Development of a road-to-vehicle information collection and distribution mechanism and utilization of ETC2.0 probe information

1. Outline of Studies and Activities

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<tr><th>出来事</th><th colspan="3">研究</th></tr>
<tr><td>2001 ETC運用開始

2009 ETC2.0車載器の販売開始

2011 高速道路での路側機整備開始

2011 ETC2.0運用開始

2015 一般道路での路側機整備開始</td><td colspan="3">フェーズⅠ【路車間での情報の収集・配信機構の開発】
● ETC2.0車載器、路側機、路車間通信等の規格・仕様案作成（2006.3）
（車載器製造メーカをはじめとする27者との共同研究）
● 実証実験（首都高速道路におけるETC2.0プローブ情報の収集と道路交通情報の提供）（2006.9）</td></tr>
<tr><td rowspan="2">2015 道路交通センサス旅行速度調査でのETC2.0プローブ情報の活用開始

2017 車両運行管理支援サービス開始

2017 事故危険箇所指定でのETC2.0プローブ情報の活用開始</td><td colspan="3">フェーズⅡ【ETC2.0プローブ情報の利活用】</td></tr>
<tr><td>交通円滑化
ETC2.0プローブ情報を活用して区間旅行速度を推計する手法の開発（2014）

ETC2.0プローブ情報を活用してボトルネックを特定する手法の開発（2020）

ETC2.0プローブ情報等を活用したOD交通量逆推定手法の開発
（学識者で構成する「ICTを活用した道路交通調査体系検討会」の意見を聞きながら開発中）</td><td>交通安全
ETC2.0プローブ情報の交通安全対策への活用マニュアル作成（2017）

ETC2.0プローブ情報を活用して事故の危険性が高いエリアを抽出する手法の開発（2018）

ETC2.0プローブ情報を活用した危険事象の見極め手法の開発（2019）</td><td>物流支援
車両運行管理支援サービスに必要なシステム等の開発（2015）
(ITSサービス高度化機構との共同研究)

実証実験（物流事業者12社への車両運行管理支援サービスの提供）（2015-2017）</td></tr>
</table>

1) Background

In order to alleviate traffic congestion and reduce traffic accidents, the development of ITS (intelligent transportation system), which integrates people, roads, and vehicles into a single system using state-of-the-art information and communication technology, has been actively promoted. In particular, as of March 2006, 11 million ETC (electronic toll collection: a non-stop toll collection system for toll roads) on-board units had been in service since 2001. The ETC communication method (5.8 GHz DSRC) is expected to be used for ① "toll collection," ② "provision of road traffic information," and ③ "collection of vehicle location information (see Figure-1), as it is capable of large-capacity two-way road-to-vehicle communication). Of these, the information obtained in ③ is called ETC2.0 probe information, which includes the driving history of vehicles equipped with ETC2.0 on-board equipment (e.g., information indicating the driving position at regular intervals and the position when turning) and the behavior history (e.g., information indicating the position when emergency braking occurs), and is used to identify road traffic issues and to study and evaluate measures.

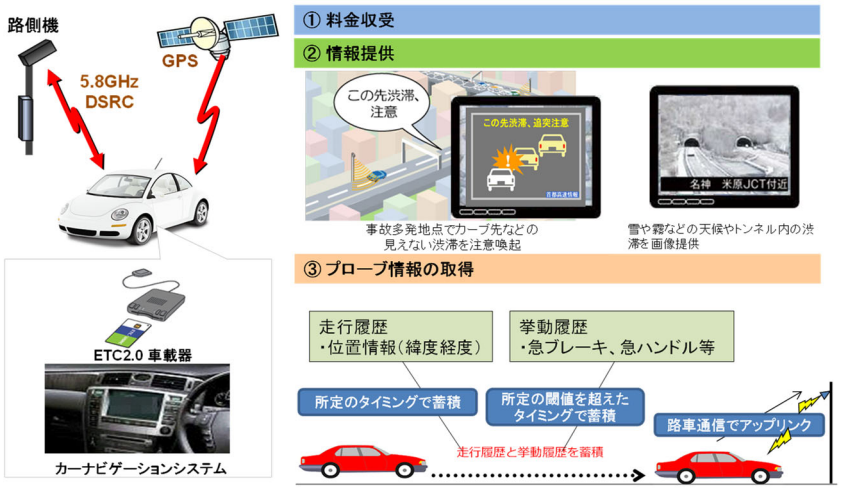


Figure-1 ETC2.0

2) Outline of Research Activities

Phase I [Development of a mechanism to collect and distribute information between road vehicles]

In joint research with 27 parties, including manufacturers of on-board equipment (OBE), NILIM studied the functions and mechanisms of roadside equipment, OBE, and vehicle-to-infrastructure communications that are necessary to realize new services such as ② and ③ above, and developed draft standards and specifications that should be commonly adopted (March 2006). In September 2006, the committee conducted an experiment on the Metropolitan Expressway to verify the effectiveness of the proposed standards and specifications by providing road traffic information and collecting vehicle location information, and established specifications for roadside equipment, on-board equipment, and vehicle-to-infrastructure communications. As a result, sales of on-board equipment began in 2009, roadside equipment in 2011, and the ETC2.0 probe information collection and road traffic information provision service also began in 2011.

