Travel Time prediction during Incident on Metropolitan Expressway

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Abstract

Although there are many studies on travel time (TT) prediction, most of the studies are for normal traffic condition. However, there is a need to develop a model to predict TT during incident. This study analyzed the impact of an incident occurrence on traffic flow using the databases of two years traffic data and one year accident record for inbound traffic on Route No. 3 Shibuya line of the Metropolitan Expressway (MEX). The prediction methods of the duration of an accident and its TT on above are proposed.

Introduction

MEX is the major expressway in the Tokyo metropolitan area, which covers four prefectures including the Tokyo central area. The total length is about 280 km and about 1.14 million vehicle trips are recorded each day. Because of the frequent congestion, provision of TT information through variable message signs boards, the “Metropolitan Expressway Radio”, and the “Metropolitan Expressway Telephone” has been a quite demanded user service.

However, the difference between the TT information provided and the actual TT is sometimes large during start or end of traffic congestion. Therefore, we need to develop a TT prediction method. Although there are many studies on TT prediction, most of them are for normal traffic condition. Hence we need to develop a model to predict TT during incident.

The first step involved building databases using two years vehicle detector data and one year accident record for inbound traffic on Route No.3 Shibuya line. The impact of an incident occurrence on traffic flow using the databases is analyzed and reported.

In this study, we propose the methodology to predict the duration of an accident and the TT during the accident.

Study Route & Data

In this paper, we focus on the inbound traffic on Route No.3 has a length of about 12 km is illustrated in Fig.1. Among 17 sections in the figure, we use all section data except sections 1, 2, and 17, because sections 1 and 2 are at a part of junction, and section 17 is further upstream than the Toll Gate on the main line.

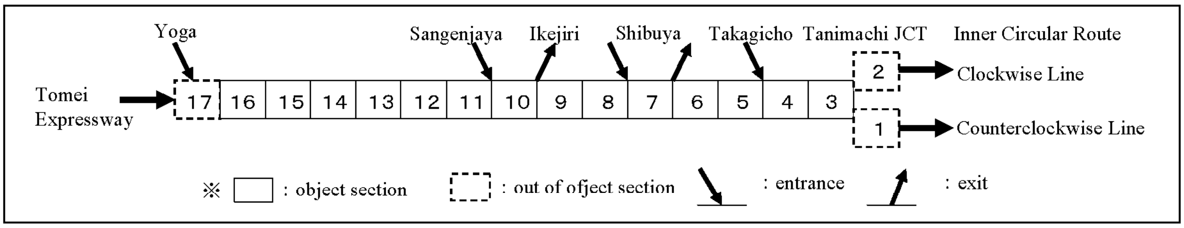


Fig.1: Study route （Route No.3 on MEX）

The incidents on the MEX can be classified into various types such as accident, break down, falling object, road work, etc. We focus solely on the accident data and use the following databases.

1) Two years vehicle detector database

- Traffic data such as traffic volume, average velocity, etc. (every 5 minutes)

2) One year accident record database

- Since this data is recorded after the event, it is not an on-line data.

Analysis of traffic condition during incident

The TT information provided is the instantaneous TT. Therefore, the difference between the TT provided and the actual TT is sometimes large at start or end of congestion, especially during an accident.Fig.2 and Fig.3 show the TT information provided (i.e. TT disseminated to users) and the actual TT.

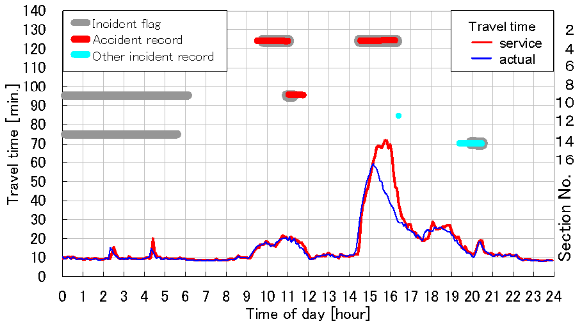


Fig.2: TT curves (a case of large difference)

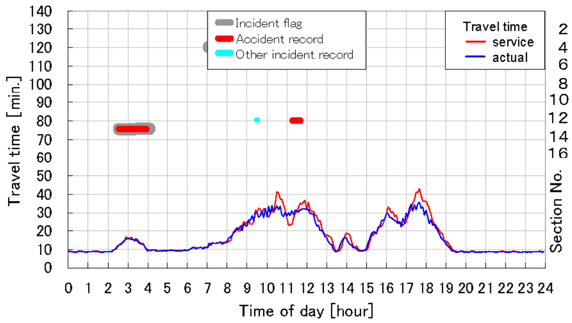


Fig.3: TT curves (a case of small difference)

Fig.2 shows that the difference between the TT information provided and the actual TT is large during accident. However, in the case of Fig.3, the difference between the two TT is very small during accident, and the TT information provided is fairly accurate.

