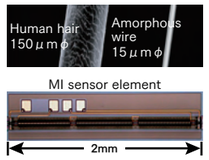
# Advanced Technologies Supporting GMPS

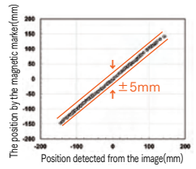
## 01 Ultra-sensitive magnetic sensor

Uses an ultra-high sensitivity magnetic sensor "MI sensor (magnetic impedance sensor)" that applies Aichi Steel's advanced material "amorphous wire".
It has the potential to detect the magnetic field of the magnetic marker even at a distance of 1m.
※The product is optimized for a distance of 20cm.



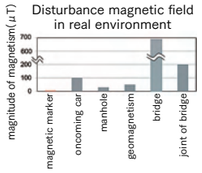

## 02 Vehicle position detection accuracy

Position detection accuracy of +-5 mm is achieved by actual vehicle measurement (accuracy of +-1mm in lab)
In the "precision docking" system, which closely stops at bus stops, tens of millimeters can be realized in combination with vehicle control even for large buses.



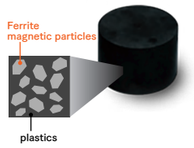

## 03 Magnetic noise disturbance rejection

A noise elimination process that responds only to magnetic distribution patterns of markers was developed.
We have made it possible to extract a marker signal buried in the surrounding noise.
The effectiveness of this noise removal technology has been demonstrated in a variety of road environments to date.



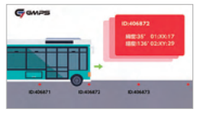

## 04 Durability of magnetic markers on road surfaces

Magnetic force of the ferrite magnet, which is the material of the magnetic marker, is semi-permanent in the natural environment. Therefore, it has a durability that is sufficiently longer than the repair period of the road surface.




## 05 Acquisition of high-precision absolute coordinates

RF-ID enables the identification of individual magnetic markers.
In addition to the conventional high-precision position detection by magnetism, it is now possible to obtain absolute coordinates.



## 06 Preventing spoofing of magnetic markers

The position information of the newly detected marker is always compared with the last detected data.
Alarms can be issued if they differ significantly from the expected.
In addition, for markers with RF-ID, the information held can be encrypted and set it so that only the authorized vehicles can read it.

## 07 Method of magnetic marker installation on road

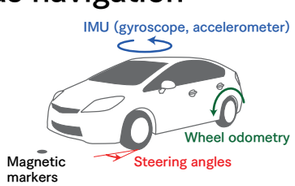
Draw an assumed driving trajectory on the road, and then bury or affix markers at predetermined intervals on it. No prior survey required.
After installation, the position can be measured in a short time using a total station, etc., starting from the position reference point.
For surface-mounted types, we are developing an automatic installation machine for continuous attachment.

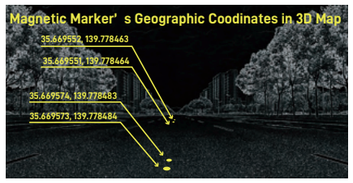
## 08 Cost of laying magnetic markers

- Marker uses ferrite magnetic materials, which are widely available around the world, and there are no resource problems or concerns about higher prices.
- The installation cost is expected to become cheaper by using automatic installation machines.
- There is no problem with the conventional disposal process for discarded asphalt generated at the time of road resurfacing.

## 09 Integration with autonomous navigation

Magnetic marker position information installed at key locations can be utilized for cumulative error correction of position, which is one of the issues of autonomous navigation, and for relocation after loss, and the accuracy of autonomous navigation can be dramatically improved.
In addition, it is possible to greatly reduce the burden of data processing required for the process of identifying the vehicle position by embedding the coordinated information of magnetic markers within digital three-dimensional maps in the future.




