Digital Infrastructure for Automated Vehicles

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Agenda

1. What is Digital Infrastructure?
   - ✓Road Environment Recognition
   - ✓Examples of Digital Infrastructure
2. “Dynamic Map” in SIP-adus*
3. International Standardization Updates
   - ✓New Proposal of DI for ADS**

*SIP-adus = Cross-Ministerial Strategic Innovation Promotion Program
Innovation of Automated Driving for Universal Services

**ADS = Automated Driving Systems

1. What is Digital Infrastructure?
(Tentative Definition)

Digital representation of road environment required by ADS, C-ITS, and Advanced Road /Traffic Management Systems

(C-ITS = Cooperative-ITS)

Road Environment Recognition

- ✓ High definition (HD) digital road map
- ✓ 3D image data, point group data, vector data
- ✓ Lane-level location referencing
- ✓ Additional land marks for positioning accuracy
- ✓ Drivable areas for emergency evacuation
- ✓ Semi-dynamic data (accident, congestion, road work, …)
- ✓ Highly-dynamic data (position/speed of moving object, traffic signal timing/phase, probe, …)

Examples of Digital Infrastructure

- ✓ Local Dynamic Map for C-ITS (SAFESPOT, EC)

  …short range, vehicle-centric

- ✓ Dynamic eHorizon for ADS (Continental AG)

