FIELD EXPERIMENT WITH LOGISTICS MOBILE OPERATION CONTROL SYSTEMS USING EXISTING INFRASTRUCTURE

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1. Summary

Universal Traffic Management Society of Japan (UTMS) has constructed high-efficiency logistics systems (mobile operation control systems--MOCS) using infrared beacons (thirty-thousand beacons are planned to be installed by 2001) that the National Police Agency has been introducing to the infrastructure of the ITS system. This paper outlines a field experiment carried out in Tokyo using the present systems, and also describes the results of demonstration tests, expected effects, and future tasks.

2. Objectives

Great economic advantages and prevention of traffic congestion can be expected by efficiently controlling logistics using ITS, because the parking of unloading and other vehicles can be minimized. The National Police Agency plans to establish the ITS system for efficient logistics using the existing infrastructure (infrared beacons). UTMS is constructing efficient mobile operation control systems, MOCS, according to the plan of the Agency, and is demonstrating a guideline for the practical application of the systems by verifying and evaluating their functions through field experiments. In practice, the guideline will be used for arranging efficient MOCS and establishing operating plans at the prefectural UTMS promotion and steering committee.

3. Field experiment

3.1 Experimental system

The existing infrastructure (infrared beacons and U-type traffic information system) is utilized.
Fig. 1 shows the configuration of the experimental system and the general information flow chart.

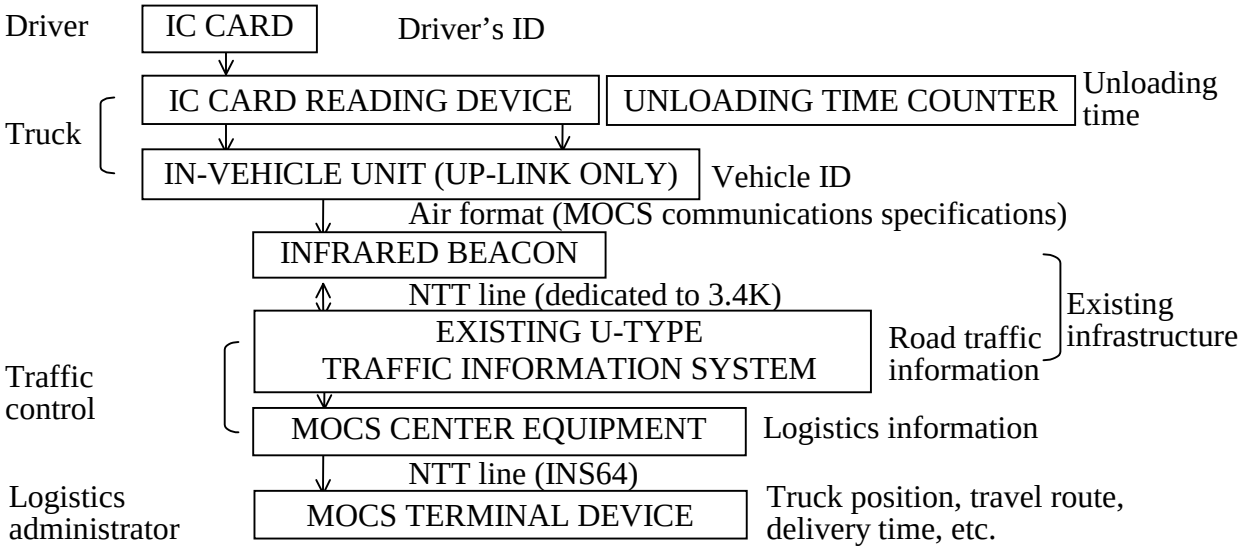

Fig. 1 Configuration of experimental system

3.2 Functions of MOCS

A logistics administrator can receive the following information from a display monitor at an MOCS terminal device installed at the office of the administrator.

(1) Current positions of vehicles
"Time," "vehicle name," and "driver's name" of a truck that was the last to pass the position of an infrared beacon on the map screen are displayed. This map screen also displays road traffic information including congestion information.

(2) Vehicle travel locus
The travel locus of an assigned vehicle or driver is displayed on the map screen.

(3) Time required to travel through an assigned section
The total time of all vehicles that have traveled through a section is assigned freely.

(4) Status of operation for each vehicle
Time required for one delivery job (defined by the time from departing to returning to delivery center).
(Delivery time) = (travel time) + (unloading time)
The delivery time can be controlled by the sum of travel time and unloading time.