Phase II [Utilization of ETC2.0 probe information]

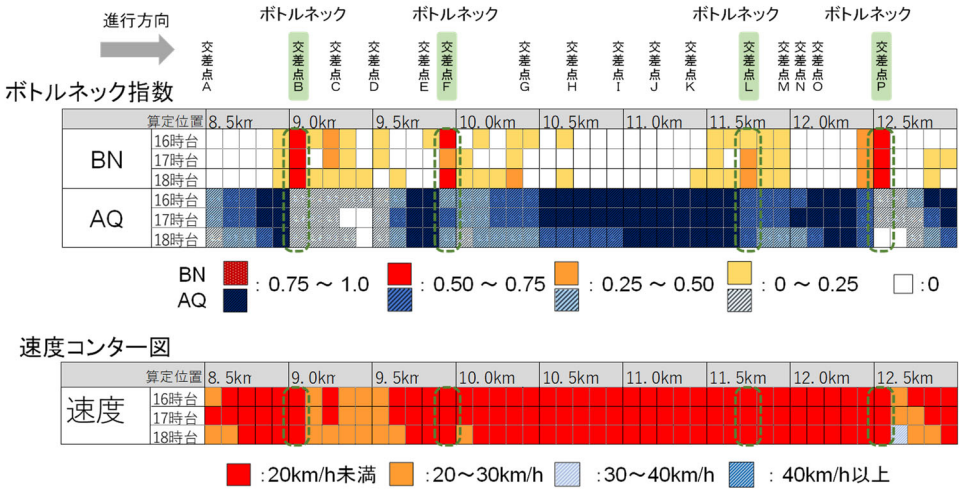
In order to utilize ETC2.0 probe information in road administration, equipment specifications were developed for probe data processing devices. As a result, processing equipment has been deployed at each regional development bureau, etc., making it possible to determine the travel speeds and locations of emergency braking on a section-by-section basis. According to the Road Traffic Census (FY2015), this travel speed information was used in 66% of the surveyed sections (approximately 99% for expressways and urban expressways, and 87% for general national highways).

In addition, a method to identify bottleneck points based on travel speeds from ETC2.0 probe information and a method to extract potential accident areas based on sudden deceleration data have been developed and are being used in the study of road policies. Furthermore, to support vehicle operation management for logistics companies, a system for extracting and distributing information on specific vehicles was developed through joint research with the Organization for ITS Service Advancement, and the effectiveness of the system was confirmed through a demonstration experiment (2015-2017) involving 12 logistics companies.

2. Main Research Results

◆ETC2.0 probe information application method (traffic smoothness): Method for identifying road congestion bottlenecks

The bottleneck index was developed for the purpose of identifying bottlenecks, which are the starting points of traffic congestion on the road network. This index analyzes travel speed and other data from ETC2.0 probe information, assigns points to the bottlenecks based on whether they are "at the beginning of traffic congestion" or "affected by traffic congestion ahead," and quantifies the frequency of occurrence over the measurement period. As shown in Figure-2, the conventional "speed contour map" analysis has difficulty identifying bottlenecks (the bottlenecks visually confirmed by the road administrator are intersections B, F, L, and P), especially when there are consecutive congested sections. In contrast, the method developed in this study makes it possible to properly identify bottlenecks by using a bottleneck (BN) indicator, which shows that the section is at the head of traffic congestion, and an indicator (AQ), which shows that the section is affected by traffic congestion ahead (the section is not a bottleneck).



The BN value in the figure indicates the percentage of time when the segment in question is "congested" and the adjacent segment ahead is "uncongested." The AQ value in the figure indicates the percentage of time when both the segment in question and the adjacent segment ahead are "congested"; a segment with a small AQ value (not affected by congestion ahead) and a large BN value (at the head of congestion) is considered to be a bottleneck.

