MITSUBISHI ELECTRIC
Changes for the Better

"Strategic Innovation Promotion Program (SIP) for Automated Driving Systems/Large-Scale Field Operational Test/Dynamic Map/Change detection/Automated mapping for dynamic map "

FY2017 annual report

March 31, 2018

Mitsubishi Electric Corporation

Outline

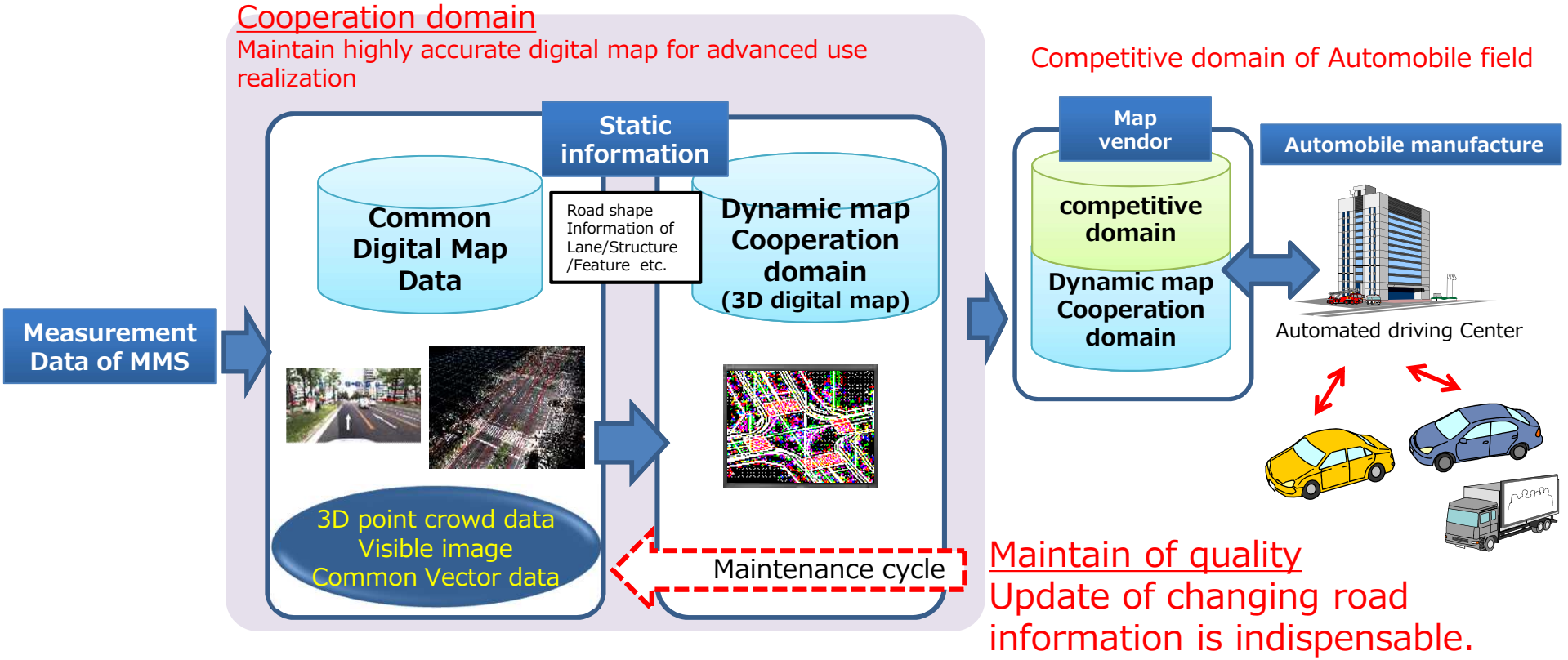
1. Purpose of R & D

2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps
   (1) Practical verification of Automated mapping /Change detection Application tool
   (2) Improvement effect verification by Automated mapping /Change detection technology application

3. Verification of Real Time Automated mapping /Change detection Technology
   (1) Adaptation of Automated mapping /Change detection technology to real-time operation environment

4. Conclusion

1． Purpose of R & D



For spread and promotion of use of Static high-precision 3D maps :

○ Securing the quality of the map that contributes to the operation of the automatic driving system
⇒Shorter map creation time

○ Reduction of user burden cost ⇒Reduction of cost of mapping

Purpose of this work ： Verification of improvement effect of map creation / update by application of automation technology

2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

(1) Practical verification of Automated mapping /Change detection Application tool

・Selection of feature to be evaluated

Select the following as the feature to be evaluated:

・Road extremities

・Road lines

→It is the most important feature showing the shape of the road. Because it is a line, drawing takes the longest time, and them to be improved by automation.

