

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

No.	Title	Principal Researcher
No.31-3	Performance verification of roadside stations as centers of transportation, logistics, regional exchange, and disaster prevention and the optimal multi-purpose location problem	Nagaoka Univ. of Tech. Prof. Kazushi SANO

In order to clarify the efficient placement of roadside stations in a wide-area network and the amount of facilities required, this research discusses the functions of roadside stations to be utilized as transportation, logistics, regional exchange, and disaster prevention bases, and establishes a method to index the effectiveness of each function for each base based on the proximity between bases in a wide-area network and a multi-purpose optimal placement planning method.

### 1. Backgrounds and Objects

Michinoeki, or roadside stations should serve as relay and nodal points in transportation and logistics networks, along with other transportation hubs such as expressway rest facilities (SA/PA) or Basta-Shinjuku. At the same time, they should also function as places for drivers' rest and time adjustment. To maximize these utilities, the optimization of their location in the wide-area network is necessary. In case of large-scale disasters which occurred frequently recently, roadside stations are expected to serve as depots for emergency supplies, and bases for volunteer activities from emergency to recovery phase.

Current policies do not response to these problems so far. For example, only linear plans such as "locate SA/PAs every XX km" has been discussed. In recent years, the use of probe data such as ETC2.0 has made it possible to grasp the actual usage of road users in terms of area and time, and the practical application of wide-area network simulation technology has made it possible to evaluate measures with fine temporal resolution. The foundations for starting new initiatives are now in place.

This project proposes a method for quantifying how effectively roadside stations can fulfill the following functions: (1) wide-area transportation and logistics network, (2) regional exchange, and (3) stockpiling supplies, transportation depot, and activity base in the event of a disaster. We also propose a method for quantifying how effectively these functions can be demonstrated. We also propose a method to determine the optimal layout of roadside stations in a wide-area network by using multi-objective optimization theory.

### 2. Activities in Research Period

Theme 1: Development of a database on the use of existing facilities using ETC2.0 probe data, etc.

The project used ETC2.0 probe data, commercial vehicle probe data, and other traffic data to quantitatively determine the use of roadside stations (number of vehicles using the station, origin and destination of vehicles using the station, stopping time, arrival and departure times, number of stops by travel time period, and stopping locations). The survey covered roadside stations in the Kanto region and Niigata Prefecture, with trips that included the surveyed roadside stations in their routes.

Next, a questionnaire survey was conducted among 1,193 roadside station managers nationwide to supplement the Roadside Station DB by MLIT. The questions included the functions of tourism and disaster prevention, the purpose of development, the importance of the three basic functions (rest function, information provision function, and regional cooperation function), the importance of evaluation factor facilities, and items related to the maintenance status. In addition, data on facility attributes such as facility size, functions, and user characteristics, socioeconomic data such as population and production value, and traffic data such as access time to highway interchanges were collected for roadside stations in the Kanto region, and were compiled as tertiary mesh data.

On the other hand, a web-based questionnaire survey was also conducted targeting users of roadside stations. The questions asked were the status of use, satisfaction with the facilities used, and the level of importance. The number of users and time of use were measured at nine roadside stations in the Niigata-Kanto region by registered location, and the number of roadside station users obtained from the ETC2.0 data was corrected.

## Theme 2: Development of a performance verification method for a wide-area transportation and logistics network hubs

In order to clarify the requirements of roadside stations as bases for wide-area transportation and logistics networks, we conducted a literature review and interview surveys to clarify the state of development of roadside stations and facilities with similar functions (SA/PAs and private logistics facilities).

Next, focusing on the rest function of roadside stations, we categorized stopover behavior patterns by means of a Web questionnaire survey, and constructed a model of stopover facility selection behavior for each pattern. Using commercial vehicle probe data, we showed that the number of vehicles stopping at a roadside station can be estimated from the attributes of the station and the surrounding environment. We refined this stopover facility selection behavior model and conducted a performance test of roadside stations in the Kanto region.

On the other hand, we developed a simplified method for performance verification of rest functions for wide-area traffic (passenger cars and freight vehicles), temporary evacuation functions for road users, and wide-area traffic node functions, and conducted performance verification of roadside stations in the Kanto metropolitan area and six prefectures. In addition, a prototype of a simplified evaluation system that can easily evaluate the functions of rest areas for freight vehicles, temporary evacuation of road users, and wide-area disaster prevention was developed.

## Theme 3: Development of a method for verifying the performance of roadside stations as bases for regional exchange and disaster activities

We identified the expected functions of roadside stations for the purpose of disaster prevention based on the previous disaster cases (2004 Niigata-Fukushima Heavy Rain to 2017 Northern Kyushu Heavy Rain), a questionnaire survey of roadside station managers, and interviews with roadside stations damaged by the Northern Kyushu Flood (2017) and Typhoon No. 15 and No. 19 (2019). In addition, focusing on information provision and stopover behavior as one of the regional exchange functions, we developed a model to estimate the round-trip rate based on the trajectory data of ETC2.0 probe data using roadside stations, developed a method to quantitatively evaluate the effect of information provision, and were able to measure the benefits.

By clarifying the requirements and criteria for facilities and equipment necessary for the

functions of a wide-area disaster prevention bases (entry base, rescue center, and wide-area supply center), we developed a performance verification method and conducted a performance verification of existing roadside stations. As a regional disaster prevention center, we developed a performance verification method for a facility with functions equivalent to those of a designated evacuation center in a municipality, and constructed a system for selecting the optimal location in Nagaoka City.

We also developed a method to check the performance of the functions as a living base in depopulated areas, as a regional public transportation node, and as a shelter, and constructed a system to select the optimal location in Nagaoka City.

