ESTABLISHMENT OF HEROINE
Hanshin Expressway Real-time Observation-based & Integrated Network Evaluator

SAITA Koichi*, KURAUCHI Fumitaka**,
OKUSHIMA Masashi***, DAITO Takehiko****

* The second technological chief clerk
Hanshin Expressway Public Corporation, Dep. of Management, Traffic Control div.
Osaka Center Bldg. 1-3, 4-chome, Kyutaro-machi, Chuoh-ku, Osaka 541-0056, JAPAN
Phone: +81-6252-8121, FAX: +81-6252-7410, E-mail; daito@tss-lab.com

**Research Associate
Kyoto University, Dep. of Civil Eng.
Yoshida-Honmachi, Sakyo-ku, Kyoto 606-8501, JAPAN
Phone:+81-75-753-5126, FAX:+81-75-753-5907,
E-mail: kurauchi@urbanfac.kuciv.kyoto-u.ac.jp

*** The Japan Research Institute, Limited
10-19, MinamiSenba 3-chome, Chuo-ku, Osaka 542-0081, JAPAN
Phone: +81-6-6243-7870, Fax: +81-6-6243-7872, E-mail: okushima.masashi@jri.co.jp

****Managing Director
Transportation System Studies Laboratory Co., Ltd.
Dai-1 Suehiro Bldg. 1-20, Nishinakajima 7-chome, Yodogawa-ku, Osaka 532-0011, JAPAN
Phone: +81-6-6101-7001, FAX: +81-6-6101-7002, E-mail; daito@tss-lab.com

SUMMERY

Hanshin Expressway Corporation has started the upgrade construction of the new traffic control system in the autumn of 2001. In this paper, we present HEROINE, which is a traffic simulator, as one of topics of a new system.
First of all, we propose the concept of HEROINE that has multipurpose use for many users, and settle on the operation procedure and the system requirement. Secondly, we establish the system configuration and the subsystem that satisfies many requirements. HEROINE includes some subsystems, which are 1) Traffic Demand Estimation, 2) Flow, 3) Route choice behavior, 4) Traffic control and 5) Output and Store processing. After model establishment, we make validation and that we confirmed to be able almost to secure reproducibility of the model. Finally, we confirmed the prospect of practical use through the case study in some phases.

INTRODUCTION

The traffic control system was adopted on the Hanshin Expressway in 1969. Since then, the system has been continuously developed and expanded, until it is now recognized as one of the most advanced traffic control systems in the world. [1]

The upgrade construction was begun in the autumn of 2001 with some new faculty, based on the 1998-2001 research results which had to be achieved with a new system. [2] Especially, the expectation of HEROINE (Hanshin Expressway Real-time Observation based & Integrated Evaluator) is that a lot of users may use it for multipurpose, as one of the topics of the new system.

CONCEPT OF HEROINE

Purpose and User

The concept of HEROINE extends to a multipurpose use for many users.

The purpose is classified into 1) Short Term Traffic Forecast Information, 2) Real-time Traffic Forecast for Evaluating Alternative Measures, 3) Long Term Traffic Forecast and 4) Evaluating of Traffic Management Measures.

A user is defined as including a traffic control officer, maintenance group, planning group, which are a staff of the public corporation and the other driver.

Fig.1 shows the concept of HEROINE.

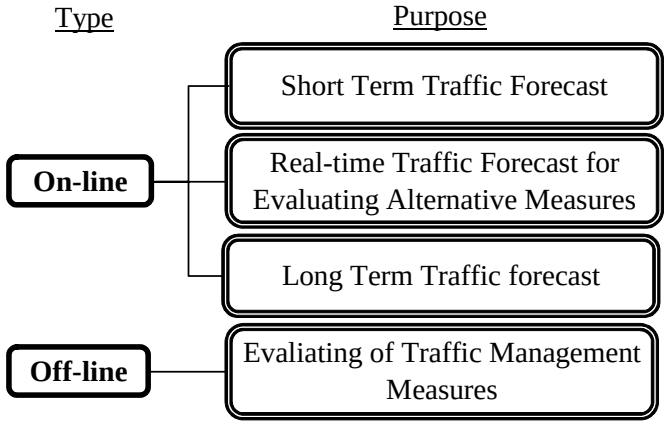

Fig. 1 The Concept of HEROINE

Requirement and Use Cases

The requirements of HEROINE user's is as follows.