Example of Urban highway

Target feature	Manual drawing work time
Road extremities	12hr
Road lines	17hr
Road signs	3hr

Main feature of highway

No	feature	attribute
1	Road extremities	place (line)
		Accessibility to the out of the roadway
2	Road lines	place (line)
		Lane marker type
		Line type
		Line color
		Line width
3	Road markings	range (surface)
4	Road signs	point (surface)
		Road sign type
5	Road markings (character)	range (surface)
		Road surface marker type

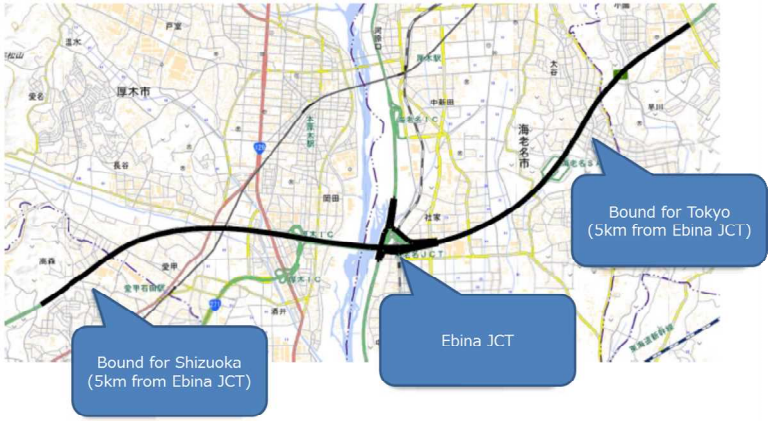
2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

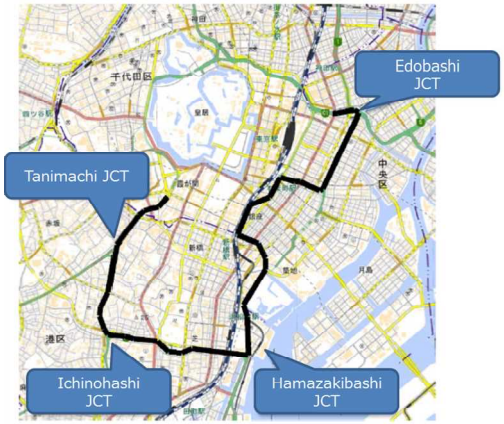
(1) Practical verification of Automated mapping /Change detection Application tool

・Selection of evaluation condition / evaluation course

Evaluation course① Intercity highway about 10km
(5km from Ebina JCT)
Evaluation course② Urban highway about 10km
(Inside of Metropolitan Expressway C1)
Evaluation course ③General road about 5km
(Shimbashi station～Odaiba)

No.	conditions
1	Includes entrance IC and exit IC
2	Including satellite invisible section
3	Including points of increase or decrease of the number of lanes





2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

(1) Practical verification of Automated mapping /Change detection Application tool

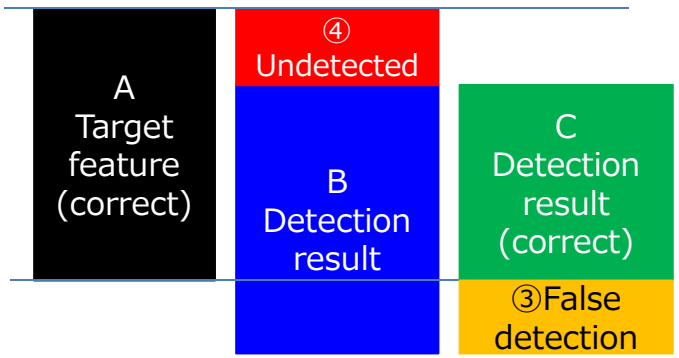
・Practical verification of Automated mapping

	Intercity highway : total 41.1km			
Target	Correct answer rate ①	Detection rate ②	False detection rate ③	Undetected rate ④
Road extremities	91.7%	97.1%	8.9%	2.9%
Road lines	90.7%	92.3%	10.0%	7.7%

	Urban highway : total 35.37km			
Target	Correct answer rate ①	Detection rate ②	False detection rate ③	Undetected rate ④
Road extremities	90.2%	94.4%	10.5%	5.6%
Road lines	86.3%	93.3%	14.8%	6.7%

	General road : total 11.53km			
Target	Correct answer rate ①	Detection rate ②	False detection rate ③	Undetected rate ④
Road extremities	69.7%	73.4%	31.9%	26.6%
Road lines	49.9%	52.7%	51.0%	47.3%