(5) Road passing conditions
"Time," "vehicle name," and "driver's name" of a vehicle that has passed each infrared beacon on an assigned date. In addition, a logistics administrator can register a delivery destination mark on the map screen.

3.3 Details of experiment

(1) Experiment area
Three wards in Tokyo, that is, Adachi, Katsushika, and Edogawa.

(2) Periods of experiment
- March 8 ~ 19, 1999
- Planned in March 6 ~ 17, 2000

(3) Major items of experiment

For the experiment in 1999
- Verification of operating conditions of communications systems (from IC card to MOCS terminal device)
- Verification of accuracy for determining current position of a truck
- Verification of accuracy for tracing travel route of a truck

For the experiment in 2000
- Verification of accuracy of controlling delivery time
  (For this purpose, infrared beacons dedicated to checking and controlling delivery time are installed at the entrance and the exit of a delivery center, and an unloading time counter is mounted on a truck.)
- Verification of effective use of road traffic information such as congestion information, in logistics tasks
- Overall evaluation of MOCS systems by logistics administrators

3.4 Results of experiment

3.4.1 Results of field experiment in 1999

(1) Results of systems operation
The number of total up-links for 19 trucks operated during the period of the experiment (10 days) was 2,751. The number of infrared beacons in the experiment area was 185. Trucks passed infrared beacons at intervals of five minutes or less for 60% of all trips.

The systems were confirmed to have worked normally as data were communicated as expected through IC cards -> card reading devices -> in-vehicle units (up link only) -> infrared beacons -> U-type traffic information systems -> MOCS center equipment -> MOCS terminal devices.

(2) Accuracy in determining current locations of truck
The accuracy in determining the location of a truck immediately after passing an infrared beacon can be represented by the time delay between the time a truck passes the infrared beacon and the time the information is displayed in the MOCS terminal device of the logistics administrator.

- Time delay in transmitting information
  Three minutes on average (however, passing time is precise without a delay, because it is added at the U-type traffic information system).

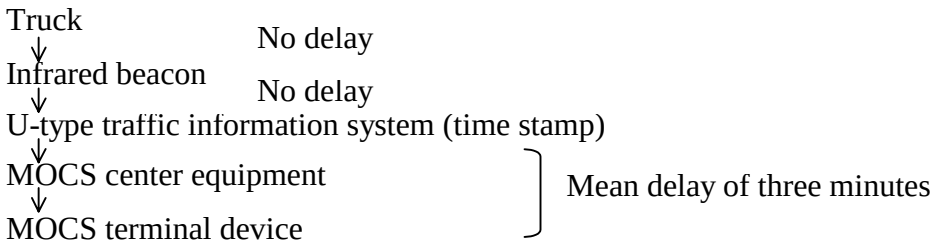

Fig. 2 Time delay in transmitting information

- Accuracy of time passing infrared beacon
  Information on a truck passing an infrared beacon is transmitted to MOCS terminal device with the time. The accuracy of this passing time was compared to the record memorized by the driver.

  According to a summary of total errors at each collection point, the errors were not more than ±1 minutes, so this result is excellent considering that drivers manually recorded memos after monitoring watches.

- Accuracy for time a truck passes an intermediate location between infrared beacons
  The time a truck passes an intermediate location between infrared beacons was estimated from the time the truck passed an infrared beacon, distance between the intermediate location and the beacon, and mean speed of the truck, and the accuracy was verified by comparing it to the record memorized by the driver when passing the intermediate location.

  Most errors between both data were not more than ±4 minutes, except for several locations where errors were six to eight minutes. This is because variations in speed of the truck during congestion, if any, were not considered since the mean speed was used to estimate the time for passing the intermediate location. Considering the circumstances, the result might be satisfactory.

(3) Accuracy of tracing travel routes of trucks
Travel routes were questionnaire surveyed by listening to drivers during the period of the experiment, and survey results were compared to travel locus data output from MOCS terminal devices as a verification of tracking travel routes. Vehicles subjected to the experiment included three types: 2t, 3t, and 4t trucks, and the travel loci differed by type.

The result will be reasonable because the present infrared beacons are installed only in trunk roads.

(4) Questionnaire survey to logistics administrators
- Evaluations from administrators were generally good with comments such that submitted information was valuable.
- Drivers strongly requested more compact in-vehicle units. The present system was only experimental, however, the units must be made smaller or built into dashboards for practical application.