  …short to middle range, vehicle-centric,

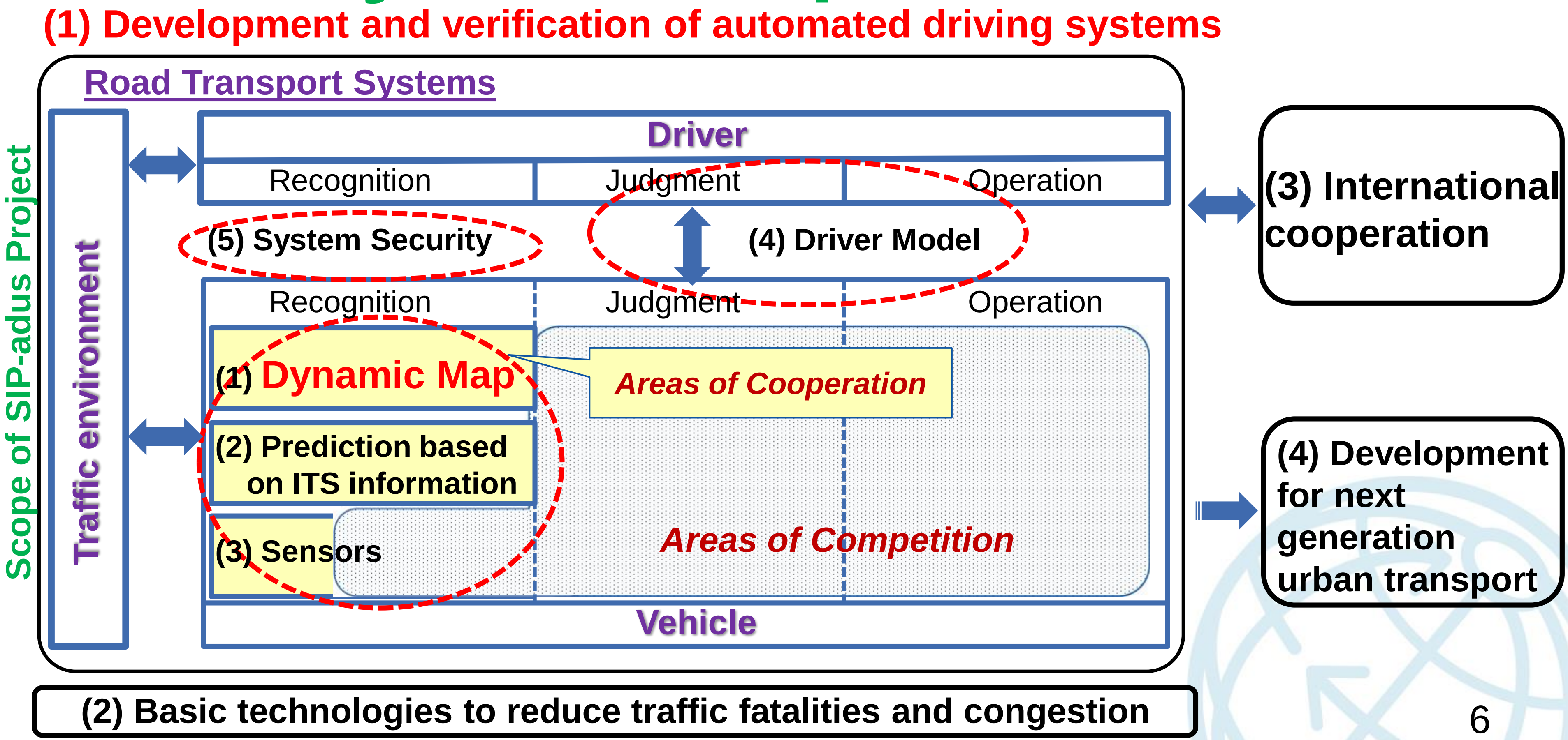
  cloud sourcing

- ✓ Dynamic Map for ADS (SIP-adus, Japan)

  …short to wide range, vehicle+center,

  cloud sourcing

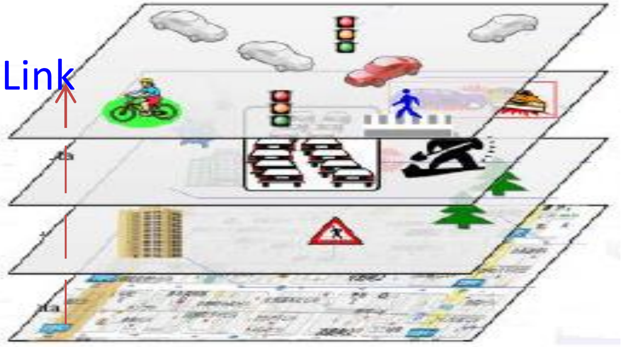
2. “Dynamic Map” in SIP-adus



"Dynamic Map" Concept

Dynamic map is not only precise map database for automated vehicles but advanced traffic information database for every vehicle

<u>under reassessment!</u>



Base (HD Static Map)

Dynamic Info. (< 1 sec)

ITS anticipative Info.
(V2V, V2P, traffic signal, etc.)

Semi-dynamic Info. (< 1 min)

Accident, Congestion, Local weather etc.

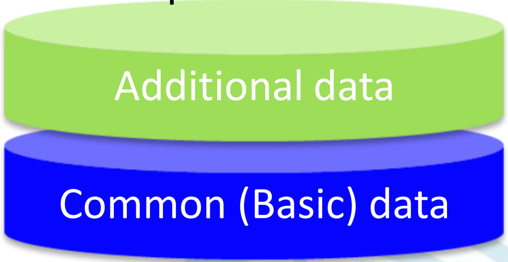
Semi-static info. (< 1 hour)

Traffic control, Road construction, Weather forecast, etc.

Static Info. (< 1 day)

Road shape, Topological data, etc.

Competitive area



Cooperative area

*Source: Mr. Seigo Kuzumaki, Program Director, SIP-adus,
European conference on connected and automated driving (April 4, 2017)

“Dynamic Map” History

- FY2014 ($23.0M): Prototyping HD Static Map
  + Use Case Study
- FY2015 ($21.4M): Prototyping Dynamic Map
  + Data Viewer
- FY2016 ($24.7M): Prototyping Dynamic Map Center
  + International Standardization