**TOPIC** In 2020, the Japanese Road Act was revised to position "Facilities to assist autonomous driving (Magnetic Markers, etc.) as a fixture to roads (in the case of private businesses, a road occupying structure)" under the provision of "Maintenance of Facilities that Assist Autonomous Driving in the Road Space."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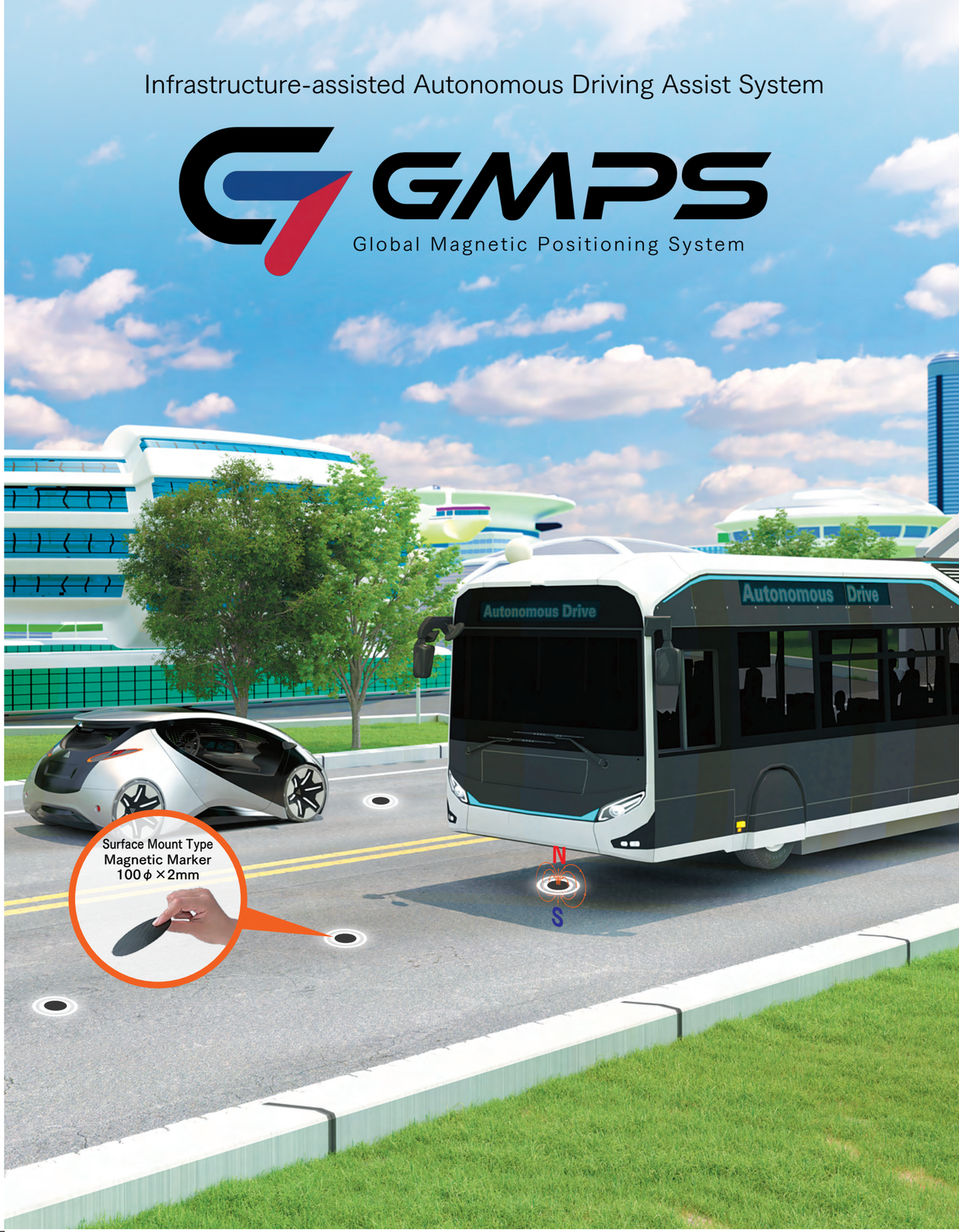
Infrastructure-assisted Autonomous Driving Assist System

