SIP-adus Workshop 2020
Dynamic Map

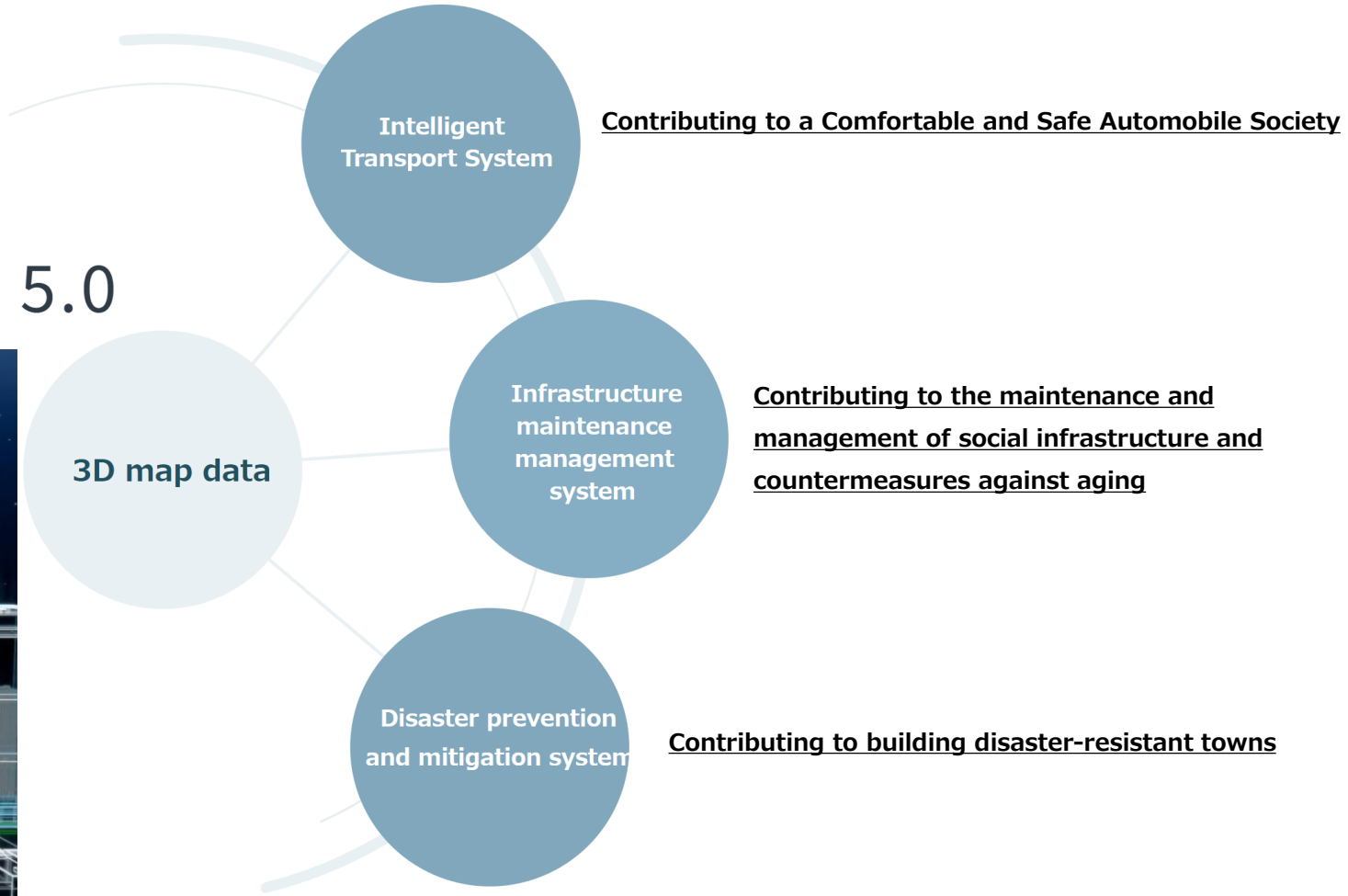
Dynamic Map Platform Co., Ltd.
Current Initiatives and Future Developments

November 11th, 2020

Dynamic Map Platform Co., Ltd.

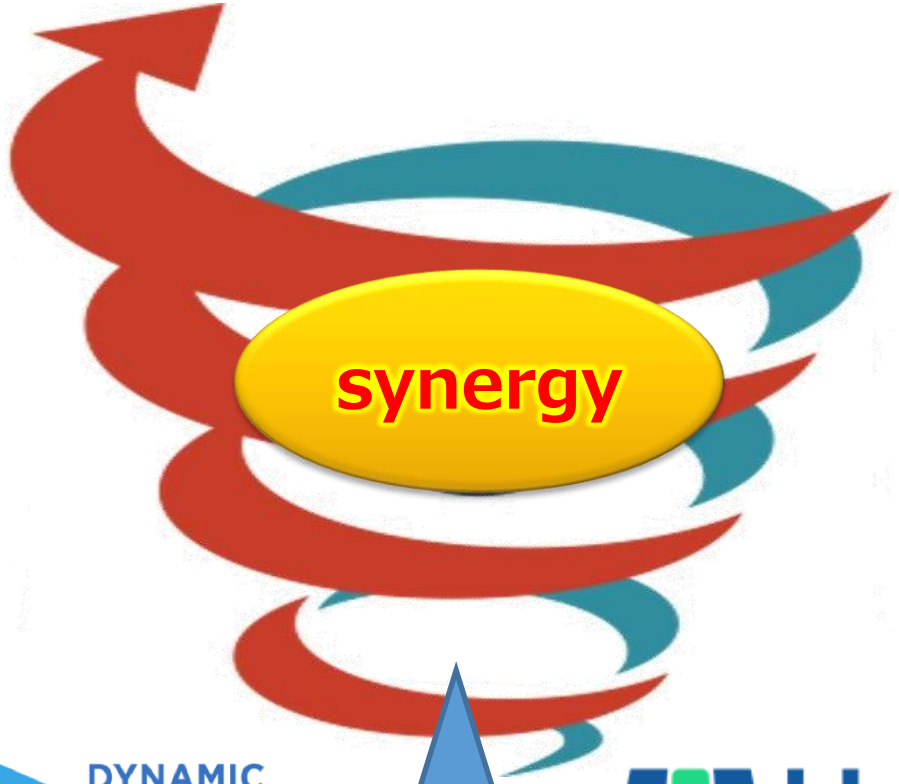
Dynamic Map Platform's Mid- to Long-term Vision