FY = fiscal year in Japan, e.g. FY2014 = April 2014-March 2015

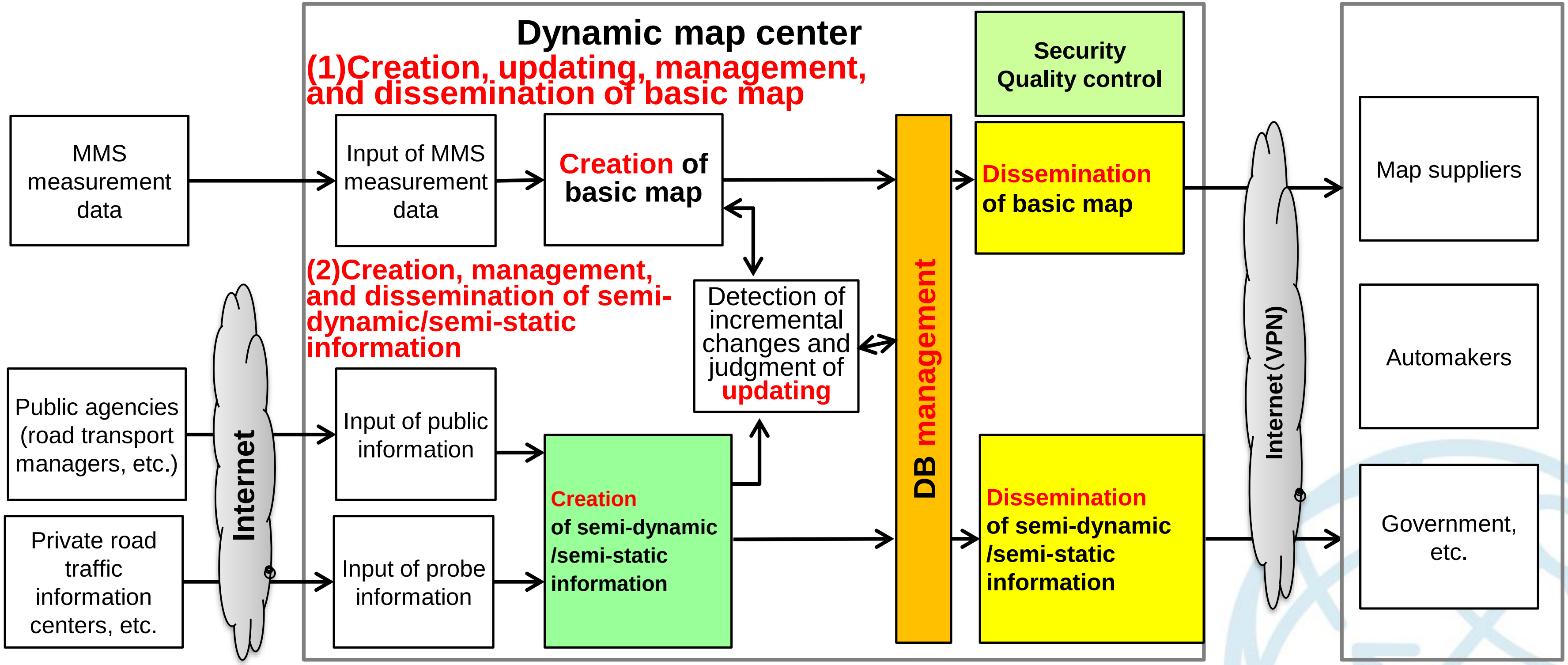
Budget = for entire SIP-adus Project, $1 = \110 (as of June 5, 2017)

"Dynamic Map" Outcome of FY2016

	Design and operation of a basic map	Use of dynamic data	Use of dynamic maps
FY2014	Prototype of lane-level map		Fleshing out use cases
FY2015	Compilation of data specifications (draft) and requirement guidelines for map-data preparation (draft)	Examination of roadmap (draft) for use and practical implementation of probe data	Requirement definition document (draft) for dynamic map data including dynamic data and viewer prototype
FY2016	**(1) Preparation of basic map by measuring road topography** **(2) Examination of functions of dynamic map center** **・Framework for updating basic map** **・Framework for collection/creation of semi-dynamic information** **・Framework for data delivery process to map suppliers** **(3) Construction of dynamic map center functions**	(2) and (3) span the first two columns	**(4) Verification of dynamic map center functions and design /implementation costs**

*Source: Summary of (FY2016) Report (March 17, 2017), SIP-adus, Cabinet Office, Government of Japan

