

## Traffic Simulation for Predicting Traffic Situations at Expo 2005

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### Abstract

We predicted the traffic situations for Expo 2005, held in Aichi, Japan, and evaluated the plan of measures, such as traffic restrictions, by using a traffic simulator NETSTREAM which we developed. This was done in response to a request from the Aichi Prefectural Police to evaluate their plans, given that we had had prior success with predicting traffic situations.

We predicted heavy traffic jams on the Chikaraishi-Nagoya Line which is a major road between Nagoya and the venues. In this paper, we describe our evaluation of possible traffic detour controls that could have been used to avoid this congestion. In addition, to maintain smooth-running transportation links for both

buses and commuters, we also evaluated the use of exclusive bus lanes on the Nagoya-Seto Expressway which is the main expressway link from the Tomei Expressway.

Based on these predictions and evaluations, we confirmed that the traffic jam information, the exclusive bus lanes (used only on weekend mornings), the prohibition of private cars within 3 km of the Expo venues, and the use of Park & Ride schemes were indispensable for reducing traffic jams around the venues and on the main roads. During the Expo, thanks to the application of these measures, there were few traffic jams and all transportation links ran smoothly.

Keywords

Prediction, Traffic jam, Traffic simulation, Traffic simulator, Traffic situation, Traffic-related measure, Expo 2005, OD flow

## 1. Introduction

Recently, in order to reduce traffic jams and help to keep transportation links running smoothly, the introduction of ITS systems and the application of measures for improving the flow of traffic are rationally performed. We have developed a traffic simulator for predicting the effect of ITS systems and traffic-related measures and have actually applied the simulator to several practical predictions.

Expo 2005 was held from May to September 2005 in Aichi, Japan. It was feared that serious traffic jams would occur around the main venues and on the main roads during the Expo, because about 15 million visitors from all around the world were expected. The Aichi Prefectural Police believed that it would be necessary to plan and implement traffic measures and traffic restrictions not based on experience and intuition as in the past, but by adopting a more rational method. Therefore, they asked us to evaluate their planned measures and restrictions, given our previous successes in predicting traffic situations.

In the present study, we predicted the traffic situations for the Expo beforehand, and evaluated the plan of the traffic-related measures and the traffic restrictions (these predictions were undertaken in 2003). For the evaluation, we used the traffic simulator NETSTREAM (NETwork Simulator for TRaffic Efficiency And Mobility)<sup>1)</sup> which was originally developed by us. This paper first outlines NETSTREAM. We then go on to

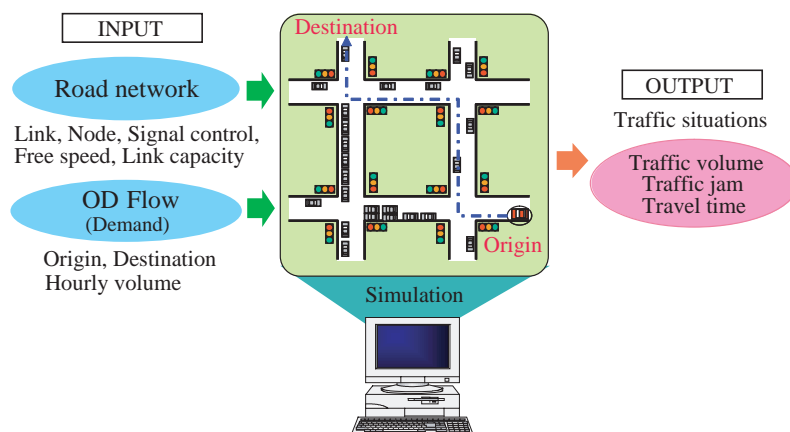
briefly explain the prediction methods that we used. Some example measures are predicted and evaluated, and then the results of applying traffic measures to actual situations are shown. Finally, we show the actual traffic situations during the Expo, and compare them with the results of our simulations.