Realizing a common 3D positioning platform that contributes to Society 5.0



Integrating technology and business synergies with Ushr to develop business

- **In Japan, we have completed the construction of about 31,000 km of expressways and are at the data maintenance stage.**
- **As a group company, we will integrate our technologies and generate synergies.**
- **Expand coverage globally, including in Japan.**



Japan

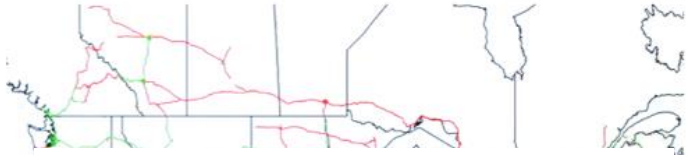
31,000 km

DYNAMIC MAP PLATFORM

DMP Group

Ushr The Best Way Forward

North America



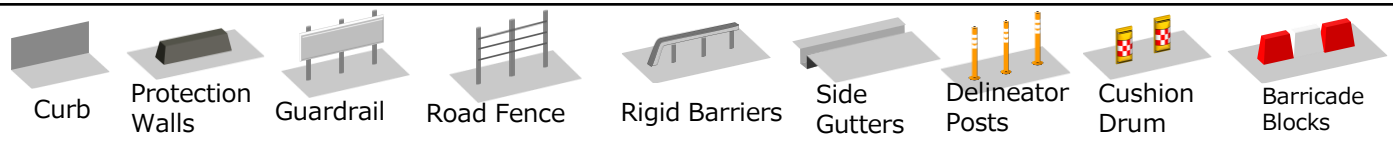
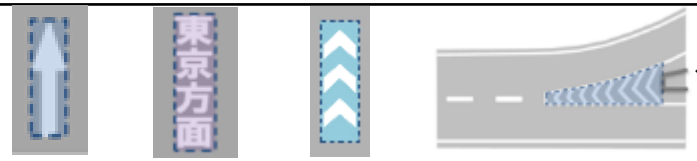
750,000 km

Current problem about road changes

3D HD-Map Road Features

We need to maintain data on a regular basis because of changing roads in many ways.

Current Lead Time **6 months/time** → **Goal: 1 month/time**

Road Features	Examples
Division Line	 Road Studs; Deceleration Markings; ←Outline of Channelizing strip
Multiple Division Line	
Road Edge	 Curb; Protection Walls; Guardrail; Road Fence; Rigid Barriers; Side Gutters; Delineator Posts; Cushion Drum; Barricade Blocks
Road Marking	 ←Fill of Channelizing Strip
Traffic Sign	
Vehicle Traffic Light	

3D HD-Map Data provide with *"Vector Data"* composed by above road features.

Today's Status : 3D HD-Map Maintenance Concerns

- For road data maintenance, it is difficult to detect road changes without road structural changes.
- It takes much cost because of operated confirmation tasks by human, therefore main issue is how to decrease the road data maintenance and update cost.

		Today's Status			
Geographical Feature Changes		**From Whom**	**How**	**When**	
With Road Structure Changes	New Road Development	✓ Road Operators' Information	✓ Monitoring the Website of Road Operators' ✓ Direct Interview	✓ 1month ahead of Changes	
	Road Extension				
	Changes to lane shape				
	Changes to number of lanes				
	Widened roadways				
	Add/remove/change ICs				
	Add/remove/change SA/Pas				
	Add/remove/change JCT				
	Add/remove/change toll gates				
	Changes in merging lanes				
Without Road Structure Changes (changes with small and medium scale)	Changes to number of lanes	✓ Road Operators' Information	✓ Same as "With Road Structure Changes"	✓ 2 to 4 weeks ahead of changes	✓ **Incomplete coverage of information**
	Widened roadways				
	Changes in merging lanes				
	Add/remove/change roadside structure	✓ None	✓ None	✓ None	✓ **Difficult to detect Road changes**
	Add/remove/change channelizing strips				
	Add type/color of carriageway markings				
	Add/remove/change emergency stopping areas				
	Repainting of carriageway marking				
	Add/remove/change road signs				
	Add/remove/change road marking				
	Add/remove/change traffic lights				

Methods of confirming changes and current changes

Amount of road changes with small and medium scale

DMP confirmed changing points by visual comparison for the Metropolitan and Tomei Expressway (Up-down), totally approximately 1,300 km.

Units: counts

feature	Add	removal	attribute change	Total
Division Line	16	2	1671	1689
Multiple Division Line	1	0	4	5
Road Edge	259	53	177	489
Road Marking	569	91	547	1207
Traffic Sign	216	175	453	844
Vehicle Traffic Light	1	1	5	7
All				4,241

A total of 4,241 changes were found to be highly distributed (3.3 locations per 1 km).

Current procedure for road change detection of small-mid scale

It is not possible to grasp change events with small and medium scale only from foresight.
To detect road changes, it is required that we gather all the road images in Expressway to compare before and after.