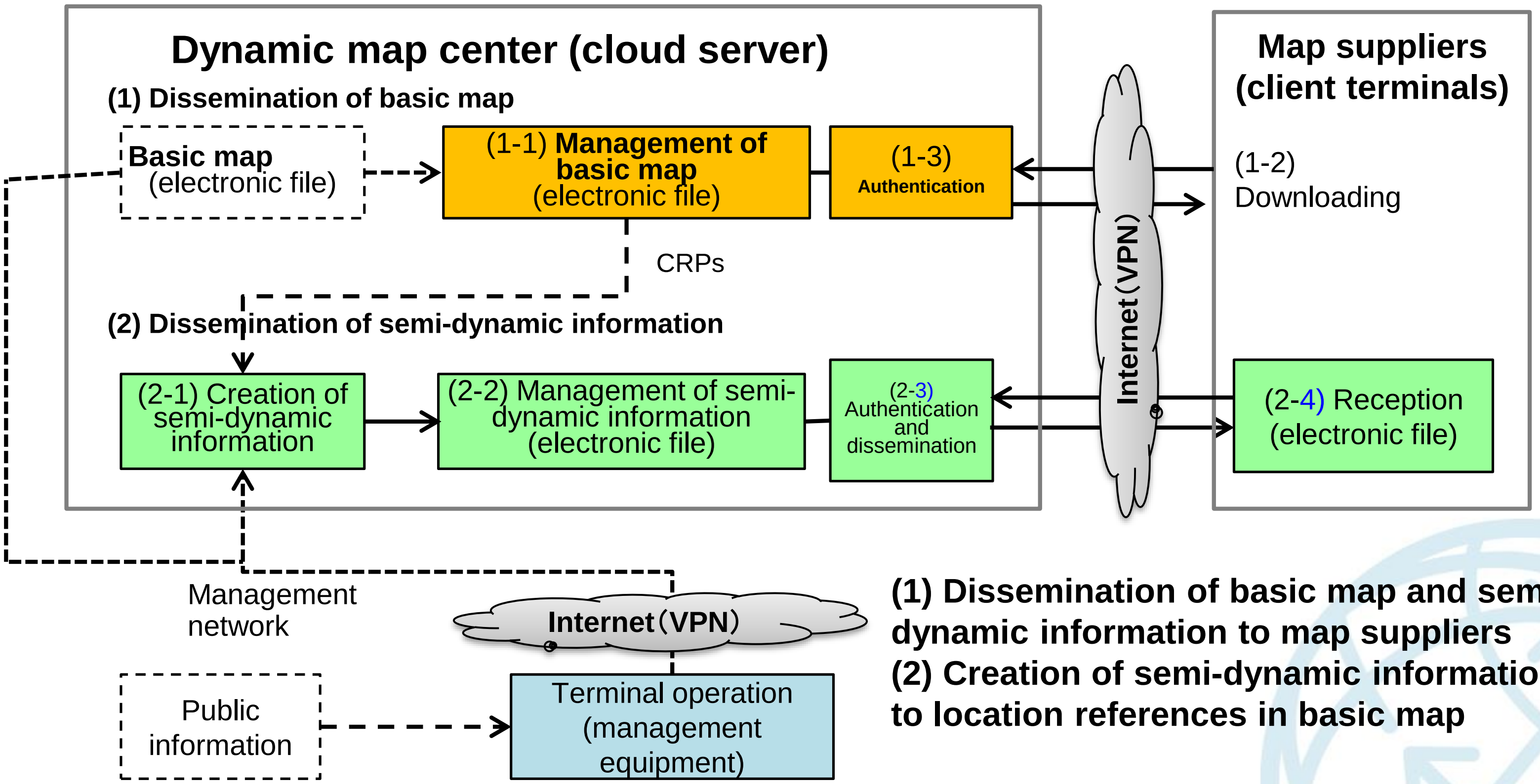
Key functions of dynamic map center (1)



*Source: Summary of (FY2016) Report (March 17, 2017), SIP-adus, Cabinet Office, Government of Japan