Table 1 Infrared beacon passing intervals

INFRARED BEACON PASSING INTERVAL (MIN)	RATIO (%)
~ 5	60
6 ~ 20	15
21 ~ 60	12
61 ~ 120	9
121 ~	4

Table 2 Errors in measured infrared beacon passing times

ERROR	NUMBER OF SAMPLES	RATIO (%)	
Hand-written time two minutes or more earlier	5	2	
Hand-written time one minute earlier	50	20	
0 minutes	155	64	96
Hand-written time one minute later	30	12	
Hand-written time two minutes or more later	5	2	

Table 3 Tracking travel routes

TRUCK TYPE	TRACKING TRAVEL ROUTE	ROAD USED
4t vehicle	Possible	Mostly trunk road
3t vehicle	Possible to some extent	Trunk road and byroad equally used
2t vehicle	Impossible	Mostly byroad used

Fig. 3 Results of the field experiment in 1999

3.4.2 Results of the field experiment in 2000

(1) Results of systems operation

The number of total up links for 10 trucks operated during the period of the experiment was 2,557. The number of infrared beacons in the experiment area was 227 (except for infrared beacons installed at the entrance and the exit of a delivery center). 33 percent increased in the number of average up-links a day for 1 truck. This is the result of more installation of infrared beacons and it is expected that more infrared beacons are established.

(2) Accuracy of controlling delivery time

Time required for one delivery job (defined by the time from departing to returning to delivery center).

(Delivery time) = (travel time) + (unloading time)

- Delivery time is monitored precisely by installation at the entrance and the exit of a delivery center. But there is the exception that trucks didn't pass through infrared beacons area.

- Unloading time is more than 5 minutes and less than 4 hours and 17 minutes, and it is possible to measure at intervals of 1 minute. Though the problem will resolve if a driver controls different types of stop with easy operation, the present experiment is demonstrated on the assumption that a driver never controls any operation.

(3) Effective use of road traffic information such as congestion information, in logistics tasks
The information such as road congestion is displayed on a current position of a truck screen. An evaluation from administrators was that this function is very effective in mobile operation command.

(4) Total evaluation of the present experimental system
Total evaluation of the present experimental system was good according to the results of questionnaire survey to logistics administrators. Also some tasks to make experimental system practical were founded in the present field experiment.

Table 4 Number of average up-links a day for 1 truck

	NUMBER OF AVERAGE UP-LINKS (Rate of Increase)	NUMBER OF INFRARED BEACONS (Rate of Increase)
Experiment in 1999	18.9	185
Experiment in 2000	25.1 (1.33)	227 (1.23)

Table 5 Results of collection of delivery job data

Average time for one delivery	2 hours, 7 minutes and 30 seconds
Average time for one unloading	18 minutes and 54 seconds
Number of unloading times for one delivery	1~3 times

Fig. 4 Results of the field experiment in 2000

4. Effects expected

The present MOCS used the existing infrastructure including infrared beacons and the U-type traffic information system, so an ITS can be achieved at rather low cost. Therefore, even small or medium-sized trucking companies can easily introduce MOCS. In addition, the moving point of a truck can be monitored precisely using infrared beacons as communications media. In an urban area with skyscrapers and overhead roads densely constructed, GPS cannot work satisfactorily to determine the locations of vehicles because of large errors (one-street different, etc.) caused by the irregular reflection of electric waves. In addition, an infrared beacon stores a large amount of communication information, so by also inputting information on logistics such as cargo information into IC cards, the usefulness of the systems might be enhanced.

Even with the current layout of infrared beacons, the systems can be introduced to logistics administrators working mainly on trunk roads in the vicinity of the beacons, and the administrators can utilize various items of information supplied from MOCS terminal devices in real-time and statistical data, for the efficient planning of dispatching trucks and controlling business operations with reasonable profits.

5. Future tasks

In this ITS, the density of infrared beacons installed relates closely to the accuracy in various information details such as current locations and travel routes of trucks. Therefore, infrared beacons must be installed additionally as an indispensable task in the future. However, unlike bus MOCS, the travel routes of trucks are not fixed, therefore, infrared beacons cannot be dedicated only to logistics with trucks. Under such circumstances, the accuracy of the systems will be improved in proportion to increases in the number of infrared beacons installed and their density in the future.

The systems must also be modified in the future to cope with cases of trucks traveling through a number of prefectures or using highways.