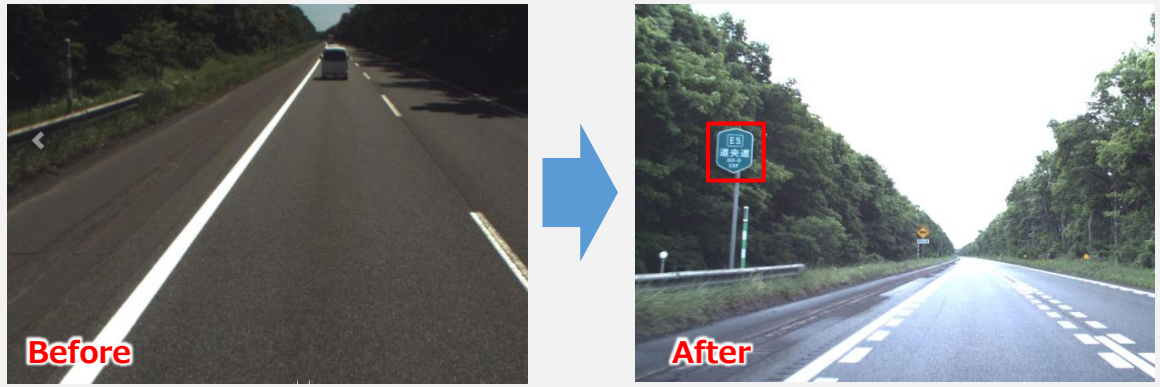
Changes associated with safety improvement measures

Example (1) Changes in the separation structure of a temporary two-lane section (installation of wire ropes)

Example (2) Countersailing prevention measures at merging section (Addition of rubber poles and road markings)

Changing events associated with expressway numbering

Example (3) Replacement of guide signs



Example (4) New installation of guide signs

Activity for the technical development to update 3D HD-MAP effectively

Challenges for 3D HD-Map Maintenance Solution

1. Consideration of narrowing down the events to be updated

Analysis of effects on self-driving cars

unique approach

2. Research and development to efficiently identify change events

Road change point extraction technology utilizing vehicle probe information (Research and Development 2- (1))

Road change point extraction technology using camera image data (Research and Development 2- (2))

2nd Phase SIP-adus Project Reports

3. Development of AI system

Development of road change point extraction function using AI

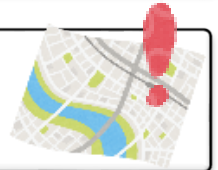
Collaborative data sharing and AI system development promotion project (NEDO *)

*NEDO: New Energy and Industrial Technology Development Organization

<Developing Process of 3D HD-Map >

Identification of change events affecting the vehicle

Extract Road Changes



Measure Road (MMS)

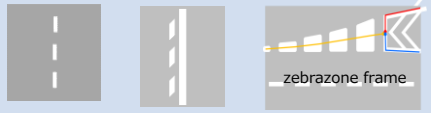
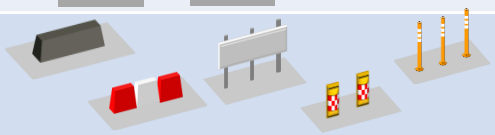
Process of Merge Point Cloud Data

Mapping 3D HD-Map

Product Release

1. Consideration of narrowing down the events to be updated

In collaboration with OEM's, we analyzed the impact on self-driving vehicles of each road feature/change event, and narrowed down the events subject to maintenance. (About 1/10)

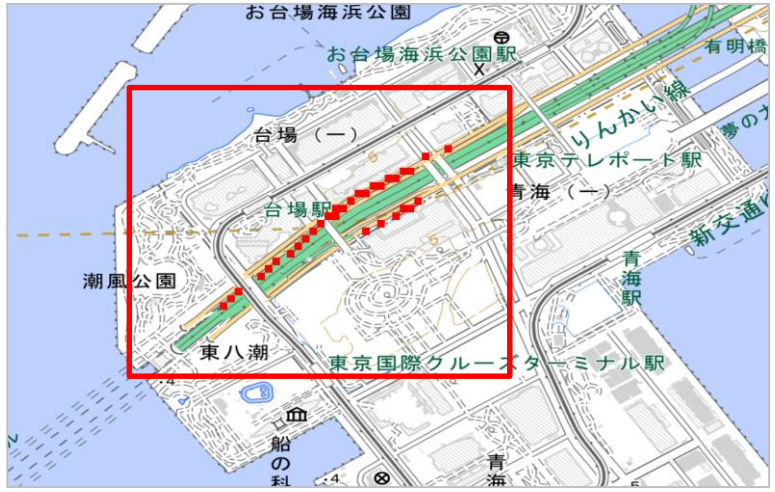
Road Features	Examples	Changing event
Division Line		[Common] ✓ Establishment or Abolition of Local Property ✓ change of features ➢Color, shape, and text ➢shape, format [By geographic feature] ✓ lot line ➢Color, Linetype ➢Location ✓ shoulder edge ➢Shape ➢Structure Changes ✓ road marking ➢Color ➢Linetype ➢Width ... etc.
Multiple Division Line		
Road Edge		
Road Marking		
Traffic Sign		
Vehicle Traffic Light		

Analysis and prioritization for each feature/change event

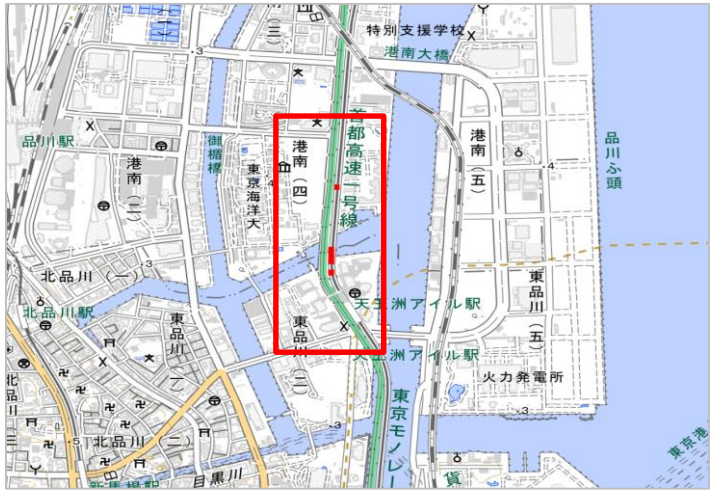
Deal only with high-priority events

2- (1). Road change point extraction technology utilizing vehicle probe information