No	Function	Overview	Conditions
1	Basic map creation, updating, management and distribution		
1.1	MMS measurement data input	Enters and saves MMS measurement data from MMS measurement vehicles.	Evaluation of data precision; measurement data
1.2	Basic map creation	Creates the basic map from the MMS measurement data.	Data structure
1.3	Database (DB) management	Registers, changes and deletes the basic map in the database.	Version/upgrade management
1.4	Basic map distribution	Creates and distributes basic map files for delivery.	Distribution units, distribution timing, communication methods
1.5	Difference detection/update judgment	Detects differences and updates in the basic map from MMS measurement data, public information and probe information.	Judgment of updates from public information Detection of differences from probe information, etc.
2	Semi-static/semi-dynamic information/(dynamic data) creation/management/distribution		
2.1	Public information input	Enters (collects) public information such as road-transport information, etc. from public institutions.	Conversion of public information
2.2	Probe information input	Enters (collects) probe information from MMS measurement vehicles, etc.	Types of probe information and methods of collection of probe information
2.3	Semi-static/semi-dynamic information Creation	Creates (converts) Semi-static/semi-dynamic information from public information and probe information	Location referencing (association) with the basic map
2.4	DB management	Registers, changes and deletes Semi-static/semi-dynamic information in the DB.	Detection of status of change (management of generation /termination), whether or not DB is needed
2.5	Semi-static/semi-dynamic information Distribution	Distributes Semi-static/semi-dynamic information.	Processing-time performance, selection of information to be distributed
3	Common functions		
3.1	Security	Performs functions such as user authentication, data encryption and communication encryption.	Scope of security, targets for protection, security protocols
3.2	Quality control	Confirms and manages the quality of the basic map and Semi-static/Semi-dynamic information.	Quality verifying methods

Functions of prototype dynamic map center (1)



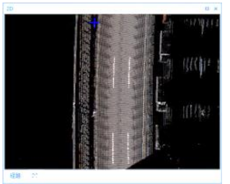
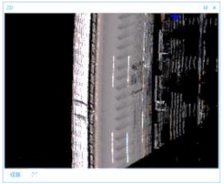
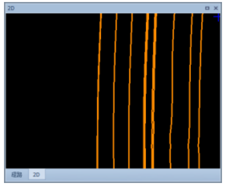
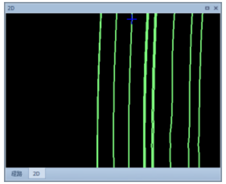
(1) Dissemination of basic map and semi-dynamic information to map suppliers
(2) Creation of semi-dynamic information linked to location references in basic map

*Source: Summary of (FY2016) Report (March 17, 2017), SIP-adus, Cabinet Office, Government of Japan

Functions of prototype dynamic map center (2)

Functions implemented in the prototype		Functions and formats applied to the dynamic map center
(1) Dissemination of basic map	1) Management of the basic map	1.4 Dissemination function of the basic map 2) Communication interface ・Dissemination in response to online requests ・Dissemination of the basic map in a specified area ・Dissemination of requests (responses to requests) ・Dissemination of files by HTTP 3.1 Security 1) Encryption of disseminated files 2) User authentication ・Formats for user names/user IDs and passwords 3) Encryption of communications ・VPN
	2) (Downloading)	
	3) Authentication	
(2) Dissemination of semi-dynamic information	1) Creation of semi-dynamic information	2.3 Creation of semi-dynamic/semi-static information 1) Conversion of public information into semi-dynamic/semi-static information 2) Setting of locational references ・Location information expression type 2
	2) Management of semi-dynamic information	2.5 Dissemination of semi-dynamic information/semi-static information 2) Dissemination on a fixed cycle ・ Dissemination of files by TCP/IP 3.1 Security 2) User authentication ・Formats for user names/user IDs and passwords 3) Encryption of communications ・VPN
	3) Authentication and dissemination	
	4) Reception	

Comparison of probe data to update maps (1)

	(1) Image data	(2) Point-group data	(3) Vector data
Possible method of updating	Image data is compared to identify locations where differences exist.	Point-group data is compared to identify locations where differences exist.	Vector data is compared at level of surface features, to identify update locations based on presence/absence of surface features or changes thereto.
Comparison **(Zoom -> next slide)**	 	 	 
Characteristics	**Cannot capture fine detail but can be used as a trigger for further observation.**	**Cannot capture fine detail but can be used as a trigger for further observation.**	**Can identify update locations on the level of surface features.**
Advantages	･Can confirm changes from the viewpoint of vehicles. ･Recognition of changes is simple and intuitive.	･Deployed on a level plane, so able to confirm positions of change with high accuracy. ･Topography can be grasped at all times regardless of the position of the moving vehicle.	･In locations where change is clearly recognized, recognition time is shortened. ･Can confirm continuous virtual surface features such as networks ･Effective in non-time-sensitive situations ･Results are easily confirmed.
Disadvantages	･Subject to seasonal fluctuations. ･Depending on driving position, parallax can occur. ･Stopped vehicles can cause some details to be missed. ･Confirmation of location information requires separate judgment.	･Large data volumes make processing time-consuming. ･Depends on the condition of GNSS during driving, so adjustment between two time-frames is required. ･Data from the previous observation must be stored at all times, making the management structure complex. ･Separate confirmation is required for attribute, which is limited to the location information.	･Plotting work is required. ･Locations that have not been updated must also be plotted.
Feasibility of automation	**Visual confirmation is easy. Machine learning is required, so the hurdles to automation are high.**	**Comparatively easy, but variance exists.**	**Changes in the shape and the locations of surface features can be detected easily.**