## 2. Outline of NETSTREAM

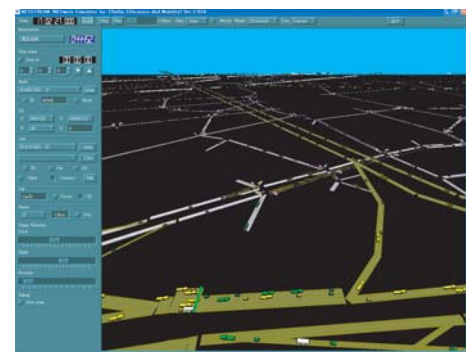
NETSTREAM was developed to evaluate the effectiveness of ITS systems such as DRGS, ETC and Traffic Information Services, as well as traffic-related measures such as traffic restrictions.

**Figure 1** is an overview of NETSTREAM. NETSTREAM uses the road networks and Origin-Destination (OD) flows as its input data. The road network database includes a huge number of links, nodes and other information. The OD flows database describes how many vehicles travel from each origin to each destination. Each car is moved based on the route choice model and the flow model.<sup>1)</sup> The simulated traffic situations can be monitored on a PC, as shown in **Fig. 2**. As a result, we can obtain traffic situations such as traffic volume and travel time.

The features of NETSTREAM are as follows: First, it is possible to simulate the traffic flows in large-scale networks such as that of the Toyota City network.<sup>3)</sup> Even for such a large-scale network, NETSTREAM calculates the motion of each and every vehicle.<sup>4)</sup> Therefore, it is possible to evaluate mixed traffic with/without ITS systems, based on



**Fig. 1** Overview of NETSTREAM.



**Fig. 2** Example of simulating traffic situations on a PC.

vehicle classifications, and so on. In addition, NETSTREAM can reproduce actual traffic situations, thanks to the use of our OD estimation method.<sup>5-7)</sup>

The major applications and achievements of NETSTREAM are listed in **Table 1**. We have applied NETSTREAM to a wide range of predictions. From the next section of this paper, we explain the prediction of traffic situations and the traffic-related measures applied at the Expo.

**Table 1** Major applications and achievements of NETSTREAM.

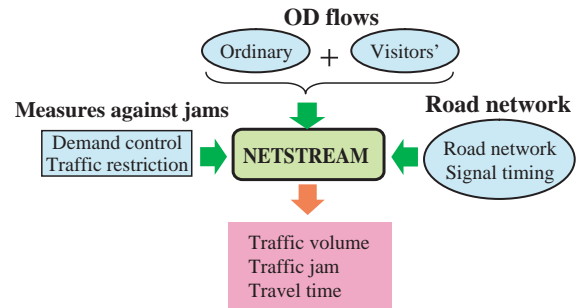
Year	Application and achievements
1997-1998	The prediction of traffic situations for the Nagano Olympic winter game, which is the contribution to Nagano Prefectural Police. <sup>2)</sup>
2002-2004	The examination of relieving traffic jams in Toyota City. <sup>8)</sup>
2003	The inspection system of traffic information which was developed for National Police Agency.
2003-2005	The prediction of traffic situations for the Expo which is the contribution to Aichi Prefectural Police.
2004 -	The evaluation of inter-vehicle communications. <sup>9)</sup>
2005	Appearance in Traffic Engineering Handbook as a representative simulator. <sup>10)</sup>

