles in metropolitan area can be examined in advance, and the prohibition routes might be eliminated.

5) Management of overtime working, speeding, and overloading: by employing dynamic examining system of monitoring center and local enforcement authorities, driving hours information can be obtained from dynamic working to file. Roadside inspection can also avoid accidents caused by overtime working. Common speeding section can be monitored by dynamic inspection, and when combining with weight-in-motion, it is able to monitor overloading activity.

6) Extension of transportation fleet management system

- o Establishment of fleet maintenance system
- o Establishment of fleet supervising system
- o Establishment of employment management system
- o Establishment of operation management system
- o Other application (through carrier's participation of system construction)

7) Other management strategy: by obtaining feedback from local transportation agencies when continuously execution of the project, it is able to propose strategies for managing metropolitan traffic.

C. Preliminary system architecture planning

The main system planning principles for this project are

economical, easy to operate and easy to manage. In order to make the system practical, the main four components: the vehicle, the monitoring center, the carrier and the enforcement, must be analyzed. In designing system architecture, OBU and the monitoring center are the main roles while network structure is constructed to allow the enforcement and carriers to access vehicle data and relevant application services. In addition to hardware and software architecture of the system, the project also proposes practical management strategies. The overall system architecture's preliminary design is as FIGURE 3. There are four main components:

- 1) Specialized trucks credential administration.
- 2) Electronic map and specialized trucks operation real-time monitoring.
- 3) Driver management system and work performance analysis.
- 4) Enforcement management and analysis.

FIGURE 3 System Architecture Planning

D. Management Strategies Planning

1) Strategy 1: Speed Management

Speed management monitors trucks' speed from origin to destination, in order to prevent vehicles from speeding. The system mainly uses real-time feedback speed data to judge speeding violation. If any violation is found, warning sound is activated in the vehicle and violation is recorded in monitoring centers' database. The working process of speed management is as FIGURE 4.

FIGURE 4 Speed Management Working Process

2) Strategy 2: Route Management

Route Management monitors trucks' trajectory from

origin to destination, in order to prevent vehicles from running on prohibited routes that trucks are not allowed. Route management matches vehicles' real-time GPS position with restricted areas or routes in electronic map, to see if vehicles are running on prohibited routes or areas. The working process of route management is as FIGURE 5.

FIGURE 5 Route Management Working Process

3) Strategy 3: Loading Management

Loading inspection is based on vehicles' weighing data before leaving the origin. Loading information feeds back to the monitoring center for storage and allows further irregular inspection. During vehicle's trip, the enforcement can also use portable scale at system's focus roadside inspection points to inspect violating vehicles and overloading vehicles. Also, by data interchange through network connection, legal vehicles don't have to repeat weighing process during the same trip, in hope that shipping efficiency could be increased. The working process of loading management is as FIGURE 6.

FIGURE 6 Loading Management Working Process

4) Strategy 4: Incident Management

Incident management is intended to increase incident response efficiency. The system replaces passive after-incident notification with active incident occurrence feedback and incident evolution monitoring, in order to achieve response time saving and deaths reduction. The working process of incident management is as FIGURE 7.

FIGURE 7 Incident Management Working Process

V. SWOT ANALYSIS

Bases on system architecture of gravel truck transportation management, SWOT (Strengths, weaknesses, Opportunities, and Threats) analysis is conducted, from government agency's point of the view, to review current business environment of gravel transport.

A. Strengths

- 1) Law or regulation enforces carriers to install odometer on every vehicle.
- 2) Pressure from public enforces gravel transport industry to adjust its operation type.
- 3) Carriers have to cost down following the change of business environment.

B. Weaknesses

- 1) Shortage of a complete CVO architecture for government agency.
- 2) Part of existing equipment is not capable with ITS/CVO system architecture.
- 3) Only few private companies are experienced in CVO.

C. Opportunities

- 1) Computerization has become future trend both in public and private sectors, and it is able to enhance compete
- 2) By planning CVO management system architecture, government agency and carriers are able to enhance their administration efficiency.
- 3) ITS/CVO has become an international trend.

D. Threats

- 1) Some fundamental issues exist in gravel transport business.
- 2) Financial difficulty in purchasing hardware and software of management system.
- 3) Difficulty in assessing benefit by introducing system; therefore, carriers are short of motivation to participate.

VI. ROLE IDENTIFICATION

According to system architecture and management strategies of CVO, the transportation system has relationship with several stakeholders, including carriers, drivers, equipment suppliers, consultants, local government agencies, central government

agencies, and general public.

A. Carriers

If carriers want to introduce ITS technologies to improve their managing efficiency, they have to invest in both equipments and software. That includes on-board receiver, fleet management software, on-board computer, mobile communication device, office automation, electronic data interchange deployment, and other technologies. By deploying these equipments, it is in an attempt to enhance business efficiency and usage of roadside facilities.

B. Drivers

It is necessary to have drivers to participate in the project so that it is able to understand more about effectiveness of the pilot project. Also, their feedback will be reference for project implementation afterward.

C. Equipment suppliers

Development of ITS/CVO needs private sectors' participation in terms of providing hardware, software and consulting service. Furthermore, private sector needs to integrate all hardware to meet the needs of project. In addition, if manufactures can have new vehicles installed of related equipment, it also contributes future promotion of the system.

D. Consultants

Professional consultants are "assistants"; in other words, they are responsible for coordination of all participants. Also, one of their tasks is to arrange works of each agency and obtain feedbacks; furthermore, to be references for next stage of project.

E. Local government agency

The role of local government agency is to infuse money for ITS related researches and to re-engineer commercial vehicle operation processes, such as credential issuing, tax exemption, and safety inspection. The purpose is to meet governmental policy and standard.

F. Central government agencies

Central government agencies have to propose ITS/CVO system architecture and provide related technologies, management, and financial supports for developing the system. That includes EDI format and system establishment as well as CVO information network construction so that real-time information is able to be delivered to certain agencies such as enforcement agency, roadside inspection units, CVO database, and other roadside facilities.

It should be noted that all participants in this project are volunteers. Success role-playing of each member is a critical factor to the success of this project. In addition, the pilot project is in an attempt to obtain more information about user's needs for a large scale implementation.

VII. CONCLUSION

It has implemented installation of on-board units and monitoring center, and the first phase of pilot run has accomplished. It has been shown the application of GPS, GIS,

vehicle data recorders, and communication technologies to truck management is feasible. It was also shown that system performance of the first phase is acceptable. It is currently in the phase of system core module establishment. In this phase, a series of demonstrations of the pilot system along with system components presentation will be held. Carriers, government agencies, equipment suppliers, consultants, and system integrators will be jointed to contribute their know-how and capability of system integration in the national trial project. It is expected to encourage future development of intelligent CVO, and enhance operation and management efficiency of transportation industry.

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