So, we analyzed the change of the cumulative trips before and after accidents. In the case of Fig.2, the cumulative curves changed significantly due to closing of a traffic lane. Furthermore, the propagation of the change was observed as this effect could ascertain one of the causes of the difference between the TT provided and the actual TT.

In the case of Fig.3, there is very little change in the cumulative curves because of low traffic volume. When the change of the cumulative trips is small, the difference between the TT provided the actual TT is small.

Thus, the existing method for calculating TT is also effective depending on the traffic condition. Therefore, it is possible to construct the system effectively using the existing TT calculation method according to the traffic condition

On the other hand, the difference between the TT provided and the actual TT was analyzed during an accident on one year accident record database. The result is shown by Table-1.

Table-1: analysis of the difference between the TT provided and the actual TT

	all	absolute error less than 10min	absolute error more than 10min
Samples (rate)	533 (100%)	247 (46%)	286 (54%)

When the absolute error (= the difference between the TT provided and the actual TT) is less than 10 minutes, the rate is 46%.

According to a questionnaire survey conducted by MEX Public Corp., a high proportion of drivers accept the 10 minutes difference between actual and predicted TT time. Therefore in the case where absolute difference of less than 10 minutes, the TT provided information is useful. Using this result skillfully, the existing method for calculating TT will be effective during an accident.

Outline of travel time prediction method during incident

Past studies on TT prediction during incident used traffic-flow simulation. However, using this approach, it is difficult to ascertain the duration of an accident.

On the other hand, we analyzed the duration of accidents using actual accident record data. Using this dataset, a statistical model was developed and the model proved to be able to predict the duration of accident satisfactorily.

The relationship between cumulative trips and TT under the FIFO discipline is shown in Fig.4. When the cumulative trips at point-X and point-Y are the same, the difference between the occurrence t-Ts and t, is the TT.

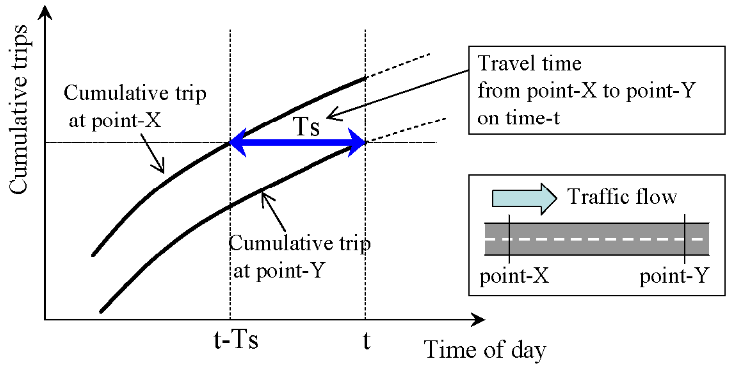


Fig.4: the relation between cumulative curves and TT

Therefore it is possible to predict TT information during incident by predicting cumulative curves from current time using the prediction method of the time during accident described below, and using the relation between cumulative trips and TT such as Fig.4.

Following are the details.

Prediction of the accident's duration

The flow of the accident processing

Fig.5 shows the flow chart of events at an accident. When accidents occur, the control member grasps the initial situation by emergency telephone call or surveillance camera in the control room.