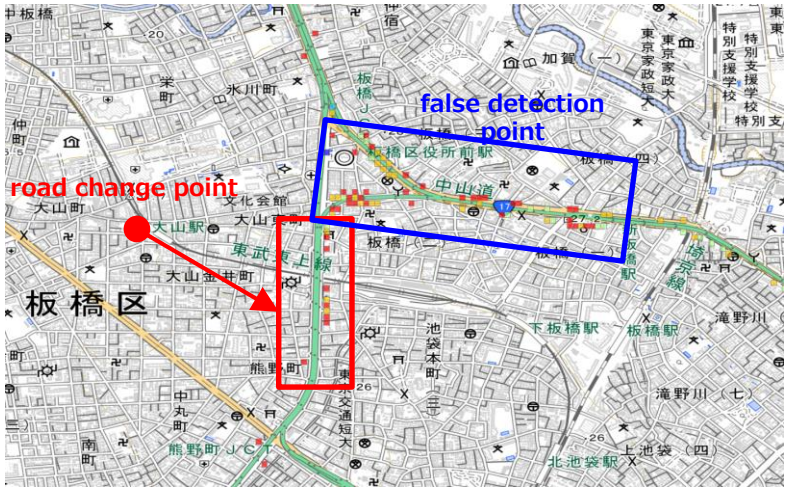
- As the result of our verification using vehicle probe data, we discovered that the following two factors had a significant impact on change point detection: 1) parallel and intersecting ordinary roads which produce noise in expressway vehicle probe data 2) the state of roads and nearby structures that have an impact on vehicle measurement precision.
- Verification found that vehicle distribution patterns could be effectively used to identify road change points in locations with ideal environments -- environments in which there is a sufficient amount of vehicle probe data, in which there are few nearby ordinary roads with high traffic volumes that produce noise in the data, and in which there are few measurement situation disparities.



Example of correctly extracting road changes



Example of False Detection Suspected of Mixing Historical Data on General Roads



Example of False Detection Suspected of Loss of GNSS Positioning Accuracy

In the existing vehicle probe information, the role in the change point detection of the 3D HD-MAP is small.

In fiscal 2020(FY2020), we will clarify the scope of utilization on paper.

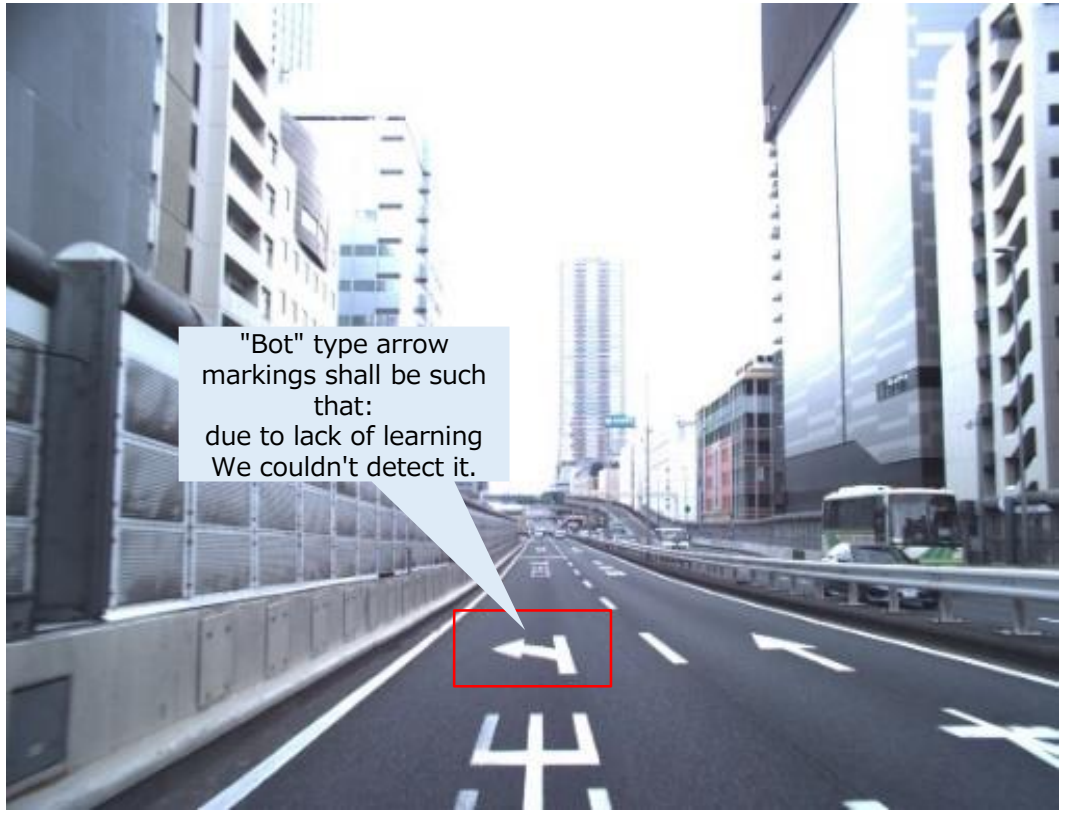
2- (2). Road change point extraction technology using camera image data