First of all, the traffic control officer requires a short term traffic condition forecast and proposal of effective use of on-ramp control when congestion occurs and events in real time, which is for support to the traffic control mission. Also, for maintenance and other events, a real-time traffic forecast is required for alternative solutions.

The other group of the public corporation requires the evaluating of traffic managements of maintenance, traffic management, and planning. Also, to support the route choice and departure time choice when a mission is ongoing requires a short-term traffic forecast information.

The other driver requires short-term traffic forecast information for the route choice in En-Route, and a long-term traffic forecast for the travel planning.

The Operation Procedure and Output

HEROINE is operated as shown in Table 1.

Also, an output item of each operation type is as shown in Table 2.

Table 1 Operation Procedure of HEROINE

Type/Purpose	Operation Procedure	Calculation Timing	Forecast Period
On-line			
Short Term Traffic Forecast	Automatic Calculation	Every five minutes, At each event input	90 minutes under Forecast Period
Real-time Traffic Forecast for Evaluating Alternative Measures	Calculation based on user requirement	At each user requirement	90 minutes under Forecast Period
Long Term Traffic forecast	Automatic Calculation	Every one hour	24 hours under Forecast Period
Off-line			
Evaluating of Traffic Management Measures	Calculation based on user requirement	At each user requirement	As user requires (within 24 hours)

Table 2 Output Item

Type/Purpose	Output	Remarks
Short Term Traffic Forecast	Forecasted congestion chart	
	Proposing effective on-ramp control	
	Forecasted travel time	Between the main points and any required
	Route comparison forecasted travel time	for via route
Real-time Traffic Forecast for Evaluating Alternative Measures	Input screen for forecast condition	Input for traffic control and managements
	Forecasted congestion chart	
	Proposing effective on-ramp control	
Long Term Traffic forecast	Traffic forecast summary table	Amount of congestion, Travel time, and Speed, etc.
	Forecasted congestion chart	
	Forecasted travel time	Between the main points and any required
Evaluating of Traffic Management Measures	Input screen for forecast condition	Input for traffic control and managements
	Traffic forecast summary table	
	Forecasted congestion chart	
	Forecast traffic condition summary table	Amount of congestion, Travel time, and Speed, etc.
	Surface road traffic condition summary table	Traffic volume, Traveler kilometer, Travel time, and Speed, etc.
	Forecasted traffic condition	(download)

SYSTEM CONFIGURATION

Outline of HEROINE

To satisfy the requirements for HEROINE, the system is established as shown in Fig.2. The outline of the system is as follows.

- The classification: Meso-scopic simulation (It is based on a macro simulation model)
- The network: Hanshin Expressway and a surface road network
- The flow: the flow density method(In the Hanshin expressway), and the I/O method(surface road)
- The treatment of the vehicle: One per one is independent
- The traffic demand: The OD traffic volume between lamps is forecast based on on-ramp traffic volume each five minutes.