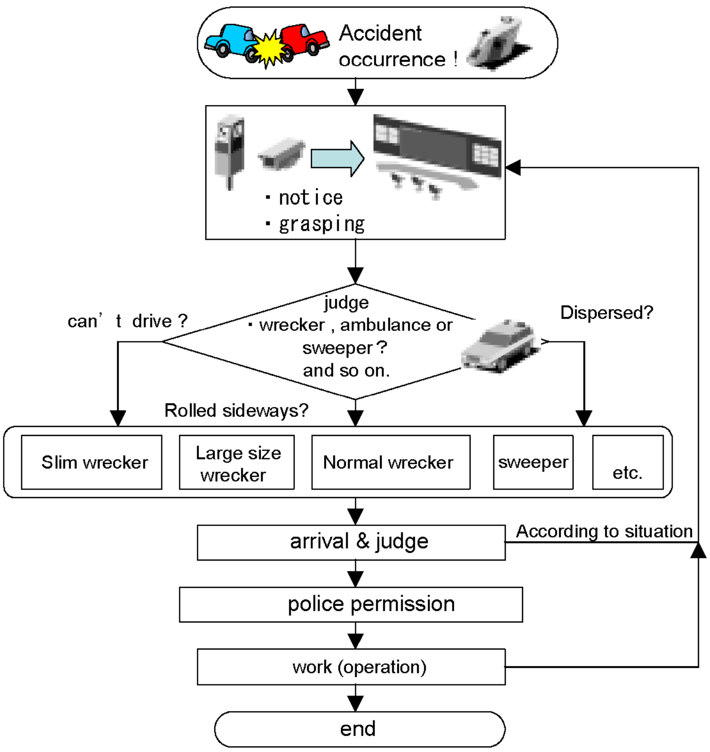


Fig.5: processing flow at an accident

Next, based on the information, the MEX patrol car goes to the accident spot and the requests to ambulance and/or wrecker are directed according to the situation.

In other circumstances, after MEX patrol car arrived at an accident spot and checked the detail situation, they may ask the a control room to request for ambulance and/or wrecker according to the situation.

At the accident spot, after the on-the-spot inspection by expressway police, the accident processing is carried out. In the work of the accident processing, a wrecker may be required. Wreckers are divided into three kinds.

<Normal wrecker> the normal size wrecker. A private contractor including JAF (Japan Automobile Federation)

<Slim wrecker> the wrecker which MEX owns. Because the wrecker is slim, it can pass through spacing between the cars in traffic congestion.

<Large size wrecker> used for pulling large-sized car which the normal or slim wrecker can't pull.

Duration of events during an accident

Fig.6 shows the duration of events of an accident from Fig.5.

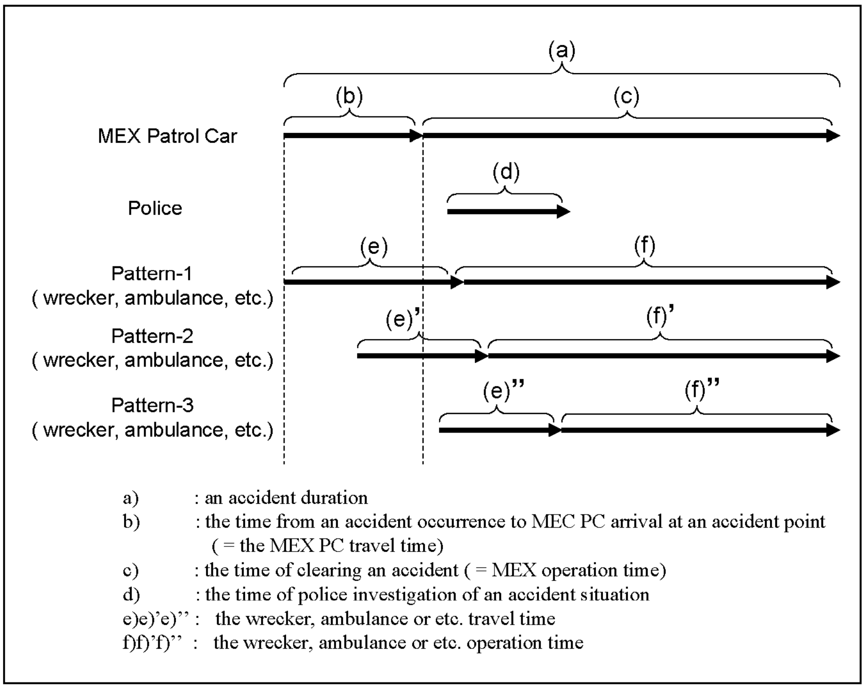


Fig.6: the items of duration of an accident

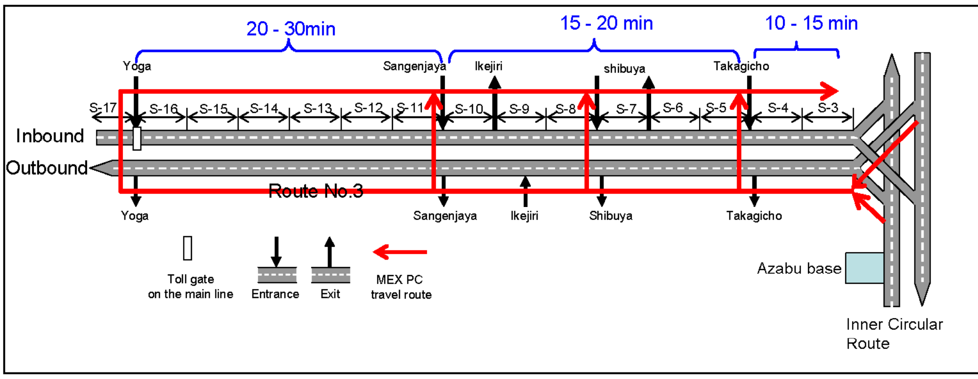
The duration of an accident (a) is the sum of the TT of MEX patrol car (b) and MEX operation time (c). According to the types or scale of the accident, the ambulance and/or wrecker are required.