### 3. Prediction of traffic situations and the application of traffic-related measures

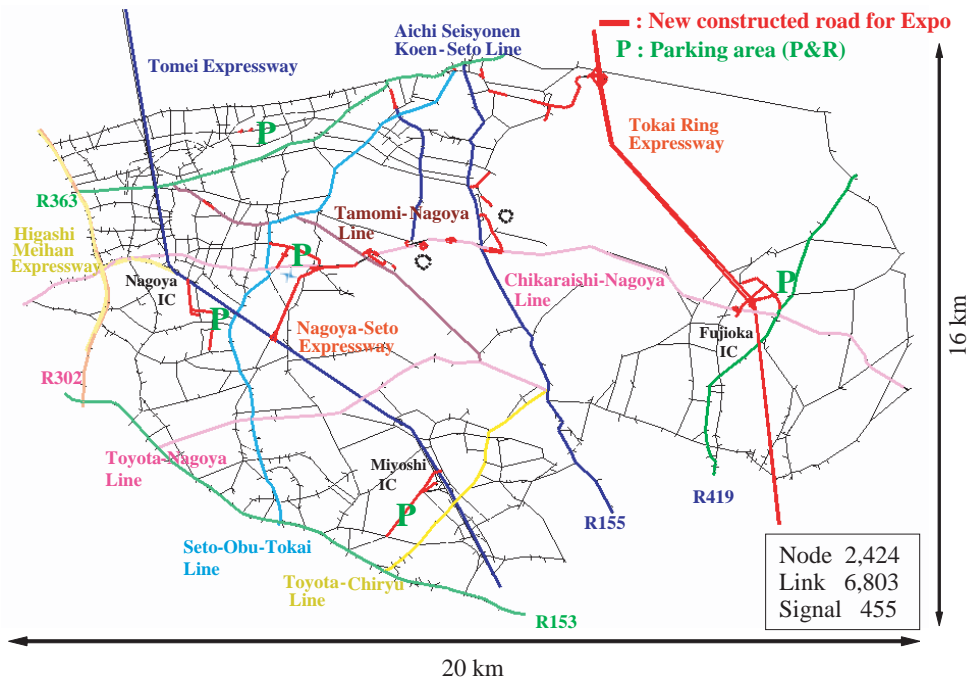
#### 3.1 Prediction method

An outline of how we predicted the traffic situations during the Expo is shown in **Fig. 3**. NETSTREAM takes a road network, OD flows, and plans for the measures to be applied to reduce jams as its input, simulates the traffic flows in the network, and then outputs the predicted traffic situations, such as traffic volume, traffic jam lengths, and travel times.

The road network for this prediction is shown in **Fig. 4**. The prediction area measures about 16 km by 20 km and includes two venues, five visitor



**Fig. 3** Outline of prediction for the Expo.



**Fig. 4** Road network for the prediction.

parking lots, major railroad stations, and expressway interchanges. The network consists of all the major roads in the area. There are 2,424 intersections (nodes) and 6,803 roads (links). Each traffic signal in the network has the same timing as its real-world counterpart (these predictions were undertaken in July 2003).

The OD flows are categorized into the following two types. (1) Ordinary OD flows: commuters, commercial vehicles, and others that are unrelated to the Expo. (2) Visitors' OD flows: visitors' private vehicles. Each type of OD flow is then estimated on the basis of the statistical data, actual traffic counts,

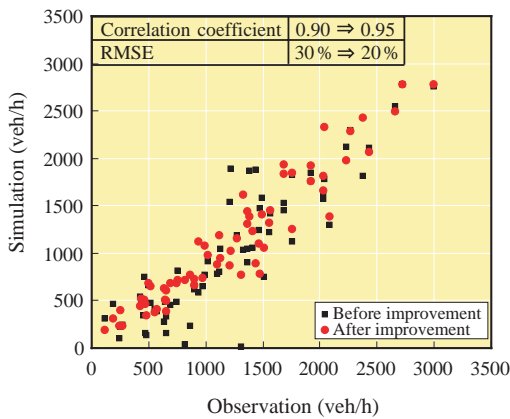
and the expected number of visitors. Ordinary OD flows are especially difficult to estimate, because no detailed surveys of these flows have been done. Therefore, we studied the method for estimating OD flows,<sup>7)</sup> and then improved the reproducibility of the actual traffic, as shown in **Fig. 5** and **Fig. 6**.

The Aichi Prefectural Police were considering implementing detour control, traffic demand control, exclusive bus lanes, the prohibition of private cars within 3 km of the Expo venues, signal control, and the use of Park & Ride schemes. We incorporated one or more of these measures into each of our simulations.