# GMPS

Global Magnetic Positioning System

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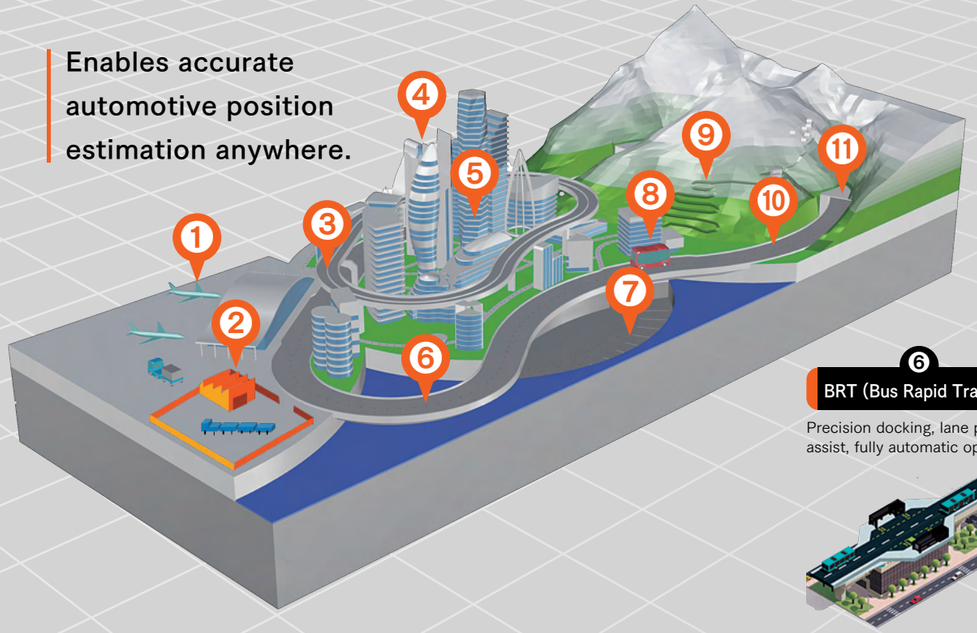
# GMPS can complement conventional autonomous driving and contribute to sooner practical implementation.

GMPS (Global Magnetic Positioning System) is an infrastructure assisted high precision vehicle position estimation system that utilizes weak magnetism.
Simply install the magnetic markers on the necessary parts of the road and mount the sensor unit on the vehicle.
Even at spots that are difficult with conventional autonomous driving, the vehicle position can be found to within millimeters.

## Use Cases

Enables accurate automotive position estimation anywhere.




### ① Airport GSE vehicle control

Automatic operation of AGVs in two-dimensional planes in airports and harbors by placing markers in a grid

### ② Factory logistics and home delivery robots

Distribution vehicles on the plant premises

### ③ Running under elevated railway tracks

Under elevated tracks where GPS signals do not reach

### ④ Driving in high-rise commercial districts

Built up streets where GPS signal multipaths occur

### ⑤ Office home-delivery robots

Vehicles for delivery between offices

### ⑥ BRT (Bus Rapid Transit)

Precision docking, lane passing assist, fully automatic operation



### ⑦ Underground parking and valet parking

Indoor valet parking

### ⑧ Precision docking at bus stops

As long as it is within the sensor width range, a single marker line can be used to achieve accurate docking by traveling in the center of the lane and shifting the width of the lane.

### ⑨ Snowfall

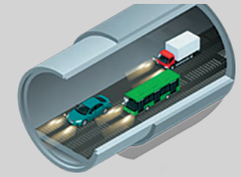
In an environment with snowfalls and fallen leaves where white line reading becomes impossible

### ⑩ Monotonic landscape, non-reflective environment, dense fog

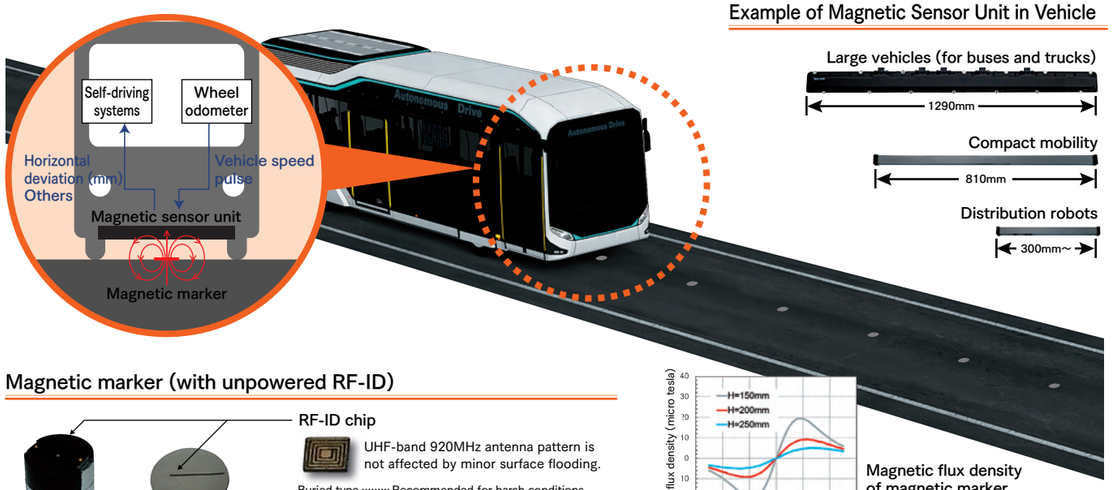
In circumstances where sensing by LiDAR is difficult