(b) and (c) include the TT of those cars (e) and those operation time (f).

And then, according to the timing of the request for the ambulance and/or wrecker, the items are classified into pattern 1-3 in Fig.6.

TT to each section of accident occurrence of MEC patrol car and slim wrecker

Fig.7 and Fig.8 show the TT to each section of accidents occurrence. Some MEX patrol cars are always patrolling on the MEX. When they get an accident reports, they go to the accident spot immediately. According to the location of accident, they get off at the next exit and get on at the nearest entrance. (the red arrow in Fig.7)



accident section	TT1* [min]	TT2* [min]
S-3	13.2	10-15
S-4	13.2	
S-5	17.4	15-20
S-6	17.4	
S-7	16.2	
S-8	19.2	
S-9	19.2	
S-10	18.0	
S-11	21.0	20-25
S-12	23.4	
S-13	28.2	
S-14	26.4	
S-15	15.0	
S-16	19.2	

TT1 : MEX PC travel time to an accident section
TT2 : standard MEC PC travel time to an accident section

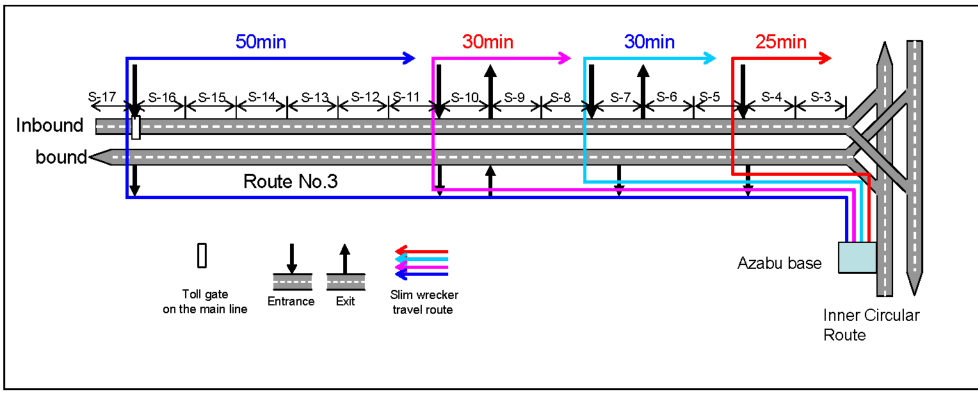
Fig.7: TT and route of MEX patrol car

Concerning the wrecker, the slim wrecker owned by MEX is described. When an accident occurs on Route No.3, the slim wrecker starts from Azabu base. Depending on the accident location, the slim wrecker gets off at the nearby exit and get on at the nearby entrance. (the color arrows in Fig.8).

Fig.7 shows that the TT of MEX patrol car is different depend on the accident location. Depend on the MEX patrol car which go round the expressway, the data has variation.

On the other hand, Fig.8 shows that the variation is comparatively small and the TT of slim wrecker is different depend on the accident location. Following is the reason.

- The slim wrecker always go from same point (= Azabu base).
- Because the wrecker is slim, the influence of the traffic congestion is small.



accident section	TT1* [min]	TT2* [min]
S-3	22.8	25
S-4	13.2	
S-5	27.0	30
S-6	-----	
S-7	33.0	
S-8	24.0	
S-9	28.2	
S-10	-----	
S-11	37.2	50
S-12	51.0	
S-13	-----	
S-14	49.2	
S-15	------	
S-16	49.8	

TT1 : Slim wrecker travel time to an accident section
TT2 : standard Slim wrecker travel time to an accident section

Fig.8: TT and route of slim wrecker

Classification of an accident

The relation between the following events and the duration of an accident are analyzed to check the scale of accidents.

