Effort for Realization of Automated Driving on General Roads

(Research period: FY2020-)

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1. Introduction

All levels of governments in Japan are working on unmanned automated driving services in limited areas with the goal of "Social implementation in more than 100 locations by 2030".[1)] As a part of that , the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been conducting the field operational tests for automated driving services based on roadside stations etc,. (hereinafter referred to as the "FOTs"[2)]) in collaboration with the Strategic Innovation Promotion Program (SIP) of the Cabinet Office.

In the FOTs, various automated driving vehicles were used according to the location of the FOTs. Of these vehicles, it was confirmed that autonomous vehicles that use only the high-precision GPS (RTK-GPS) or LiDAR to localize own vehicles could not continue automated driving when manual intervention became necessary because of terrain or weather conditions.[3)] On the other hand, with vehicle to infrastructure (V2I) type automated driving vehicles, which localize own vehicles using the magnetic force or radio wave emitted by road surface facilities (electromagnetic induction lines and magnetic markers installed on or under the road surface to support the localization of own vehicles; See **Figure 1**), no manual intervention was occurred due to the terrain or weather conditions, and stable automated driving was achieved.

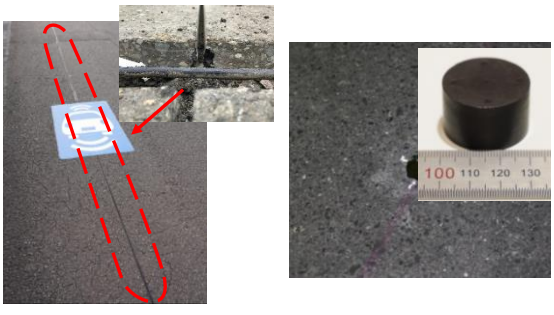

Figure 1: Example of road surface facility (Left: Electromagnetic induction line; Right: Magnetic marker)

This paper introduces the efforts to draft the technical standards and the manual for the installation of road surface facilities, as well as the survey research necessary for said facilities.

2. Technical standard for installing supporting infrastructure for automated driving (road surface facilities)

Since the effectiveness of road surface facilities was confirmed in the FOTs, the Road Act has been revised in May 2020, and road surface facilities have been positioned as the road accessories. NILIM has drafted the technical standards (installation standards) for the planning, design, and construction of road surface facilities, and the Director-General of the Road Bureau of MLIT notified the Regional Development Bureaus etc., of the standards in November 2020, through the research and deliberation by the Road Engineering Group in the Road Subcommittee of the Panel on Infrastructure Development. The standards are characterized particularly by the following.

- Defined the road surface facilities clearly.
- Specified the technical characteristics required for the road surface facilities in terms of "performance."
- Determined the design requirements of the road surface facilities not to affect the function of the pavement, the reuse of the pavement materials, or the performance of the road structure significantly.
- Stipulated that road administrators should publicly announce the locations of installed road surface facilities, so that vehicle operators can participate in automated driving services in such locations.

3. Drafting of a manual to explain the technical standard for installing supporting infrastructure for automated driving (road surface facilities)

NILIM has been conducting a series of the survey research to obtain the engineering knowledge on road surface facilities. Based on the knowledge obtained, we will draft a manual to explain the technical standard for installing supporting infrastructure for automated driving (road surface facilities), which will be reviewed by the Road Surface Facilities Sub-Working Group established in the Road Structure Standards Subcommittee of the Japan Road

Association. Here, as an example of studies, we introduce the work that was conducted to identify the optimal installation interval of magnetic markers.
In the FOTs, magnetic markers had been installed at two (2) meter interval based on empirical rules. However, if the installation interval of magnetic markers could be larger, the installation cost could be reduced. It is also assumed that the interval required for the installation of magnetic markers is different when the driving route of the automated driving vehicle is straight and when it is curved. For this reason, the tests were conducted on the test track at NILIM to analyze the relationship between the (linear) travel route of the automated driving vehicle and the installation interval of the magnetic markers, and to identify the optimal installation interval of the magnetic markers. Firstly, magnetic markers were placed on the test track under the conditions shown in **Table 1** and **Figure 2**. Then, the automated driving vehicles (**Figure 3**: Bus type, passenger car type) were driven at multiple speeds (5-30 km/h), and the vehicle's traveling track (the width of deviation from the center line of the magnetic marker) was measured using a (commercially available) drive recorder and laser pointer. At present, we are analyzing in detail the relationship between the vehicle's traveling track and the installation interval of the magnetic markers, and plan to organize a rational installation method of magnetic markers and reflect it in the draft of the manual.

Table 1: Installation interval of magnetic markers

Assumed road structure	Curvature (R)	Installation interval
Intersection (Left turn section)	12 m	(1) 1 m (2) 2 m
Non-intersection road (Curve section)	30 m	(1) 1 m (2) 2 m (3) 8 m
Non-intersection road (Straight section)	∞	(1) 2 m (2) 8 m (3) 16 m

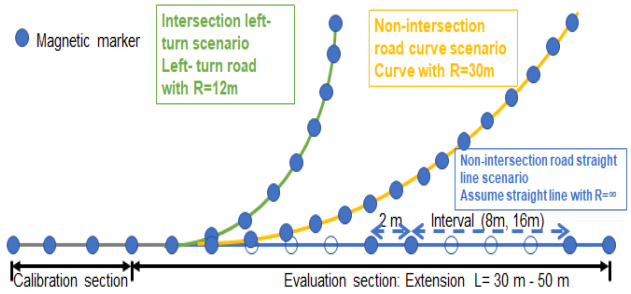

Figure 2: Installation method of magnetic markers (image)

Figure 3: Test on the installation interval of magnetic markers
(Left: Bus type, Right: Passenger car type)

4. Conclusion

A road surface facility is important infrastructure that is indispensable for continuously stable automated driving operation. The technical standard for installing supporting infrastructure for automated driving (road surface facilities) was drafted by NILIM and released by the Road Bureau of MLIT. We believe that the preparation of a manual for the technical standard will further improve the environment for the implementation of automated driving services in rural areas.
NILIM will continue to conduct the research on road surface facilities and provide the engineering support for local governments to support the social implementation of automated driving services.

☞See the following for details.

1) Public-Private ITS Initiative Roadmap 2019
https://www.kantei.go.jp/jp/singi/it2/kettei/pdf/20190607/siryou9.pdf
2) Website for automated driving service based at roadside stations, etc. in mountainous regions
https://www.mlit.go.jp/road/ITS/j-html/automated-driving-FOT/index.html
3) The 60th Conference of the Committee of Infrastructure Planning and Management, No.7172
Analysis of Issues and Responses to Automated Driving in Mountainous Regions through Demonstration Tests