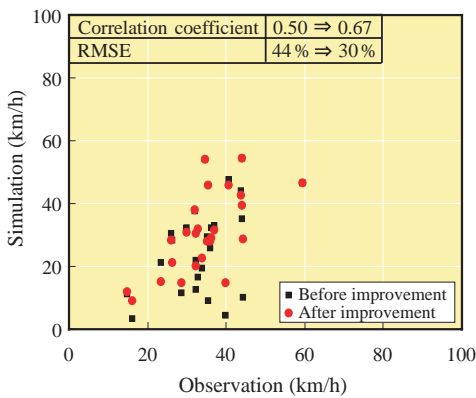
### 3.2 Prediction results and application of traffic-related measures

Using the above method, we predicted the traffic situations during the Expo. The predicted traffic jams in the evening from 17:30-18:30 are shown in **Fig. 7**. **Figure 8** shows the traffic jams on the main road on which traffic jams occurred in Fig. 7. As shown in Fig. 7 and Fig. 8, we predicted that heavy traffic jams would occur on Sunday evenings on the Chikaraishi-Nagoya Line. On this line, even in 2003 (when we made these predictions), in spite of there not yet being any visitors to the Expo, chronically heavy traffic jams occurred. By adding visitors to these situations, we predicted that the jams would be even heavier during the Expo.

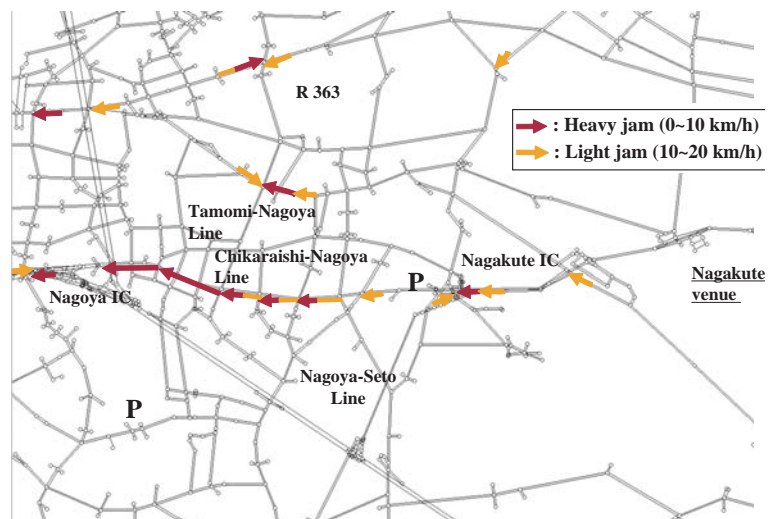
We evaluated above mentioned measures for



**Fig. 5** Results of improving the method of OD flow estimation. (Comparison between simulated volumes and observed ones)

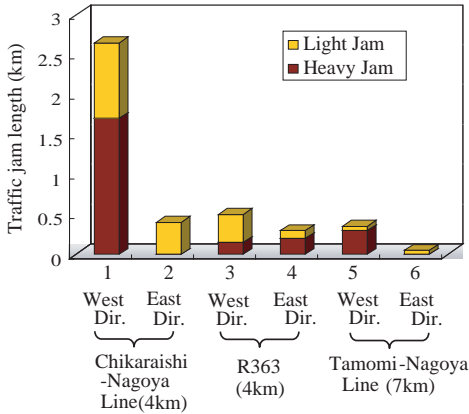


**Fig. 6** Results of improving the method of OD flow estimation. (Comparison between simulated velocities and observed ones)



**Fig. 7** Predicted results of traffic situations on Sunday evening.

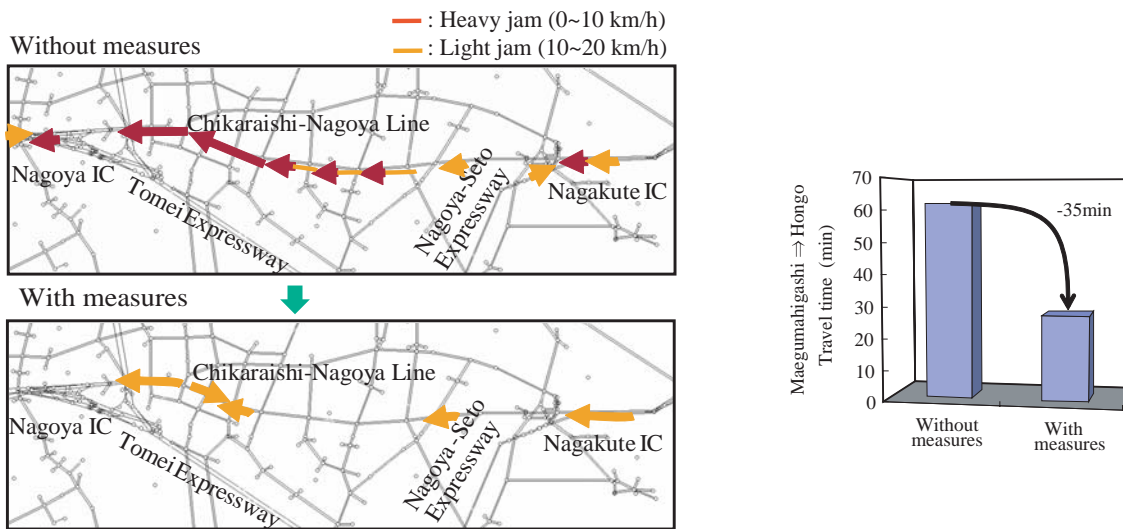
alleviating this congestion. As an example, traffic jam situations for the reduction of traffic volumes are evaluated. Consequently, if traffic volumes were