### ⑪ Running in tunnels

In tunnels where GPS signals do not reach



## System Configuration*1




### Example of Magnetic Sensor Unit in Vehicle

Large vehicles (for buses and trucks)
1290mm

Compact mobility
810mm

Distribution robots
300mm~

### Magnetic marker (with unpowered RF-ID)



Buried type
30ϕ×20mm

Surface installation type
50ϕ×2mm
100ϕ×2mm

RF-ID chip

UHF-band 920MHz antenna pattern is not affected by minor surface flooding.

Buried type ····· Recommended for harsh conditions where the road surface is scraped, such as by snow-removal vehicles

Surface installation type ··· Recommended for applications where vehicles are less likely to drive over marker or for temporary priority services




Magnetic flux density of magnetic marker

*1 Specifications are subject to change without notice during development.

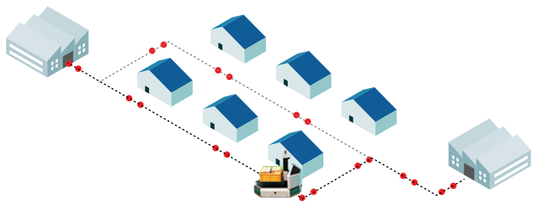
## Arrangement of Magnetic Markers

You can flexibly set the arrangement pattern of magnetic markers on the road. Through the use of RF-ID data and the setting of magnetic poles, with the marker as our landmark, we are now able to realize a free trajectory.

### Case1 Plant Logistics

**Markers not laid down evenly but used as landmarks for correcting positions.**

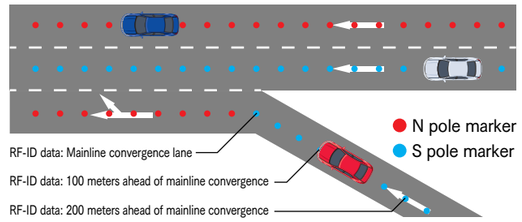
Placed as required (2m interval pair placed 10m)



### Case2 Expressway

**Corresponds to mergers and lane changes by utilizing N and S poles and RF-ID location information**

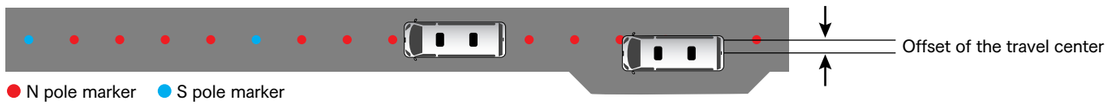
Installing different polarity by Lane + Adding RF-ID Positioning to Pre-Merger Markers




### Case3 Bus only road

**With a sinlge line of magnetic markers, in addition to passing by in the center of the road, it also provides offset and precision docking functions.**

Four N poles (no RF-ID) and one S pole (with RF-ID) are installed at intervals of 2m each.



