

**“Technical Research and Development for Road Policy Quality Improvement”  
Study Summary**

No.	Title	Principal Researcher
No.31 - 1	Basic design proposals for the next generation of ETC through the use and evaluation of ETC 2.0 data.	Tohoku University Prof. Takamasa Iryo

This study aims to propose a basic design for the next-generation ETC system that is necessary and sufficient to meet the requirements and is in continuity with the current ETC 2.0 system, based on the identification of requirements through case studies using ETC 2.0 data and other data, field experiments with new observation techniques and the development of anonymisation and external data linking techniques.

### 1. Backgrounds and Objects

The vehicle trajectory data (ETC2.0 data) that the existing ETC2.0 system continues to collect is rich in information, and multiple examples of its use in government and academia have emerged. On the other hand, data quality problems have also become apparent. The principal researcher of this study has conducted the "Construction of a hierarchical database for efficient use of accumulated vehicle track data" (Research and development of technology contributing to the improvement of the quality of road policy H28-30) in the past. In this study, that ETC2.0 data has many problems such as missing measurements, unstable sample rates and anonymisation problems, was found. Through interviews with regional development bureaus and other entities, we have also heard requests for matters that are not observable with ETC2.0, such as demand on the identification of the lanes on which each vehicle runs near an intersection.

The next-generation ETC system must satisfy these known problems and requirements with high-cost performance. To achieve this, it is essential to identify requirements through actual applications. The study of new observation technologies through field experiments is also indispensable for their introduction. Linkage with external data is also important. This study aims to propose a basic design for the next generation ETC system through requirement identification and elemental technology development, which is necessary and sufficient to meet the identified requirements, and which is in continuity with the current ETC 2.0 system.

### 2. Activities in Research Period

Research was carried out on the following five themes:

- Theme 1: Requirements identification through applications
- Theme 2: Practical feasibility study of various observation techniques
- Theme 3: Development of map-matching and anonymisation techniques
- Theme 4: Development of external data linkage technology
- Theme 5: Proposal of a basic design for a next-generation ETC system

### 3. Study Results

In Theme 1, case studies were conducted on a wide range of spatial scales and in different parts of the country, from nationwide traffic simulations using travel time data (Figure 1) to vehicle trajectory analysis at an intersection. Through these, the following requirements were identified: 'Eliminate missing measurements, even if we have to limit the number of recorded points', 'set multiple observation intervals and use them in different applications', 'make it possible to identify lanes', and 'link to external data'. Specific values were also proposed for the observation intervals.

Theme 2 showed that GPS/GNSS also has a certain level of observation accuracy, but is inadequate for identifying driving lanes (Figure 2). On the other hand, it was found that simply clipping and arranging a specific line in the driving recorder image can be used to identify the road surface conditions, such as driving lanes and snow conditions, with a significant reduction in image volume. This technique can identify the driving lanes more reliably.

Theme 3 proposed a new map-matching method, and demonstrated its performance by actual trajectory data. The positioning interval required for route identification was also quantitatively demonstrated. For anonymisation, we proposed a methodology for tracking specific vehicles in tertiary grid units while ensuring k-anonymisation, and demonstrated its performance on real data.

In Theme 4, a system that can link with various grid-base data was proposed together with a database system for vehicle trajectory data, and applied to case studies such as estimating the teleworking rate during the COVID-19 pandemic. As one method of linking a non-aggregated human flow dataset with the data of the next-generation ETC system without the personal information issue, we developed a technology for extracting the location of destinations and the time spent there, targeting sightseeing behaviour.

In Theme 5, we propose a basic design that satisfies the requirements of the case study at a realistic cost. For the *collection system*, we proposed to suppress missing measurements by setting multiple positioning intervals and to improve the quantity and quality of collected data by linking with driving recorders and smart phones. For the *storage system*, we proposed a map-matching method and a trajectory-data utilisation system to facilitate access to a vast amount of data. In the *aggregation system*, in addition to items that have shown their usefulness in case studies, such as travel time and stay data, trip information anonymised by the proposed method is also incorporated. Finally, the *utilisation system* incorporates external data linkage and traffic simulation to provide a framework for easy and extensive data utilisation.



Fig. 1 Nationwide-scale simulation calculating traffic volume changes by toll changes (Tokyo area enlargement)

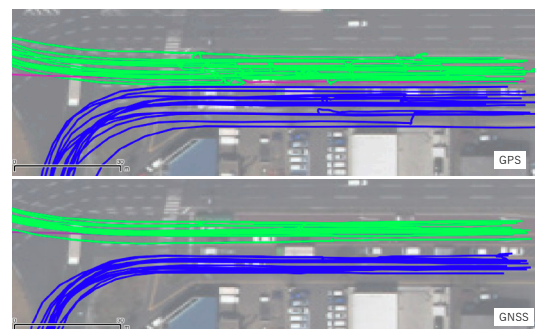


Fig. 2 GPS/GNSS accuracy comparison

#### 4. Papers for Presentation (all written in Japanese)

- Iwahara, Y., et al.: Study on Estimation of Traffic Conditions at Signal Intersections Using Vehicle Trajectory Data, Proc. of JSCE F3 (Civil Engineering Informatics), pp. I\_65-I\_72, 2022.
- Fukushima, K., et. Al.: Parameter Estimation of Signal Intersections Using Probe Car Data, Proceedings of the 60th Annual Conference on Civil Engineering and Planning, Vol. 60, 2019/12.
- Iryo, T. and Kamiya, D.: Descriptive analysis of migration behaviour and characteristics of destinations to stay using vehicle trajectory data, Journal of Civil Engineering and Planning, Vol. 63, 2021/6.
- Yasuda, S. and Iryo, T.: Evaluation of well-definedness of Macroscopic Fundamental diagram considering statistical error of observation data, Journal of Civil Engineering and Planning, Vol.63, 2021/6.
- Hashiguchi, G., et al.: Verification of applicability of map matching based on hidden Markov model, Journal of Civil Engineering and Planning, Vol. 63, 2021/6.
- Masuno, H., et.al: Extraction of potential destinations in sightseeing areas based on mobile data and map information, Journal of Civil Engineering and Planning, Vol. 64, 2021/12.

5. Future Issues: There are several elemental technologies that could be improved. These include automating the image processing of the driving recorder and extending the traffic simulator.

#### 6. Contribution to Road Policy Quality Improvement:

The quality of road policy is expected to be improved by reflecting the results in the development of the next generation ETC system and by applying the developed technologies to existing ETC 2.0 data.

7. Website: <http://web.tohoku.ac.jp/iryolabo/misc/20220311-Shindoro.html>