1. Was there a lane closed?
2. Have more than 1 MEX patrol cars gone to the accident? (A MEX patrol car is always present)
3. Was the ambulance called?
4. Was the wrecker (normal, slim or large size one) called?
5. Was a large vehicle involved in the accident?

In this analysis, the police are not factored in, because they are always present at an accident. Moreover we analyzed the relation between the duration of an accident and the case that these plural events happened in an accident. As a result, with plural factors the duration of accidents tend to be large, and with single factor the variation in accident duration is small.

On the other hand, some features become clear depend on the situation of these factors. For example, in the case of large size wrecker, the duration of an accident is more than 2 hours. In the case of the slim wrecker, it is more than about 90 minutes. Also depending on the type of the accident, like collision with falling objects or spill, the TT is more than 60 minutes.

It is possible to predict the duration of an accident, depend on the classification according to the situation. In the future, the accuracy of prediction would improve by adding the accident report data.

Travel time prediction method during accident

In case of the accident, we found that the case for which it is possible to use instantaneous TT (the conventional travel time information) was 46 %. Therefore, if we can classify case of large errors or small errors between instantaneous TT and the actual TT, we can predict travel time during an accident by using travel time prediction method other than instantaneous TT for cases where the errors are large. As a result of the data analysis of the errors between instantaneous TT and actual TT during an accident, we obtained the following characteristics.

(a) The time characteristic of the errors:

There is a difference between accident occurrence time and duration

(b) The spatial characteristic of the errors:

The characteristic of the error depends on the accident-occurrence location.

As for the travel time prediction in case of accident occurrence, the important point is not only prediction of TT when accident occurs (start of incident) but also prediction of TT during the accident. Using the above spatial and temporal characteristic, we can delineate the TT prediction method during the whole period of an accident as shown in figure 9.

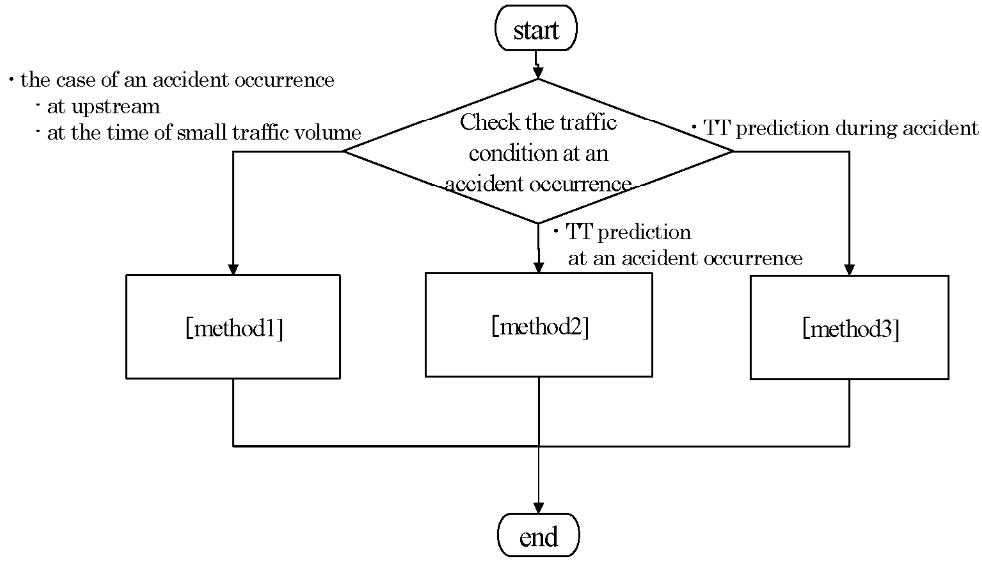


Fig.9: TT predict method during accident (3 methods)

[method-1]　instantaneous TT method

We use instantaneous TT method to predict the travel time.　This method is adapted for the case where accidents occur in the upstream section of the subject road and the traffic flow is light..

[method-2]　Polynomial model

We predict travel time by the polynomial model that expressed relation between the available-information (the traffic flow and so on) and the travel time actual value.

At the time when accident just occurs, the error is often small. We consider that it is possible to predict by using the polynomial model.

[method-3]　the new method

We use method3 when we can't obtain accurate prediction with [method1] and [method2]. In this research, we use the method of using a relation between the cumulative trips curve and the travel time.

We calculate final travel time prediction value by predicting the duration of accident in addition to the cumulative trips prediction.

It is difficult to predict travel time during an accident because of the changing road traffic condition during an accident and the duration of accident varies and so on.