Figure-2 Comparison of bottleneck index and velocity contour plots

◆Utilization of ETC2.0 probe information (traffic safety): Method for identifying areas with high risk of accidents

A method was developed to extract areas of high accident risk where countermeasures should be implemented from the data indicating the points where sudden deceleration occurred in the ETC2.0 probe information. As shown in Figure-3 (left), a simple plot of the points where sudden deceleration occurred could not identify areas with a high risk of accidents

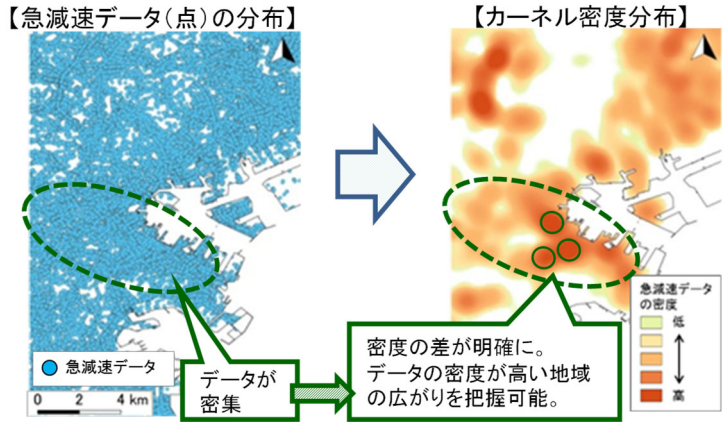


Figure-3 Identification of areas at high risk of accidents by kernel density distribution

because there were countless points. In contrast, in this study, the kernel density distribution (Figure-3, right) was used to express the extent of the areas where sudden deceleration occurs, enabling the extraction of areas with a high accident risk. This enables efficient study of areas with high priority for traffic safety countermeasures.

◆Utilization of ETC2.0 probe information (logistics support): Vehicle operation management support for logistics companies

We have developed the system necessary to realize "Vehicle Operation Management Support Services" (see Figure-4), which help logistics companies improve the efficiency of their vehicle operation management. Specifically, the system is capable of extracting the location information of vehicles using the service from a large amount of ETC2.0 probe information within five minutes of acquisition and distributing it to the logistics companies. This enables efficient operation management, such as predicting accurate arrival times and modifying operation plans. This service has been in operation since 2017, and as of March 2021, it is being used by approximately 1,000 vehicles of eight businesses.

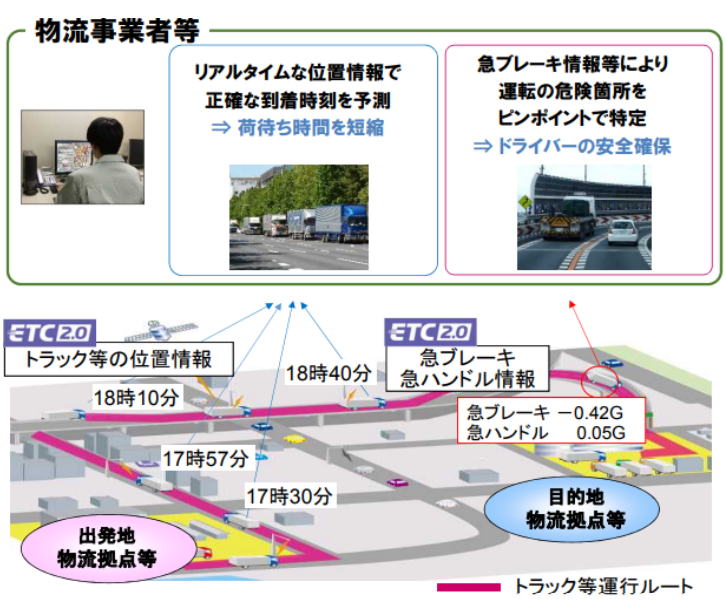


Figure-4 Image of vehicle operation management support

3. List of Related Reports and Technical Documents

- Research on how to use ETC2.0 probe information in road policy evaluation:http://www.nilim.go.jp/lab/qcg/japanese/3paper/pdf/2017_14.pdf
- Research on methods to identify road congestion bottlenecks: http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1125pdf/ks1125_05.pdf (p. 3, 4)
- Research for the introduction of methods and measures for effective and efficient traffic safety management: http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1037pdf/ks103710.pdf (p. 67, 68)
- Validating the effectiveness of vehicle fleet management support services: http://www.nilim.go.jp/lab/qcg/japanese/3paper/pdf/2018_15.pdf

4. Future Outlook

We will continue to study the issues and needs related to the use of ETC2.0 probe information and make various improvements, such as increasing the accuracy of map-matching (identifying the location of vehicles on a map), to make the information more useful. We will also conduct research on methods for confidential processing of ETC2.0 probe information and provision mechanisms for the private sector to utilize ETC2.0 probe information.