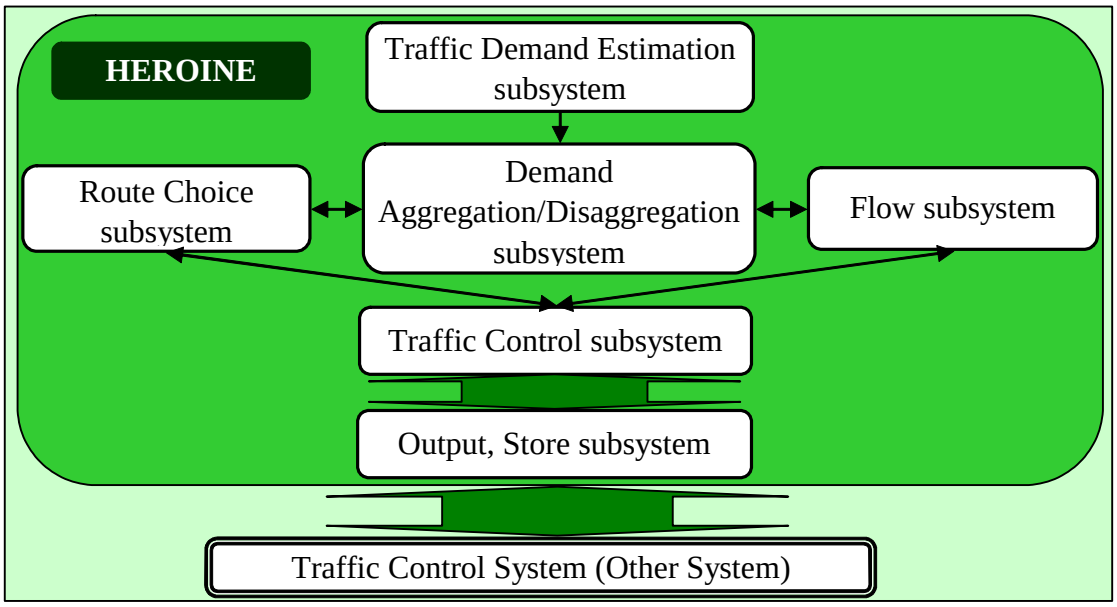

Fig.2 System configuration

Traffic Demand Estimation Subsystem

This subsystem, estimates the ON-OFF traffic volume according to time zone.
In the real-time forecast, the every 5 minutes on-ramp traffic volume of the after two hours are estimated by time series model, that prepares the method of using the neural network and the method based on the chaos theory, using the stored on-ramp traffic volume and 30 minutes ago immediately before. [3]
Next, the data is broken down into the ON-OFF traffic based on the priori OD pattern. Also, the planned data of each vehicle, which are, preferred route, departure time etc is generated.
In the long-term forecast, the ON-OFF traffic volume can be estimated within the 24 hour period.

Aggregation/Disaggregating Subsystem

In this subsystem, individual vehicle data is managed.
First of all, the planned route of each vehicle aggregates into the passing traffic for each time interval. Also, to apply to the Route Choice subsystem, break down the passing

traffic data by the flow forecast into an individual vehicle.

Flow Subsystem

The traffic flow is described by moving vehicles from upper to lower block with considering density of blocks per 10 sec. For example, inflow traffic volume, traffic condition (units in block, passed volume, velocity, occupancy, density, judge of congestion) of blocks, queue length at tollgate, several kinds of characteristics could be calculated and outputted.

Also, on the surface road network, the vehicle is moved based on the I/O method.

Route Choice Subsystem

By the driver's route choice model at the on-ramp, each vehicle's route is determined. So first of all, the probability of using a detour route to contain only surface load link is estimated by the route value (rate of congestion length, etc.), and a driver selects to use the expressway or not. Secondly, the probability of using a detour on-ramp is estimated by the route value (original ramp control or not, etc.), and a driver selects to use the original on-ramp or not. [4]

Traffic Control Subsystem

HEROINE enables the application of the on-ramp control, in which are included "On-Ramp Closure & Booth Restriction Control model" and "On-Ramp metering model (Linear Programming control method)". [5],[6]

The control is executed every five minutes. The subsystem is applied based on the traffic information every five minutes, and then the control is proposed, and executed. [2], [7]

VALIDATION OF THE FLOW MODEL

Process of Validation

The model is validated by assuming the on-ramp traffic volume to be input for an average weekday, through comparing reproducing the traffic condition with the actual traffic condition.