*Source: Summary of (FY2016) Report (March 17, 2017), SIP-adus, Cabinet Office, Government of Japan

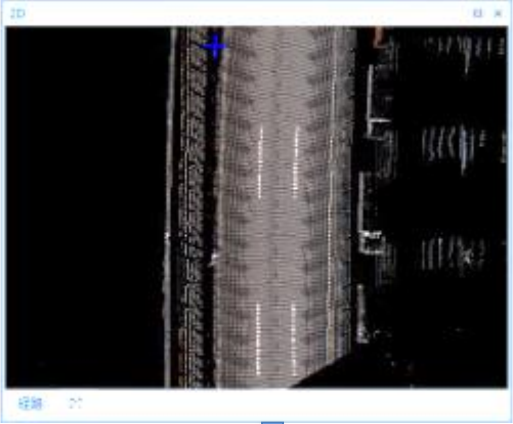
Comparison of probe data to update maps (2)

・New paved surface (dividing lines changed)
・New dividing lines (including positions)
・Improved sidewalk
・Shoulder line changed

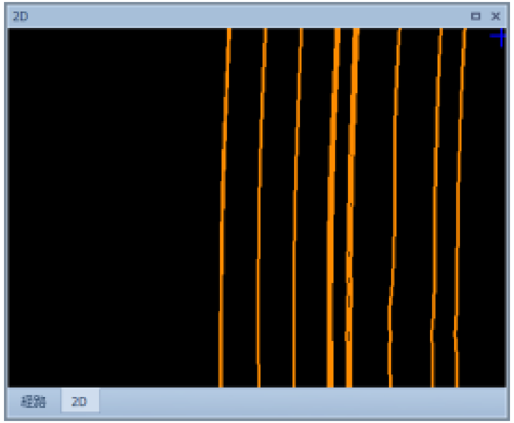
Before update

Image data

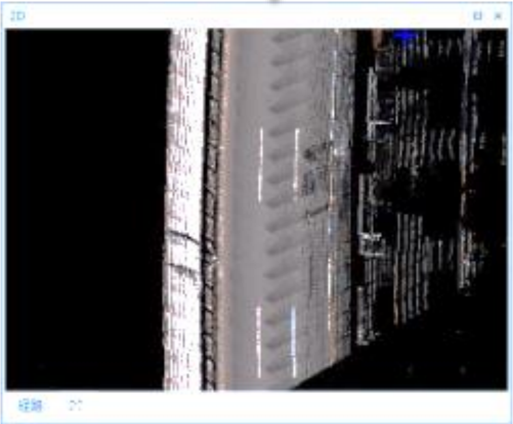
Point-group data

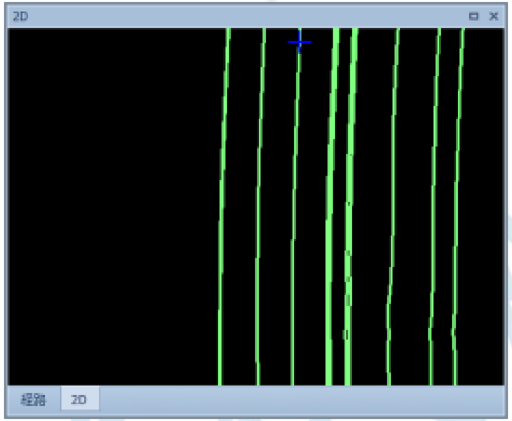


Vector data



After update





*Source: Summary of (FY2016) Report (March 17, 2017), SIP-adus, Cabinet Office, Government of Japan

Comparison of probe data to update maps (3)

(1) Judgment using image data is appropriate for local updating. To judge whether an update has been applied or not, photos can be replayed continuously to determine the changed location. This approach is suited for visual judgment but is difficult to automate.