Target value
②＝95%or more
④＝0

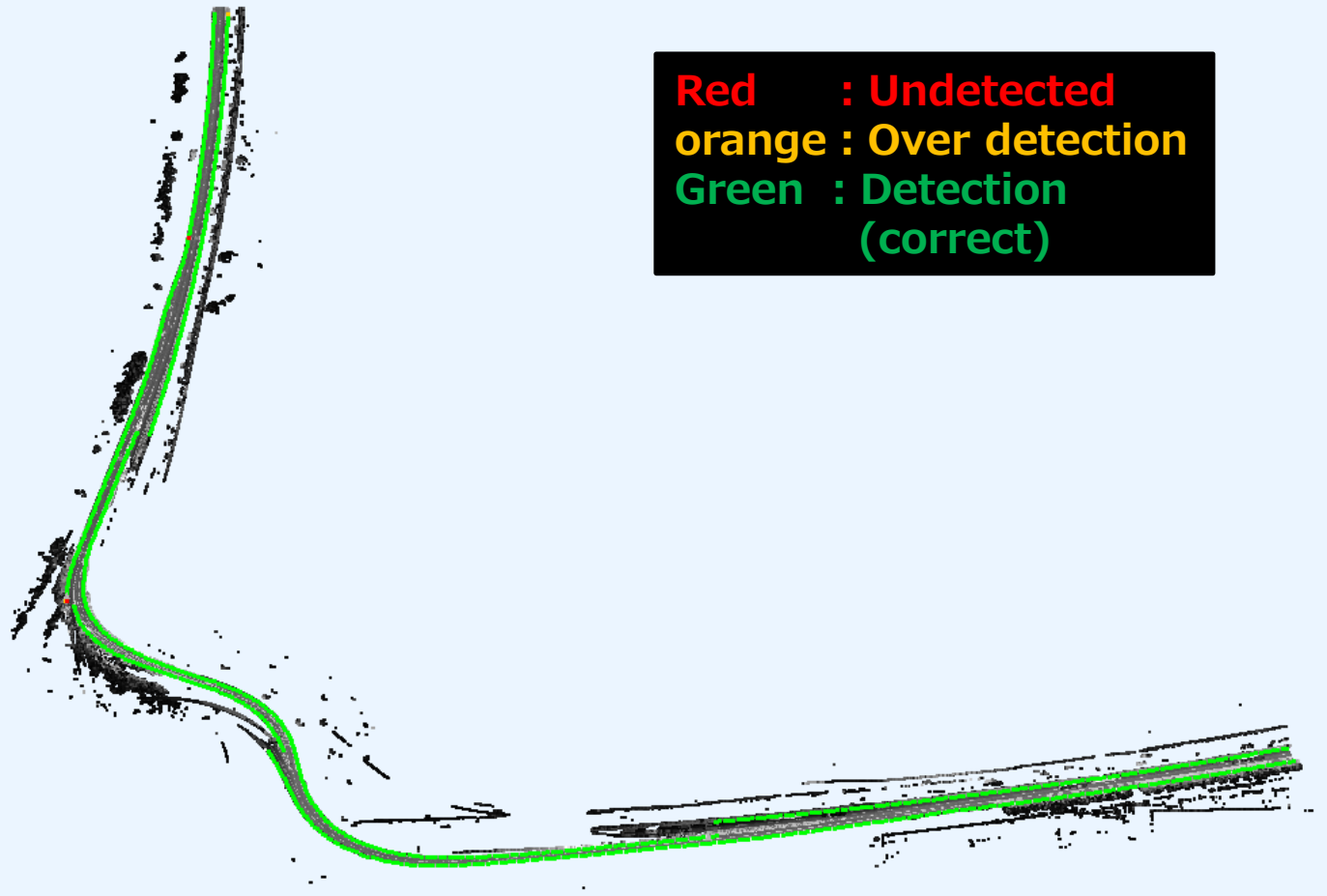


①＝C/B
②＝C/A

(1) Practical verification of Automated mapping /Change detection Application tool