The process of this validation will start with predicting the traffic volume on subsections between each on-ramps and traffic condition on the expressway, using actual data of on-ramp traffic volume, to compare to the real traffic condition data that the traffic control system observed.

Base data:

- Expressway to be validated: All routes of Hanshin Expressway network (221Km on services in 1999)
- Date and time: 21st October 1999, from 7:00am to 10:00pm
- Inflow demand volume: Traffic volume at each 5 minutes, collected by vehicle detectors at all on-ramps
- OD pattern between each on-ramps: the 21st OD research on Hanshin Expressway network on 21st October 1999
- Actual traffic condition data: Actual traffic data, such as traffic condition at each subsection, traffic volume, congestion, travel time, by Hanshin Expressway Traffic Control System

Note: Model analysis and analysis of traffic control model, such as predicted on-ramp demand model, route-choice model are omitted.

Result of the Validation

The inflow volume, 6780,000 vehicles per 15 hours, came in from on-ramps. The simulation predicted the length of all congestion to be 383 km times hours. The actual congestion length that the traffic control system observed was 406 km times hours, regarding the difficulty of predicting congestions extended from other highways. As a result, both congestion section and time zones, and the drawer situations almost adjusted to the actual value.

Figure 3 compares the simulated value by HEROINE to actual value observed by the traffic control system. Generally we evaluate the simulation as good in terms of congestion tendency, such as increase and decrease, and features of each time period. Figure 4 compares the result of each line's simulation. The result well simulated the actual traffic value, except a few points where congestions take place for some unique situation which we will have to improve.

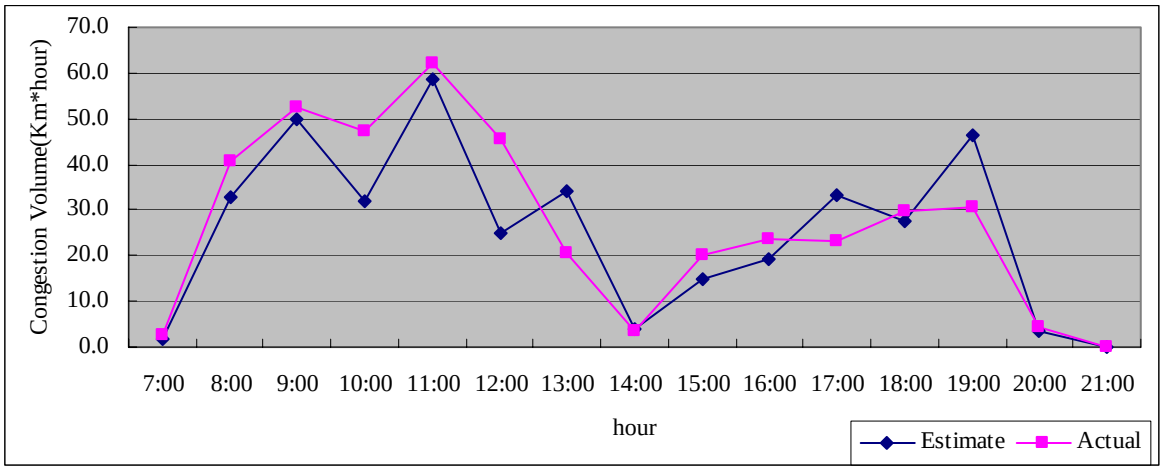

Fig.3 Traffic Congestion Volume each Hour

CASE STUDY; EVALUATION OF TRAFFIC INFORMATION AND TRAFFIC CONTROL

Process of Case study

As a case study of HEROINE, we try to make an evaluation forecast of the effect of the offer of traffic information and the traffic control. Output the basic data as shown in the above, and do the following forecast of three cases.

- Case 1：Estimation under potential of inflow demand
- Case 2：Traffic Information Offer (Not Control)
- Case 3：Traffic Control(On-Ramp Closure& Booth Restriction Control)

Here, Case 0: As for the current state estimation, the inflow traffic as the results value becomes input data. This input data is "Inflow traffic as the result of offering traffic information and selecting the route", and not "Inflow demand traffic.