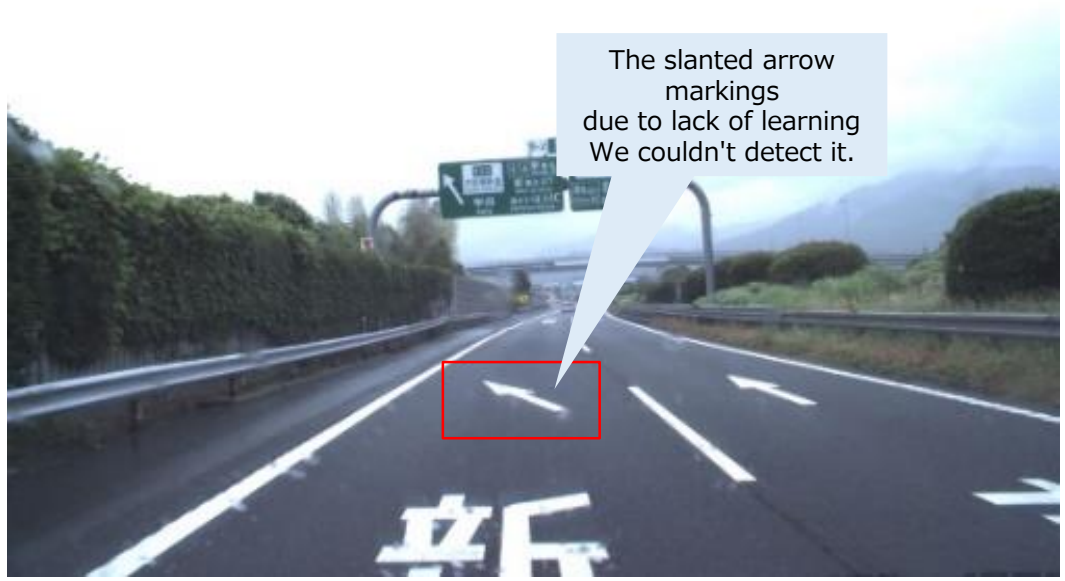
- In FY2019, 3 companies of A, B and C with the following elemental technologies were used to detect the change point.
  - ✓ Identifying geographic features from in-vehicle camera images
  - ✓ Localization of the detected feature
  - ✓ Compare old and new and detect change points
- As a result of the comparative evaluation of the three companies, it was found that Company A system was the most suitable for road change point extraction.

	Technical requirements for road change point extraction			
	It is possible to recognize the constituent features of a 3D HD-MAP.	In addition to GNSS For the identification of locations Maintain Systems	with a map of our company capable of being compared	can be compared by feature
Company A	△	○	○	○
Company B	△	○	× It can be compared only with the map made by B company.	× You can only compare by area.
Company C	△	× In GNSS alone, fail to detect changes correctly	○	○

2- (2). Road change point extraction technology using camera image data

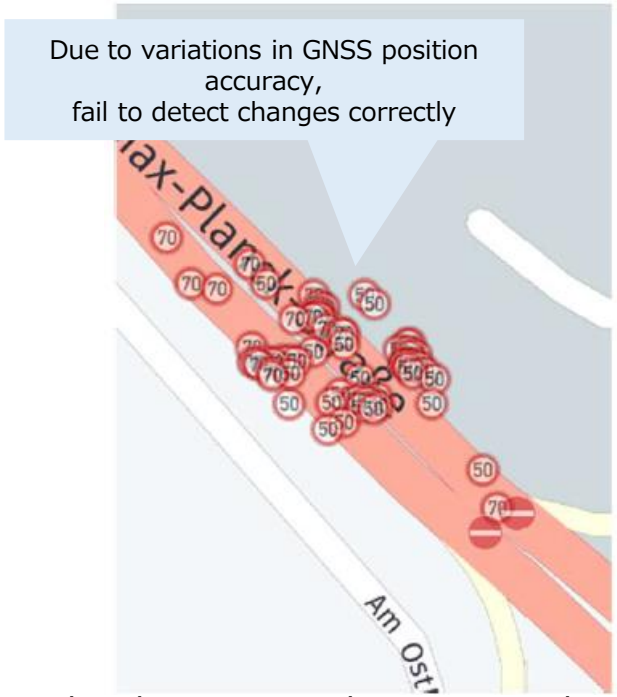
■ Since each system has a difference in the feature to be detected, it is adapted to the constituent feature of the 3D HD-MAP.



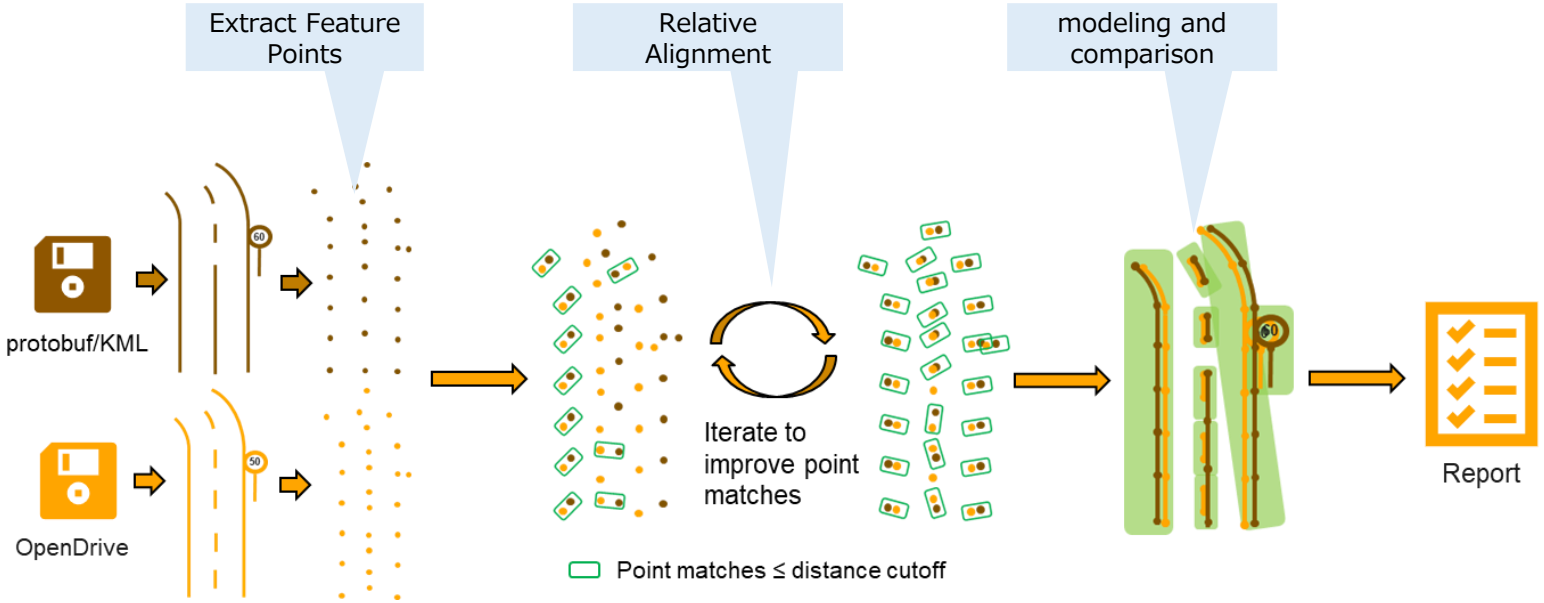


2- (2). Road change point extraction technology using camera image data

- Systems dependent on GNSS location accuracy may not detect changes correctly
- It is useful that system to relatively localize before and after changes.