・Practical verification of Automated mapping

Example of Intercity highway Road extremities

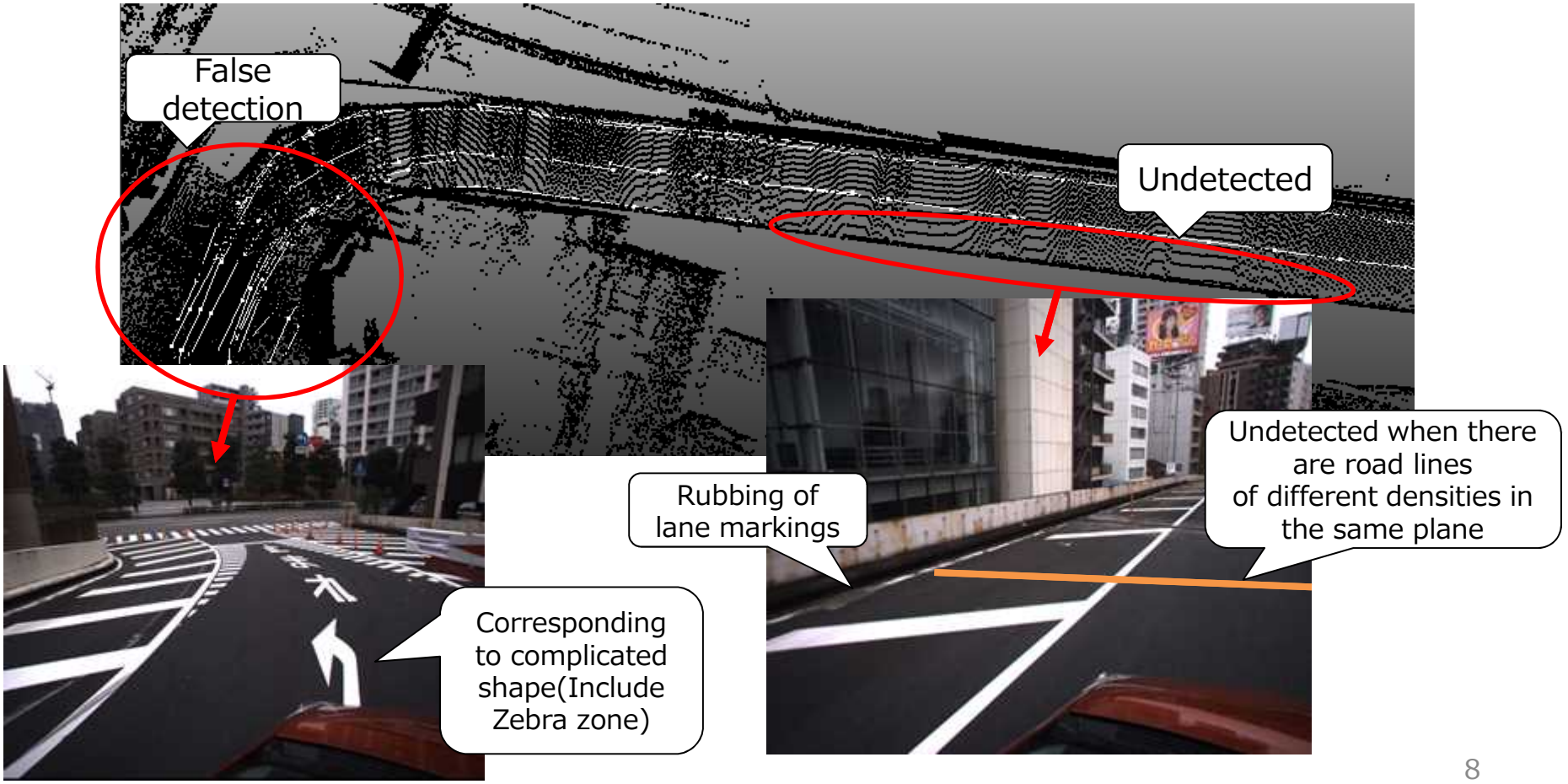


2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

(1) Practical verification of Automated mapping /Change detection Application tool

・Practical verification of Automated mapping

Example of false detection of Urban highway Road lines

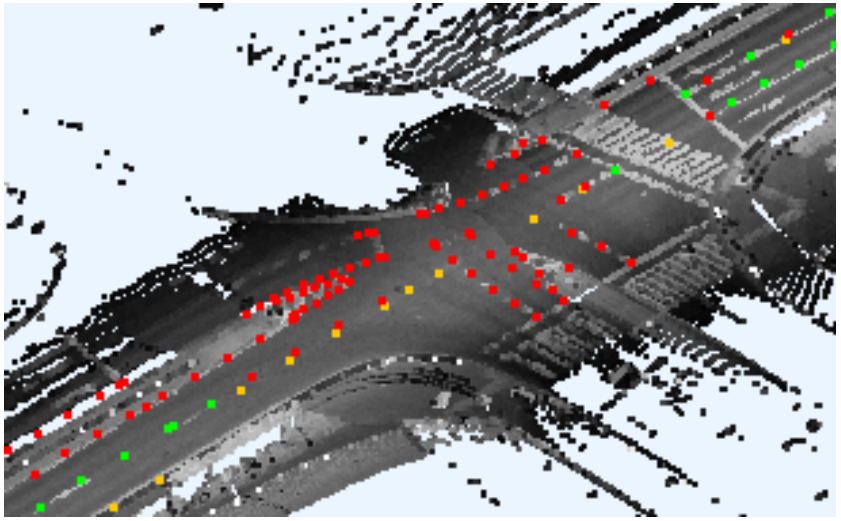


2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

(1) Practical verification of Automated mapping /Change detection Application tool

・Practical verification of Automated mapping

Example of false detection of General road



Red : Undetected
orange : Over detection
Green : Detection (correct)

Automated mapping tool is developed for highway correspondence, and at the intersection of general road Confirmed that it can not respond.
→General road correspondence anticipated by FY 2018.

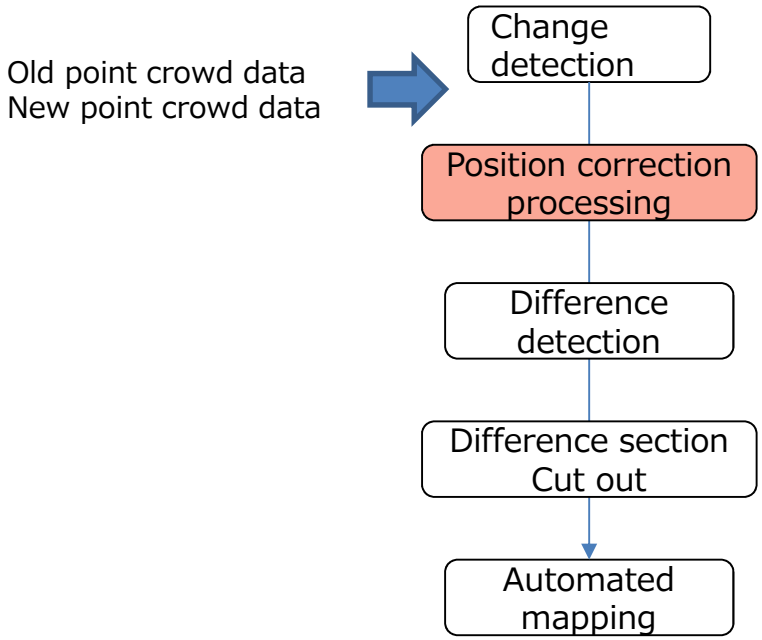
2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

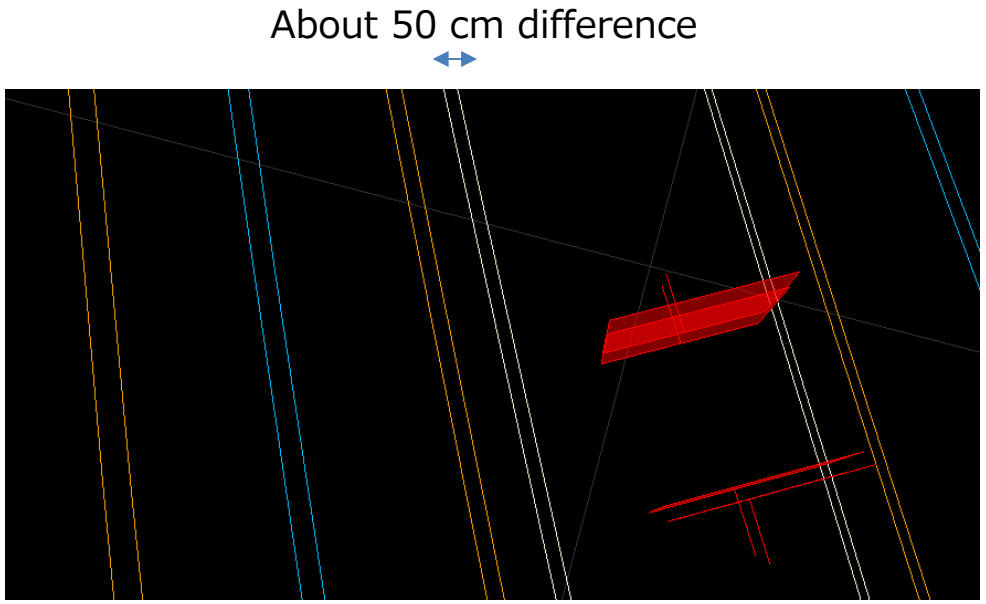
(1) Practical verification of Automated mapping /Change detection Application tool