So, the probability of route choice in the on-ramp is calculated from the road traffic condition in the estimation result of the current state, and estimate the traffic demand volume which is the on-ramp traffic volume "It is sure to do" rebated to an original amount of demand.

In case 1, forecasts that is assumed with all these traffic flows in. That is, the forecast result of Case1 is a traffic condition for which there is no traffic information. And, we compare it with case 2 and 3.

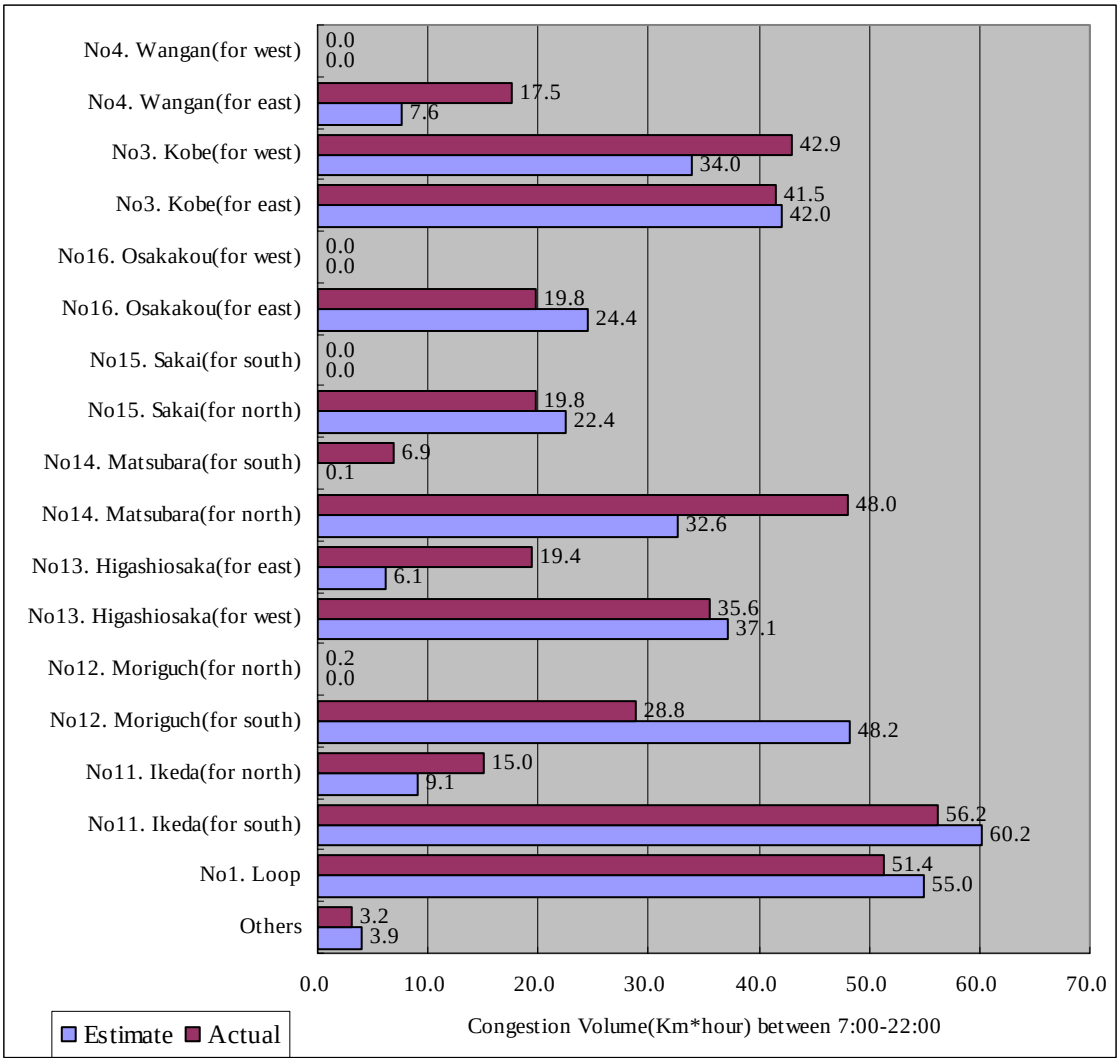

Fig.4 Traffic Congestion Volume each Route

An effect of traffic information offer and on-ramp control

First of all, the number of the inflow is at least the reproduction result of the current state, and has increased in order of case 1, case 2, and case 3. The purpose of this result reason is for the detour traffic to the surface road to do the recovery use, because the congestion decreased by the traffic information and the on-ramp control.

The effect of the traffic information offer is an amount of congestion: 31% decrease, a total travel time: 6% decrease and the average travel speed had a 7% recovery.

The effect of the on-ramp control is in amount of congestion: 57% decrease, a total travel time: 19% decrease and the average travel speed increased by 23%, which is an extremely big effect.

Table3 Evaluation of Traffic Condition on Expressway

	Estimation under potential of inflow demand	Traffic Information Offer (Not Control)	Traffic Control (On-Ramp Closure & Booth Restriction Control)	Current Estimation
Inflow traffic volume (vehicles)	680,625 (1.000)	681,786 (1.002)	683,756 (1.005)	678,108
Congestion Volume (Km*hour)	484.6 (1.000)	336.5 (0.694)	207.2 (0.428)	382.7
Total Travel Time (hour)	204,808 (1.000)	192,991 (0.942)	164,954 (0.805)	201,613
Average Speed (Km/hour)	51.3 (1.000)	54.7 (1.066)	63.2 (1.232)	52.1

Between 7:00-22:00

TOWARDS THE GROWTH OF A USEFUL SYSTEM