<Example where GNSS alone cannot detect changes>



<relative localization mechanism>

2- (2). Road change point extraction technology using camera image data

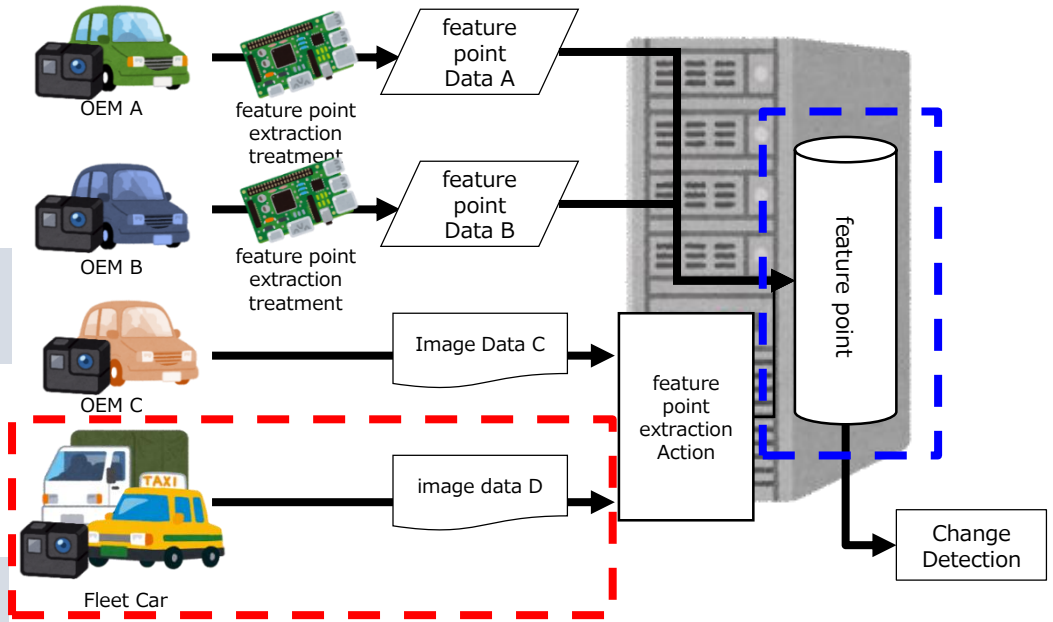
■ To arrange an operation method for actually collecting camera image data

- Various methods can be considered for operation (right view)
  - ① Operation of extracting feature points on the edge side (Vehicle) and transmitting/collecting them to the server side
  - ② Operation of collecting and storing images such as drive recorders on the server side

The challenge is to define and standardize the requirements and specifications for "feature point" and "Camera image data".

- ① take time to build operations
  - ➢ OEM, Tier 1 should be aligned with hardware and business

It is necessary to examine the operation method of (2) with an eye to quick practical application.



[Image of operation method for collecting camera image data]

[Activities in FY2020]

- ➢ **Demonstrate using Fleet Car for rapid commercialization (Red Dash)**
- ➢ **Compile requirements and specifications for "feature point" and "Camera image data" (Blue Dash).**

R&D of change-point extraction system using AI technology (FY2019)

■What is an automatic change point extraction system using AI technology?

This system develops a learning model using image data, compares old and new image data, and automatically detects changed features.

① Using AI technology to learn features of geographic features from image data

- Learning Example

Road Edge (rubber pole)

Traffic sign

Division line

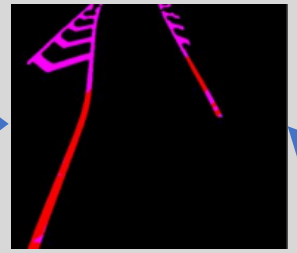
② Feature extraction from image data based on learned information

Road features
- Linear: red
- Dashed line: Green
- Arrow : Yellow
- Text : Blue
- Zebra : Pink

③ Image comparison to detect changed features

old image data

road feature extraction



new image data

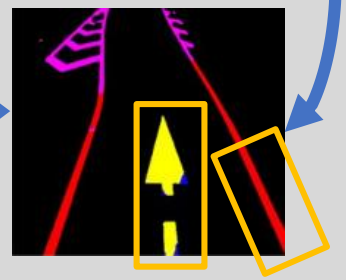
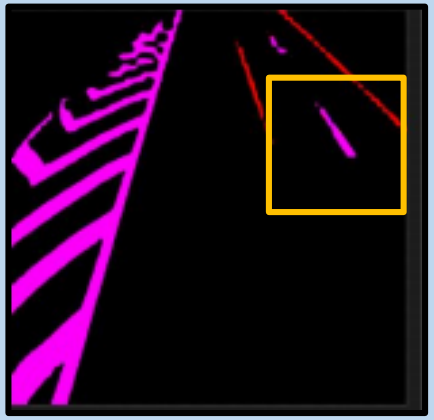


image comparison
① Add Arrow
② Division Line Extension

Major Challenge for FY2020

- **Feature recognition in distant view of image**



The tip of the arrow that appears relatively far is collapsed.
In the right figure, it is mistakenly recognized as a diagonal line of zebra (painted pink).