・Practical verification of Change detection

At the time of Change detection, processing taking measurement error into account is necessary.

Process flow





Example of difference by measurement error

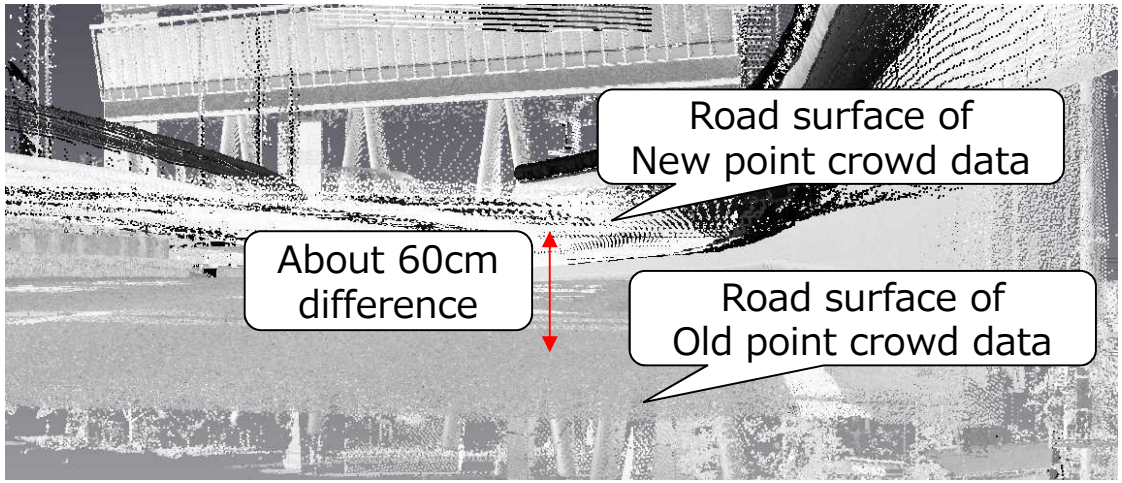
2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

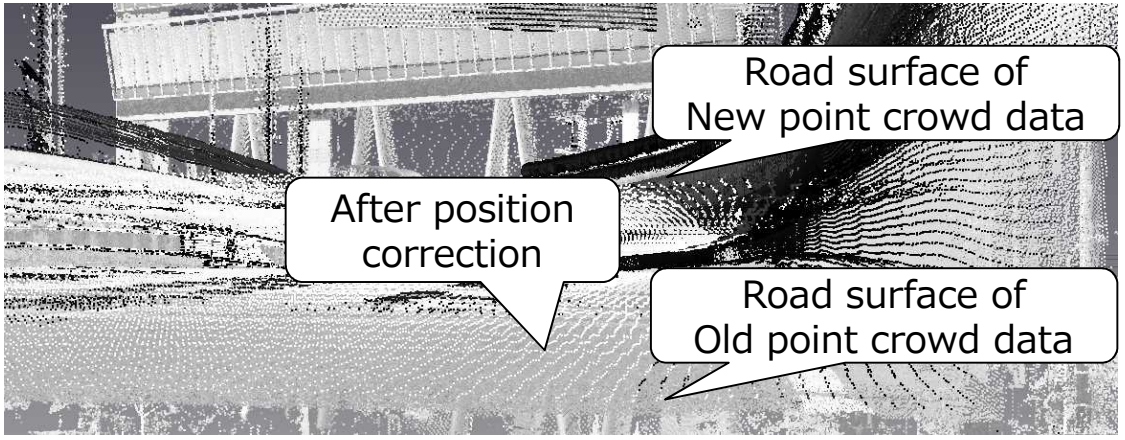
(1) Practical verification of Automated mapping /Change detection Application tool

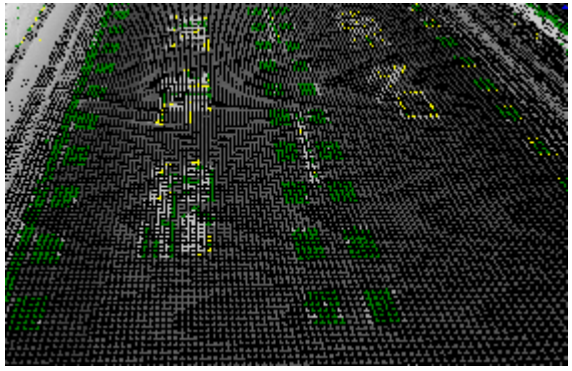
・Practical verification of Change detection

Shape point matching of new point cloud data to old point cloud data, correct position and extract the following as difference:

- Shape difference : add
- Shape difference : delete
- Reflected luminance difference : add
- Reflected luminance difference : delete







Change detection result after position correction
→ Detecting that deceleration signs are added to lane markings(Reflected luminance difference : add)

2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

(1) Practical verification of Change detection /Automated mapping Application tool

・Consideration of difference update by probe information

Probe information image: Low resolution → Difference detection (Obtaining updated information) → Update attribute information / Remeasurement by MMS

Image by MMS

Equivalent to drive recorder image

Probe information Point crowd: Sparse → Superimposition of statistical data → Acquisition of features

→Is it possible to utilize by superimposing data statistically even for data with point cloud sparse?