#### Theme 4: Development of a method for optimal layout planning of roadside stations

Using a wide-area traffic simulation, we verified the accessibility of roadside stations and evaluated the applicability of the method. For example, for the rest function, we proposed an evaluation index for the nearest roadside station on the route of each trip obtained from the simulation, which aggregates the stopover potential calculated by the time distance from the origin of each trip to the roadside station and from the roadside station to the destination, so that the value for each facility can be obtained. Using the above data, the optimal allocation problem for the purpose of minimizing the average travel distance (i.e. optimized accessibility) was solved using two types of mixed integer programming (a p-median problem, which assumes demand in the neighborhood of the roadside stations and assumes round-trip travel between demand points and facilities, and a flow capturing type problem, which assumes demand in a wide area and assumes flows with an origin and a destination). The average distance traveled after rearranging all the facilities was greatly reduced compared to the current situation, suggesting the effectiveness of the optimal layout.

In addition, based on integer programming, the multi-purpose optimal layout of roadside stations in Kanto region was studied by focusing on the differences in various assumptions. In the optimization calculation, we used the following eight patterns [(accessibility or coverage) x (neighborhood demand or wide-area demand) x (normal conditions or disaster conditions)] and their multi-objective optimizations: [(considering land price or not considering land price) x (free facility stopover or facility stopover near the middle) x (all facilities or some facilities)] to estimate the change in demand trends. We conducted elaborate optimization calculations by introducing 1 km mesh data for Tokyo and 11 prefectures and actual road network times that also take congestion into account. The effect of the placement of "disaster prevention roadside stations" as relay points for relief supplies was also quantitatively determined.

### 3. Study Results

Establishment of performance verification method

Establishment of a simplified performance verification method

Establishment of data base for performance verification

Solving the optimal layout plan of a roadside station at the level of a real problem

### 4. Papers for Publication

- 1) Takao TAKAHASHI, Kazushi SANO, Kiichiro HATOYAMA: Possibility of Regional Revitalization through Collaboration between Roadside Stations and Neighborhood Stores, Journal of the Eastern Asia Society for Transportation Studies, Vol.13, p. 1150-1159, 2019
- 2) Takeshi TAKEUCHI, Takao TAKAHASHI, Kazushi SANO, Kiichiro HATOYAMA and Yoko MATSUDA: ANALYSIS OF TOURING ACTIVITY BASED ON THE LOCATION

AND FACILITY CHARACTERISTICS OF ROADSIDE STATIONS: Journal of JSCE D3 (Infrastructure Planning and Management) Vol.76, No.5 (Infrastructure planning review Vol.38), p.I\_603-I\_608, 2021.

- 3) Masahiro ARAKI, Kiichiro HATOYAMA, **Kazushi SANO**, Takao TAKAHASHI : Feasibility of Implementing Ride-Sharing Service as Public Transportation System Considering the Effect of Promoting Exchange in Aging and Depopulated Areas, JSTE journal of traffic engineers (Special Issue) Vol.7, No.2, p. A\_185-A\_192, 2021.
- 4) Yudai Homma, Shinichiro Kai, Ryota Horiguchi, **Kazushi Sano** and Takashi Oguchi: Optimal Location of Roadside Stations Assuming Various Users and Functional Development, Journal of JSCE, D3 (Infrastructure Planning and Management) Vol.77 No.5, p.I\_777-I\_786,2022
- 5) Shintaro Terabe, Ryota Onose, Hideki Yaginuma, Kosuke Tanaka, Multi-criteria analysis for evaluating the function and location of roadside rest areas to improve disaster preparedness, Asian Transport Studies, Volume 8, 2022, 100075, <https://doi.org/10.1016/j.eastsj.2022.100075>.
- 6) Maika KUBO, **Kazushi SANO**, Takao TAKAHASHI, and Yoko MATSUDA: Optimal Location of a Roadside Station as a Transportation Node for the Last One Mile: Journal of the Eastern Asia Society for Transportation Studies, Vol.14 (Accepted)
- 7)Kaoru OHNUMA, Towa TSUKADA, Emiri KAKOI, **Kazushi SANO**, Takao TAKAHASHI, and Yoko MATSUDA: Factors Attracting Customers Based on Estimated Number of Users of Roadside Stations, Journal of the Eastern Asia Society for Transportation Studies, Vol.14 (Accepted)

## 5. Study Development and Future Issues

We developed a prototype of an evaluation system that calculates the index of each roadside station to be constructed on an arbitrary mesh in the Kanto region by inputting their attributes. At present, the system has only four functions: (1) rest function for wide-area traffic (freight vehicles), (2) wide-area disaster prevention base function, (3) temporary evacuation function for road users, and (4) customer attraction function.

In addition, a demonstration experiment for social implementation is also necessary. With the help of a subsidy from Niigata Prefecture, we plan to conduct a demonstration experiment in September 2022 at "Michi no Eki Ryokan no Sato Wajima" in Nagaoka City, Niigata Prefecture, on how to revitalize the local community by utilizing a roadside station, including a carpooling service to and from the station, a mini supermarket, product delivery, and holding events.

## 6. Contribution to Road Policy Quality Improvement

At present, the simplified evaluation system developed in this study is a prototype, but it will be sufficiently practical to check feasibility by developing data on a national level and adding other functions. Municipal administrators only need to select a mesh of sites to be established and input the attributes of the roadside station, and the evaluation values of the roadside station are output. The manager of the roadside station can also see what effects may emerge by changing the attributes of the roadside station, and this information can be used for investment decisions.

## 7. References, Websites, etc.

None.