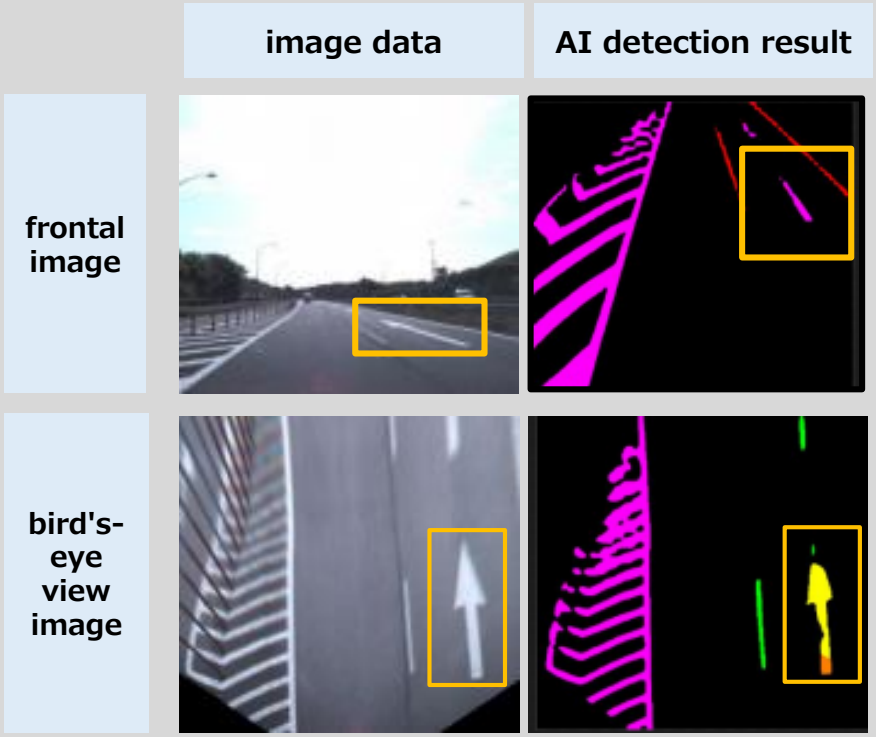
Current activity in FY2020 to resolve issues

■ Key Challenges: Recognizing Landscapes in the Perspective of Images

◇Adoption of bird's-eye view model

① Select a linear part on the image and draw a straight line.
② Set 4 points based on the convergence points connecting each line (red line)
③ The set 4 points are defined as a, b, c, d, and the image is converted into a bird's eye view (right view) by converting them into another 4 points e, f, g, h which form a rectangle.

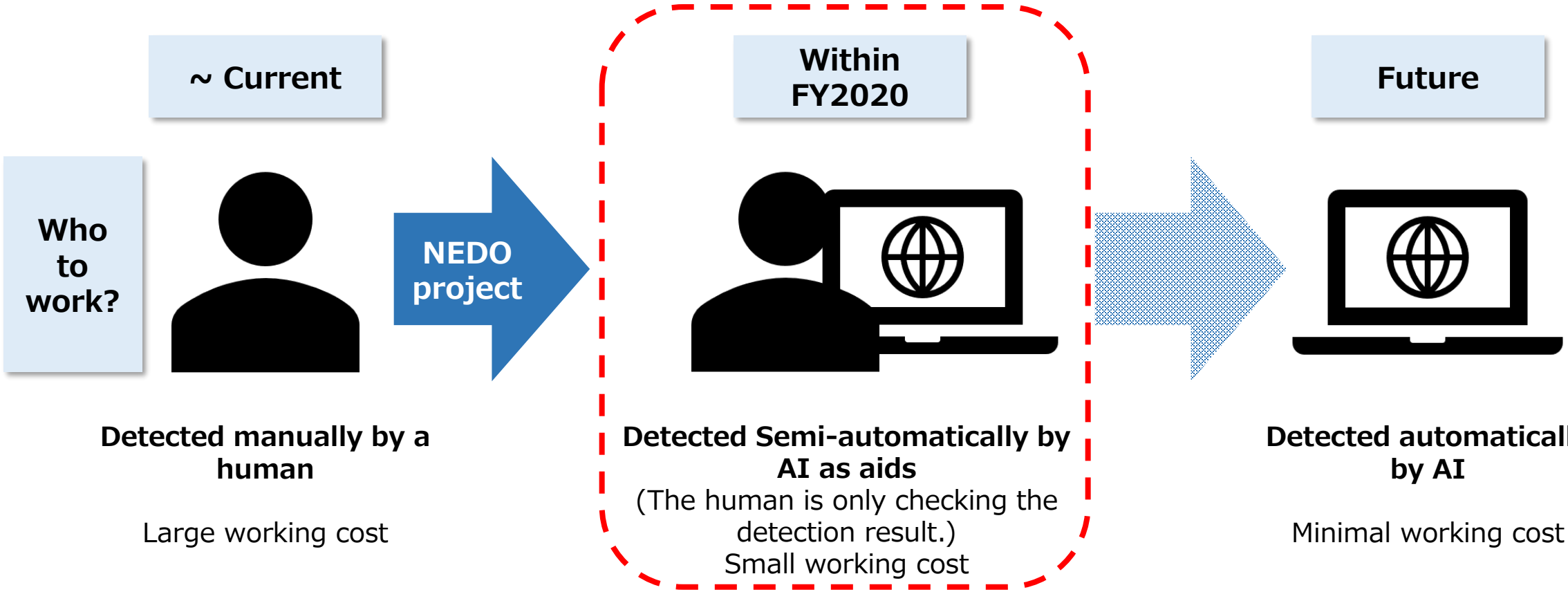
◇Detection result after bird's-eye view



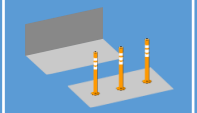
The tip of the arrow that was crushed in the front image was reproduced by making a bird's-eye view (lower left view).
In lower right view, AI recognized it as an arrow (painted yellow)
=>A bird's-eye view makes it possible to recognize distant objects

Final outcome objective = semi-automation of change detection tasks using tools

■Currently, we are developing a tool that can be used in the actual work for changing detection operation.