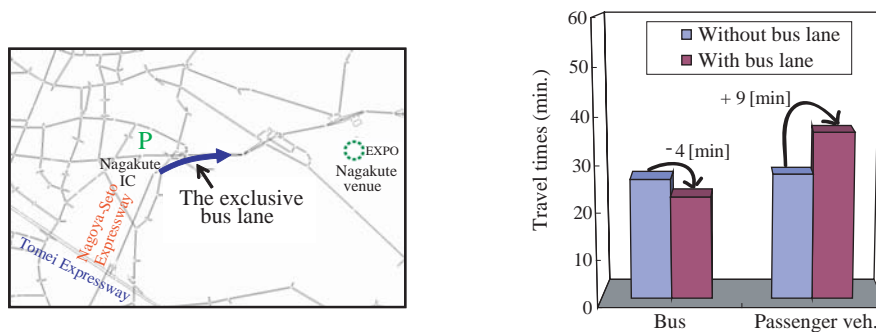
**Fig. 8** Predicted results of traffic jam length on Sunday evening.

reduced by 15 % as a result of applying detour control to the Chikaraishi-Nagoya Line, the traffic jams could be virtually eliminated, as shown in **Fig. 9**, with travel times reduced to less than half.

In addition, the Aichi Prefectural Police planned the use of an exclusive bus lane on the offramp of the Nagoya-Seto Expressway. This was intended to keep bus traffic running smoothly, since this expressway was to be specially constructed for the Expo and was to be the main road route to the venues. We, therefore, predicted the traffic situations and evaluated the use of the bus lane. An example of our results is shown in **Fig. 10**. On weekday mornings, the exclusive bus lane would reduce bus travel times. The travel times for passenger vehicles, however, would be increased. So, to ensure that the exclusive bus lane would not adversely affect commuters, the exclusive bus lane was not implemented on weekday mornings, but



**Fig. 9** Prediction example of the detour control in Chikaraishi-Nagoya Line on Sunday evening.



**Fig. 10** Prediction example of the exclusive bus lane in Nagoya-Seto Expressway on weekday morning.

only on weekends.

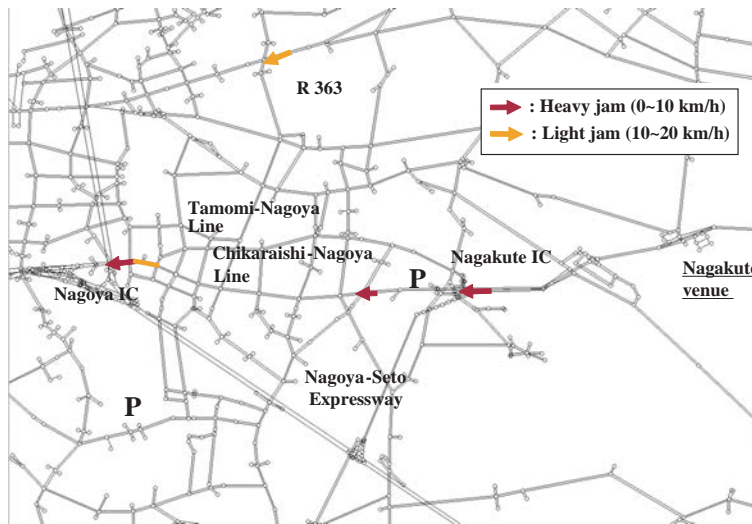
In this way, we used simulation to evaluate the traffic situations with/without each of the various measures in place. As a result, we confirmed that the following measures would be essential to keeping the transportation links running smoothly, and these were actually applied during the Expo; information on traffic situations, exclusive bus lanes (weekend mornings only), prohibition of private cars within 3 km of the Expo venues, and the use of Park & Ride.