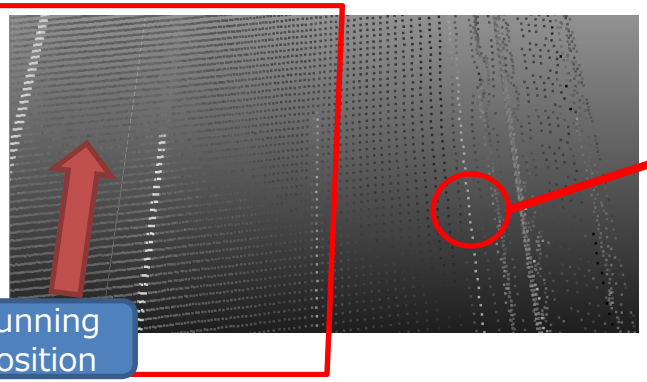
2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

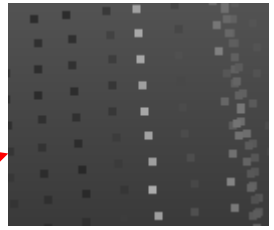
(1) Practical verification of Change detection /Automated mapping Application tool

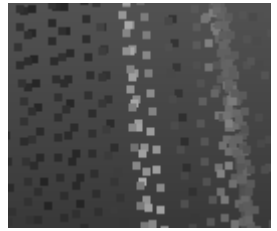
・Consideration of difference update by probe information

Range of drawing
(Up to the adjacent lane)

Standard Laser
27K points/sec



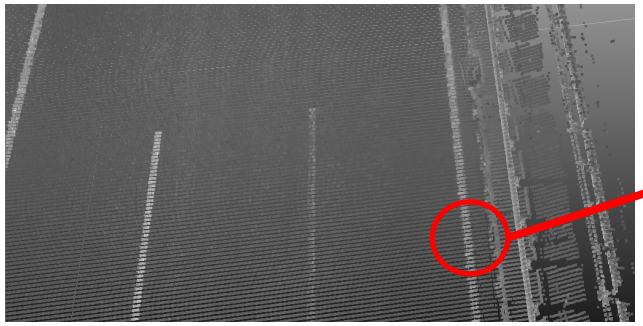


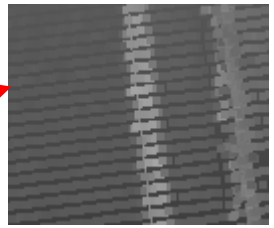


For standard lasers, the neighboring lanes have low point density.

Measurement error is superimposed by superimposing multiple data, but point density improvement