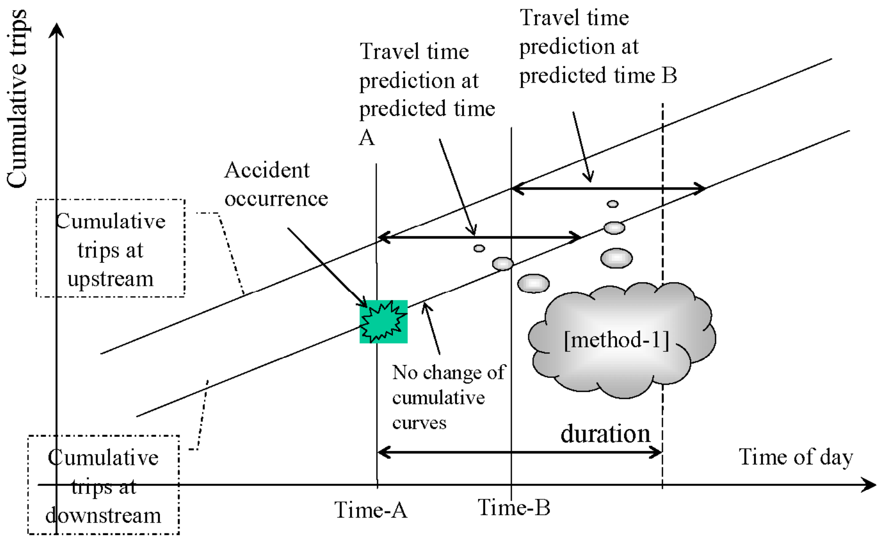
In such a case, [method3] which considers the temporal-change of the traffic condition and the duration of accident is applied.

For [method3] which use the result of the prediction of the accident duration, Fig.10 shows that it is possible to improve the value using the new information during the accident.

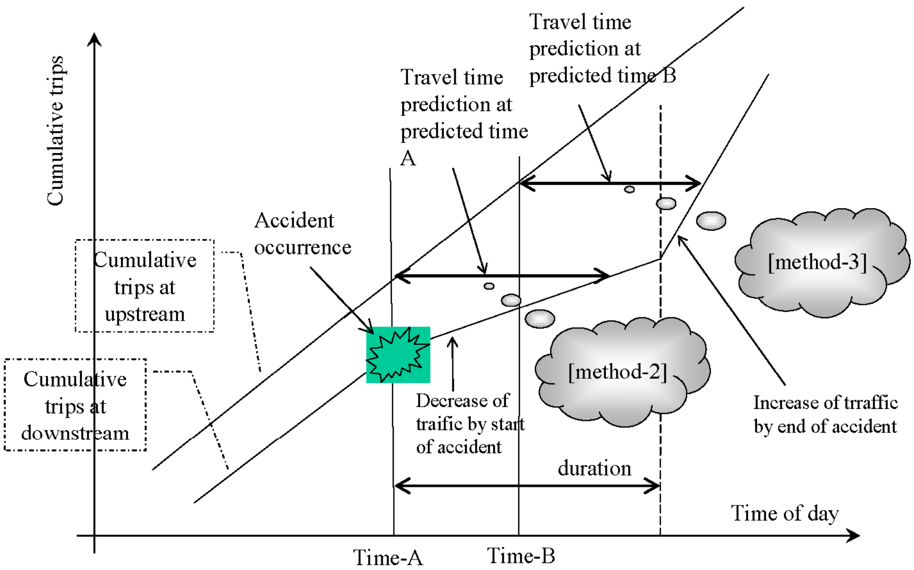
In [method3], we presuppose cases that can obtain clear shape in the cumulative-trips-curve.

In this research, when the form of the cumulative trips curve wasn't clear (when another accident occurs in the same time, and so on), we excluded from the analysis data. In such cases, we must adopt other method.

Applying these methods, more accurate TT information can be provided for all types of accidents.



(a)the case of no impact of accident on traffic



(b) the case of observable impact of accident on traffic

Fig.10: Outline of TT prediction with 3 method

Conclusion

In the TT prediction study during incidents, the vehicle detector data and the accident record data on the MEX was analyzed. This study shows that it is possible to predict the TT information during incident.

The followings are the major remarks:

- It is possible to construct the system effectively using the existing TT calculation method according to traffic condition.
- Duration of accident can be predicted satisfactorily using statistical methods based on critical factors impacted on the accident.
- It is likely that the TT information during incident can be predicted by predicting the cumulative curves from current time using the above estimated accident duration, and predict TT from the cumulative curves.

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