**3.3 Actual traffic situations during the Expo**

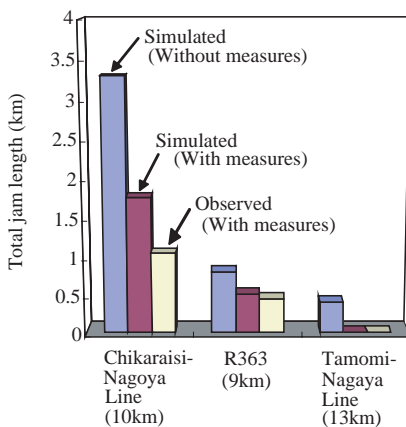
Through the application of the above-mentioned

measures, there were very few traffic jams and the transport links kept running smoothly throughout the Expo, as shown in **Fig. 11**. Comparisons between the simulations and observations are shown in **Fig. 12** and **Fig. 13**. These figures clearly show that the simulated traffic situations with the measures in place closely correspond to the actual situations that arose. It is said that, as a result of introducing these measures, the number of vehicles actual fell from the pre-Expo levels, such that the number and length of traffic jams was greatly reduced.

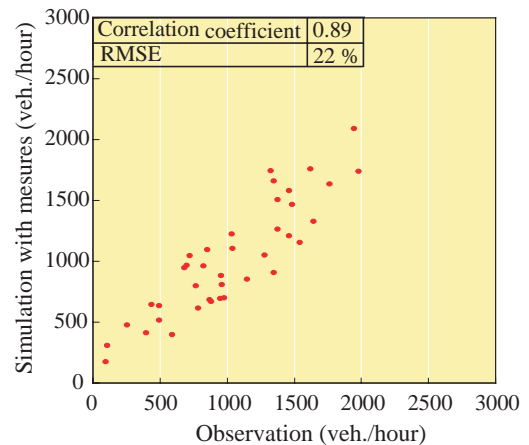
Through these predictions, we were able to contribute to the evaluation of traffic-related



**Fig. 11** Actual traffic situations on a Sunday evening during the Expo. (May 4, 2005. 149,000 Visitors)



**Fig. 12** Comparison between simulated jam lengths and observed ones on the Sunday evening.



**Fig. 13** Comparison between simulated traffic volumes and observed ones on the Sunday evening.

measures and the smooth running of the transport links during the Expo.

#### 4. Conclusions

We predicted the traffic situations for Expo 2005, held in Aichi, Japan, and evaluated the proposed traffic-related measures and traffic restrictions by using the traffic simulator NETSTREAM. As a result, heavy traffic jams were predicted on the Chikaraishi-Nagoya Line. If the traffic volumes were reduced by 15 % through the application of detour control, it was possible to have a situation where there were very few jams, with travel times reduced to less than half. In addition, to ensure keep smooth bus and commuter traffic, the use of exclusive bus lanes on the Nagoya-Seto Expressway was evaluated. As a result, we found that the use of an exclusive bus lane would be disadvantageous to commuters traveling by car. Therefore, the exclusive bus lane was not implemented on weekday mornings, but only on the weekends.

From these predictions and evaluations, we confirmed that information on the traffic situations the exclusive bus lanes (weekends only), the prohibition of private cars within 3 km of the Expo venues, and the use of Park & Ride were indispensable to reducing the traffic jams around the venues and on the main roads. During the Expo, as a result of applying these measures, there were very few traffic jams and all transportation links kept running smoothly.

In this way, we were able to contribute to the evaluation of the traffic-related measures and the smooth running of the transportation links during the Expo.

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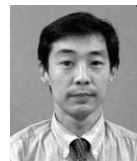
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