High density Laser
1M points/sec

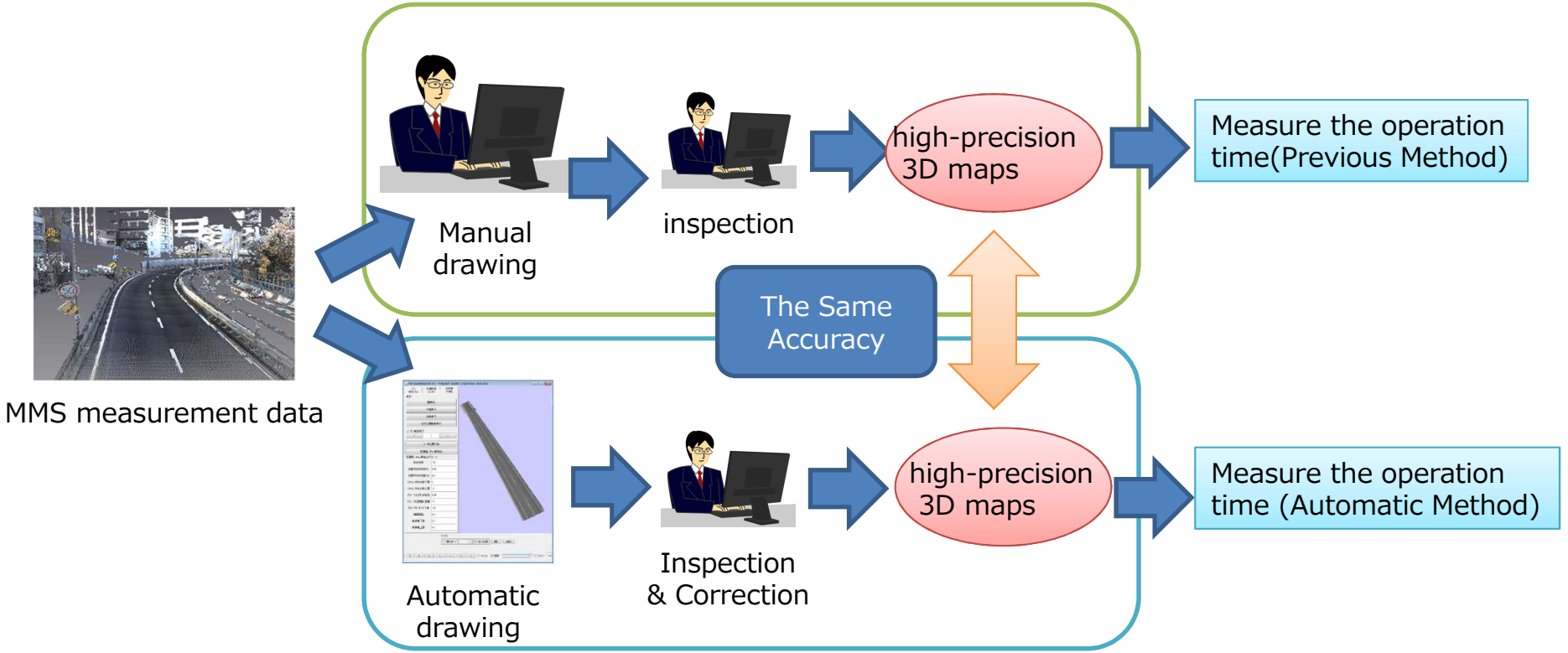




A sufficient density of points is obtained with a high density laser

Verify the accuracy difference after drawing
Mean error : 23.9cm
→Application to static highly accurate 3D digital map itself requires improvement in accuracy. Checking whether the number of lanes or road width has changed are able to apply.

(2) Improvement effect verification by Automated mapping/ Change detection technology application



2. Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps

(2) Improvement effect verification by Automated mapping/ Change detection technology application

	Intercity highway				
Target	Measurement Distance [km]	Operation time[hr]			Improvement Effect ((2)+(3))/(1)
		(1)Manual	(2)Automated Mapping	(3)Inspection & Correction	
Road extremities	41.10	114.0	1.2	28.0	25.6%
Road lines		94.0		55.0	59.8%

	Urban highway				
Target	Measurement Distance [km]	Operation time[hr]			Improvement Effect ((2)+(3))/(1)
		(1)Manual	(2)Automated Mapping	(3)Inspection & Correction	
Road extremities	35.37	57.0	1.5	16.5	28.9%
Road lines		51.0		40.5	79.3%

	General road				
Target	Measurement Distance [km]	Operation time[hr]			Improvement Effect ((2)+(3))/(1)
		(1)Manual	(2)Automated Mapping	(3)Inspection & Correction	
Road extremities	11.53	52.0	0.9	16.9	32.6%
Road lines		55.5		62.9%	113.4%

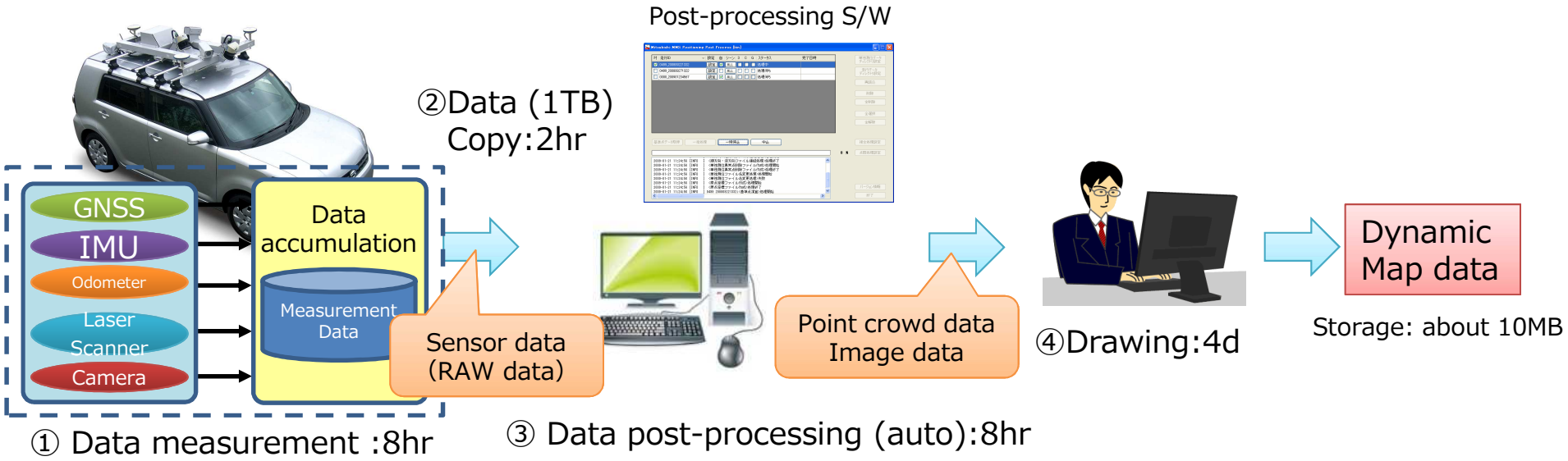
There are many erroneous detections of lane markers due to the influence of the Zebra zone, the road surface markers and the deceleration road surface markers, and it tends to take time to correct.
On general roads, the current Automated mapping is highway correspondence, does not correspond to intersections, and the lane markers has been manualized after deletion of the Automated mapping result, so cases exceeding 100% have come out .

3 .Verification of Real Time Automated mapping/ Differential Extraction Technology

b-2. Verification of Real Time Automated mapping/ Differential Extraction Technology

(1) Adaptation of Automated mapping / Change detection technology to real-time operation environment

Reduction of map creation time and cost is indispensable for promoting the use and utilization of Dynamic maps. For that purpose, it is necessary to shorten the overall process of data measurement, post-processing, and drawing work on MMS and study labor saving.