GMPS

# Demonstrating Reliability in Various Environments in Japan

# GMPS demonstration

| | Timing | Region | Location | Sponsored by | Features |
|---|---|---|---|---|---|
| 1 | 17-Nov | Higashiomi City, Shiga Prefecture | Michi-no-Eki Okueigenji Keiryu no Sato | Ministry of Land, Infrastructure, Transport and Tourism | Drive in mountainous areas where GPS signals do not reach |
| 2 | 17-Dec | Ginowan City/ Kitanakagusuku Village, Okinawa Prefecture | | Cabinet Office | Implemented precision docking to accurately align with and stop at the bus stop. |
| 3 | 17-Dec | Taiki Town, Hokkaido | Michi-no-Eki Cosmall Taiki | Ministry of Land, Infrastructure, Transport and Tourism | Drive in snow where reliability of on-board cameras is not sufficient |
| 4 | 18-Feb | Ina City, Nagano Prefecture | Michi-no-Eki Minami Alps Mura Hase | Ministry of Land, Infrastructure, Transport and Tourism | Traveling in tunnels where GPS signals do not reach or narrow dog-legs with a road width of 4.5m |
| 5 | 18-Apr | Kitakyushu City, Fukuoka Prefecture | Kitakyushu Science City | Kitakyushu City | Steady running at a maximum speed of 40km/h and control adjustment at the intersection left-turn |
| 6 | 18-Oct | Hitachi City, Ibaraki Prefecture | Hitachi BRT some routes | Ministry of Economy, Trade and Industry<br>Ministry of Land, Infrastructure, Transport and Tourism | Exclusive bus roads and public roads using abandoned rail lines |
| 7 | 18-Dec | RikuzenTakata City, Iwate Prefecture | Ofunato Line BRT Vicinity of Takekoma Station | JR East | Carried out alternate passage with oncoming vehicles on roads exclusively for buses and precision docking control |
| 8 | 19-Jan | In an airport restricted area | 4 airports including Haneda Airport | Ministry of Land, Infrastructure, Transport and Tourism | Run below the boarding bridge where GPS does not reach in airport restricted areas |
| 9 | 19-Feb | Tama City, Tokyo Metropolitan Government | Tama New Town | Tokyo Metropolitan Government | Driving on public roads that GPS cannot reach due to pedestrian bridges and street trees |
| 10 | 19-Nov | Onagawa Town, Oshika County Miyagi Prefecture | | Miyagi Prefecture | Returning ultra-compact shared electric vehicles to the station by unmanned driving |
| 11 | 19-Dec | Shibukawa City, Gunma Prefecture | | Gunma Prefecture | Traveling while performing roadside-to-vehicle communication in which the vehicle receives signal information, etc. from magnetic markers installed on the road surface |
| 12 | 19-Dec | Kesennuma City, Miyagi Prefecture | Kesennuma Line BRT Yanaizu-Rikuzen Yokoyama | JR East | Large buses run steadily at a maximum speed of 60km/h |
| 13 | 20-Jun | Ota Ward, Tokyo Metropolitan Government | Haneda Airport | Cabinet Office | Steady driving at a maximum speed of 60km/h while performing precision docking control, lane change, and right/left turn |
| 14 | 20-Jun | Ota Ward, Tokyo Metropolitan Government | Tenkubashi International terminal | Cabinet Office SIP | Circulation of public roads around airports |
| 15 | 20-Jul | Sanda City, Hyogo Prefecture | Woody Town | Ministry of Economy, Trade and Industry | Running with 2800 magnetic markers installed over almost entire course (6km) |
| 16 | 2020 | Hitachi City, Ibaraki Prefecture<br>Otsu City, Shiga Prefecture<br>Yokohama City, Kanagawa Prefecture<br>Sanda City, Hyogo Prefecture<br>Kitakyushu City, Fukuoka Prefecture | | Ministry of Economy, Trade and Industry<br>Ministry of Land, Infrastructure, Transport and Tourism<br>Ibaraki Kotsu<br>Keihan Bus<br>Kanagawa Chuo Kotsu<br>Shinki Bus<br>West Japan Railway Company | Public Implementation of Automated Drive Buses on BRT Routes<br>Creation of new transport axes and livelihoods at urban centers<br>Sustainable transport services in suburban residential areas in the Hill area of the Tokyo metropolitan area<br>Ensuring Intra-Regional Transportation to Improve the Quality of Life in Suburban Residential Areas<br>Travel below elevated roads (about 1.3km) where GPS is difficult to reach between airports and railway stations |
| 17 | 20-Nov | Tokoname City, Aichi Prefecture | Chubu International Airport Island | Aichi Prefecture | Running on railway bridges or terminal buildings where GPS cannot reach |
| 18 | 21-Jan | Tokoname City, Aichi Prefecture | Chubu International Airport Island | Aichi Prefecture | Drive level 4 through the restricted area |
| 19 | 21-Feb | Hamamatsu City and Mori-machi, Shuchi-gun, Shizuoka Prefecture | Hamamatsu SA, Enshu Morimachi PA | Ministry of Economy, Trade and Industry<br>Ministry of Land, Infrastructure, Transport and Tourism | Track-following unmanned fleet running on highway SA/PA and ramp-ways |

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