Ideal state of each initiative

Process \ feature	lane centerline	lot line	multiple lot line	shoulder edge	road marking	road sign	signal
							

Extract Road Changes

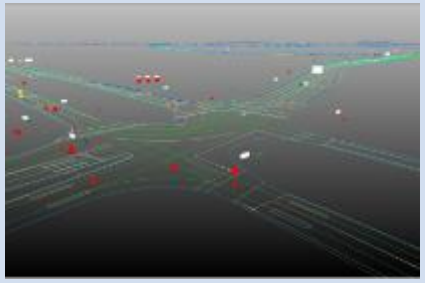
Since it is necessary to collect and accumulate various road traffic environmental data in response to constantly changing road conditions,
Work within SIP across industry, government, academia, and government

Measure Road (MMS)

Research and development in DMP

- Reduce maintenance costs by utilizing existing data held by administrative agencies and private companies
- Adoption of measurement methods other than MMS such as satellite images and aircraft LiDAR

Mapping 3D HD-Map



Research and development in DMP

- Establishing rational and competitive processes by developing and improving tools for IT, automation, and other technologies at a lower cost

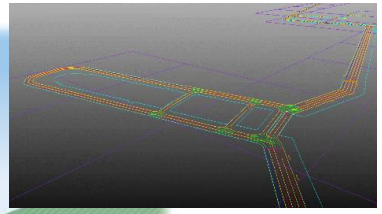
Integrating SIP R&D and proprietary technologies to improve DMP maintenance processes

Future Business Development

Future Business Development: Multipurpose Business Development

Multipurpose Business Direction

We will contribute to the realization of a safe, secure and comfortable society by expanding applications other than automatic driving and responding to diversifying needs.

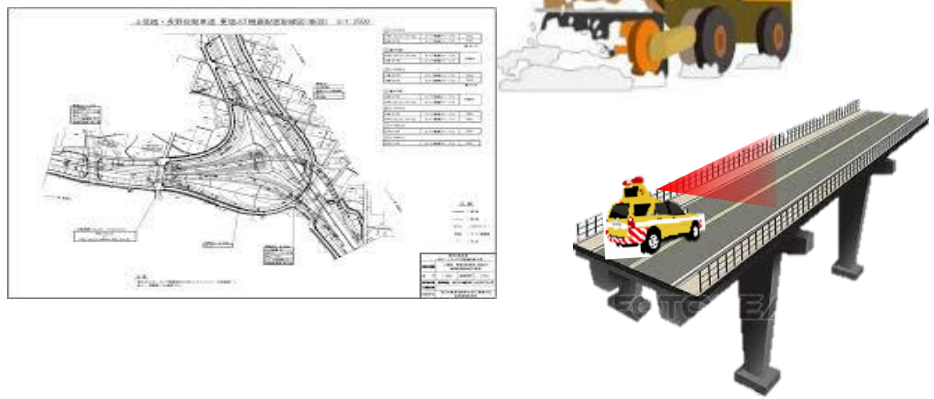


Future Business Development: Multipurpose Business Development

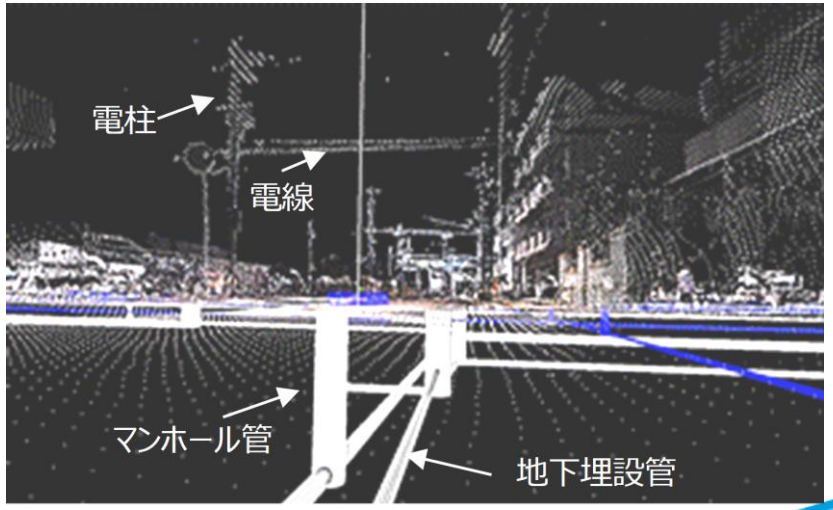
Utilizing high-precision 3D position information (change extraction, etc.) contributes to saving personnel in various management tasks despite a decrease in the number of skilled workers

1. infrastructure management

① Road Management (Road managers)
- Sophistication of maintenance and management
- Support for snow removal and weeding
- road pricing
- Advancement of traffic information, etc.



② Facility management (communications, power, gas) Infrastructure companies)
- Management of utility poles and wires
- underground buried object management
- BIM/CIM



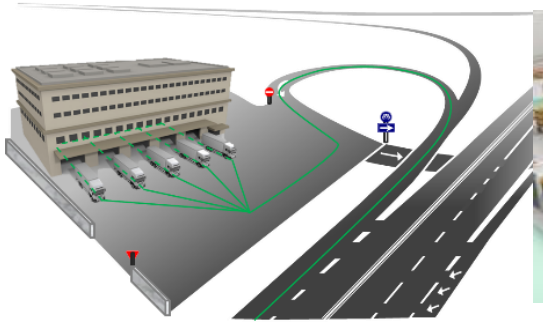
Future Business Development: Multipurpose Business Development

By supporting the safe operation of automatic mobility using the 3D HD-MAP, it contributes to securing safe means of transportation for the vulnerable road users and solving the labor shortage.

2. automatic mobility

① narrow range mobility
- Regional Transport MaaS/Tourism MaaS/Medical MaaS
- Flying Cars, Drones

② Logistics (Logistics and manufacturing companies)
- Driving support to distribution bases
- Automated transport robots at factories



③ Airports and harbors
- automatic bus and truck
- Automatic towing tractors, automatic snow removal equipment, etc.

Future Business Development: Multipurpose Business Development

To provide a safe, secure and comfortable solution utilizing high-precision 3D position information.

3. Other

① Simulation
- Disaster prevention and mitigation (Inundation, flooding, etc.)
- Development for automatic operation system
- Insurance (Response to accidents, etc.)

② Entertainment
- personal advertising
- Games, etc.

Safe and Comfortable Autonomous Driving Technology for the World!