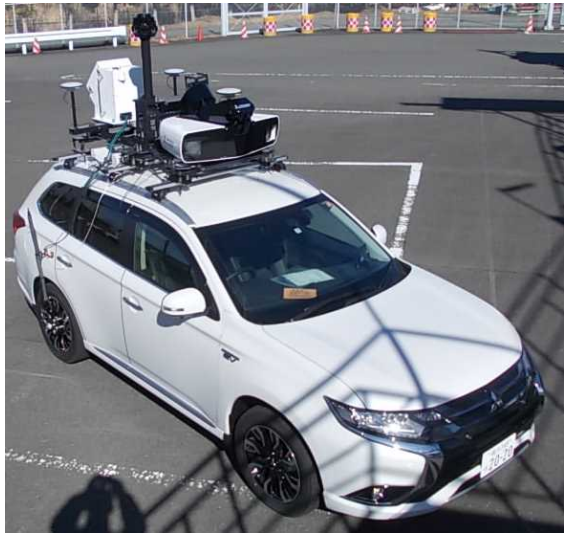
Example of from measurement by MMS to generation of dynamic map data

3 .Verification of Real Time Automated mapping/ Differential Extraction Technology

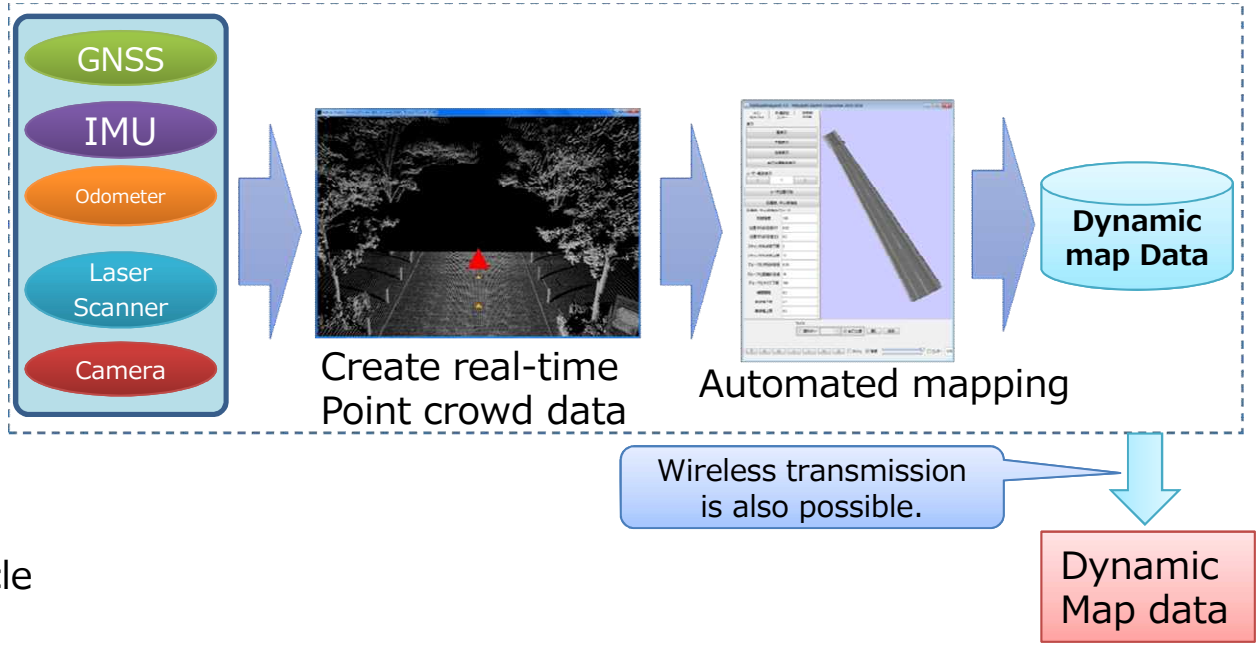
b-2. Verification of Real Time Automated mapping/ Differential Extraction Technology

(1) Adaptation of Automated mapping / Change detection technology to real-time operation environment

Combined with real-time MMS technology, Real time implementation of automation technology.



Installed in our laboratory vehicle



Storage: about 10MB

→Measure and verify in real field in FY 2018.

4. Conclusion

・We evaluated the automation technology, confirmed the effectiveness, and clarified the parts of need improvement and future tasks.

・ Implementation of real-time technology for real field verification next fiscal year.

Evaluate and verify performance, improvement effect, utilization method.

Contents	FY 2017				FY 2018			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
①Practical verification of Automated mapping /Change detection technology of Static high-precision 3D maps		Update location survey	Evaluation method examination					
(1)Practical verification of Automated mapping /Change detection Application tool (Data acquisition/analysis/evaluation)			measurement	analysis	evaluation			
(2)Improvement effect verification by Automated mapping /Change detection technology application (Evaluation Procedure Establishment of evaluation indicators)				Drawing (auto/manual)	summarize			
②Verification of Real Time Automated mapping /Change detection Technology								
(1)Adaptation of Automated mapping /Change detection technology to real-time operation environment		Implementation S/W for real-time MMS			Operation verification			
(2)Practical verification of Real-time Automated mapping /Change detection technology(Validation with real field)					Route selection	measurement analysis	Evaluation summarize	