In this paper, we introduced the outline of HEROINE, which the traffic simulation will be newly established at the next traffic control system of Hanshin Expressway, and described the model's validation and application.
It is difficult for us in the space restriction to introduce a detailed examination result concerning the model analysis and a detailed system design. However, it is shown to be able to expect to supply to practical use through the function and operation as the outline, and the introduction of the validation result.
We are expecting HEROINE to continue to grow and improve into a useful system which will generate numerous case studies both off-line and on-line and also improve the predictive accuracy in online use through implementation.

REFERENCES

[1] http://www.hepc.go.jp/ (http://210.155.83.178/english/index.html) 02/07/01
[2] “Reports of Research & Study Committee about Traffic Control System on Hanshin Expressway”, from 1999 to 2002. (in Japanese)
[3] “A Study of Estimating On-Ramp Traffic Volume of Time Series Method Using Neural Network on Urban Expressway”, T. Okubo, T. Tsuchida, T. Daito. M. Okushima, T.Akiyama, “Proceedings of the Annual Conference of Civil Engineering and Planning Research in June 2002”
[4] “Evaluation of traffic control measures, in urban expressway network, based on route choice behavior analysis”, A.Takano, N.Uno, Y.Iida, T.Naganuma, “Proceedings of Japan Society of Traffic Engineers,” 21, pp329-332, 2001. (in Japanese)
[5] “Reports of Research & Study Committee about Measure for Reducing Traffic Congestion on Hanshin Expressway”, 1981. (in Japanese)
[6] “Evaluation of Ramp Metering Control Measures in Urban Expressway Network.” K.Takei, T.Yukimoto, M.Okushima, T.Daito, “Proceedings of Japan Society of Traffic Engineers”, 21, pp233-236, 2001. (in Japanese)
[7] “Evaluation of On Ramp Metering on Hanshin Expressway Using Traffic Simulator(HEROINE)”, T.Yukimoto, M.Okushima, N.Uno, T.Daito, 9th ITS World Congress 2002.