(2) Judgment using point-group data is promising, as it can determine planar position instantly. However, on ordinary roads, etc. where GNSS capturing condition is poor, such data can lack credibility.

(3) Judgment using vector data is the most appropriate approach, as major surface features that can obstruct driving, such as dividing lines and edges of roadways, as well as landmarks, are amenable to a degree of automatic processing.

✓ **Depending on the size of changes, it may be necessary to use all three approaches to update maps.**

*Source: Summary of (FY2016) Report (March 17, 2017), SIP-adus, Cabinet Office, Government of Japan

Perspective on FY2017

- **FY2017 ($30.2M): Dynamic Map Implementation**
- **Field Operational Test of SIP-adus Project**

FOT Period: autumn 2017 ～ beginning of 2019

Purpose

1. To activate R&D
2. To prove each elemental technology
3. To enhance international cooperation and harmonization
4. To build social acceptance

Participant

- OEM/supplier
- university/research organization
- ministries, government officers
- foreign OEM/supplier
- journalist

*Source: Mr. Seigo Kuzumaki, Program Director, SIP-adus, European conference on connected and automated driving (April 4, 2017)

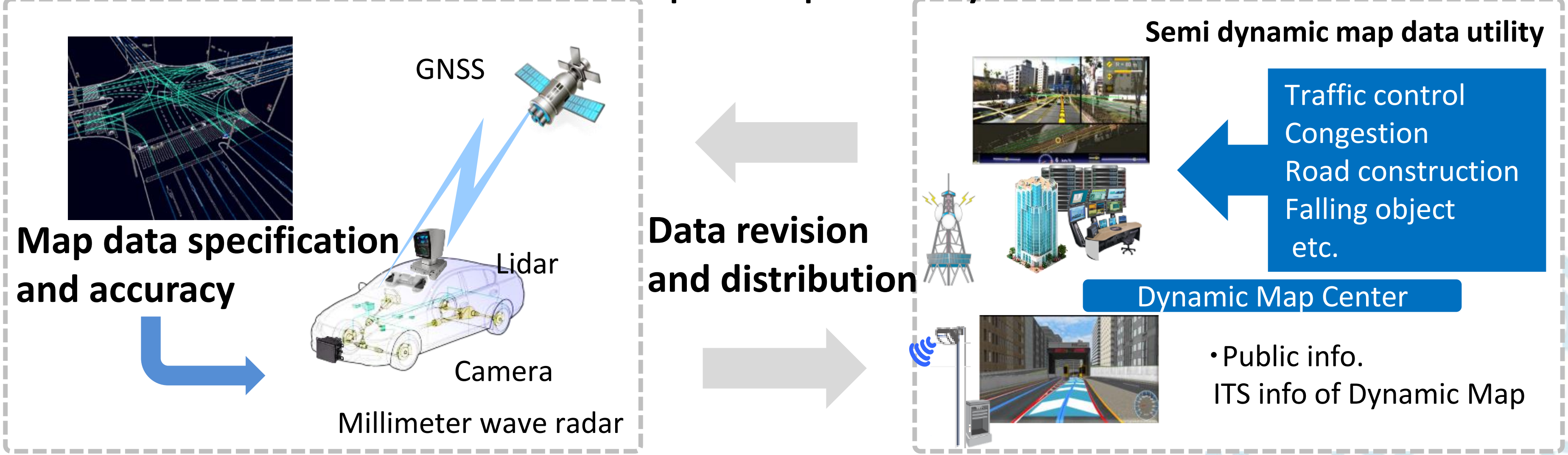
FOT of SIP-adus Project

- FOT Test site
  - Arterial roads in Tokyo
  - 300 km of expressway
  - New test facility for ADS at JARI (Japan Automotive Research Institute)
- ADS Level 2 on highway by 2020

“Dynamic Map” FOT

Dynamic Map FOT is:
- ☐ To validate 3D high-resolution digital map data;
- ☐ To validate data collection and distribution method;
- ☐ To verify the utility of semi dynamic information.

✓ The map data is provided by SIP-adus



*Source: Mr. Seigo Kuzumaki, Program Director, SIP-adus, European conference on connected and automated driving (April 4, 2017)

3. International Standardization Updates

New Proposal of DI for ADS (1)

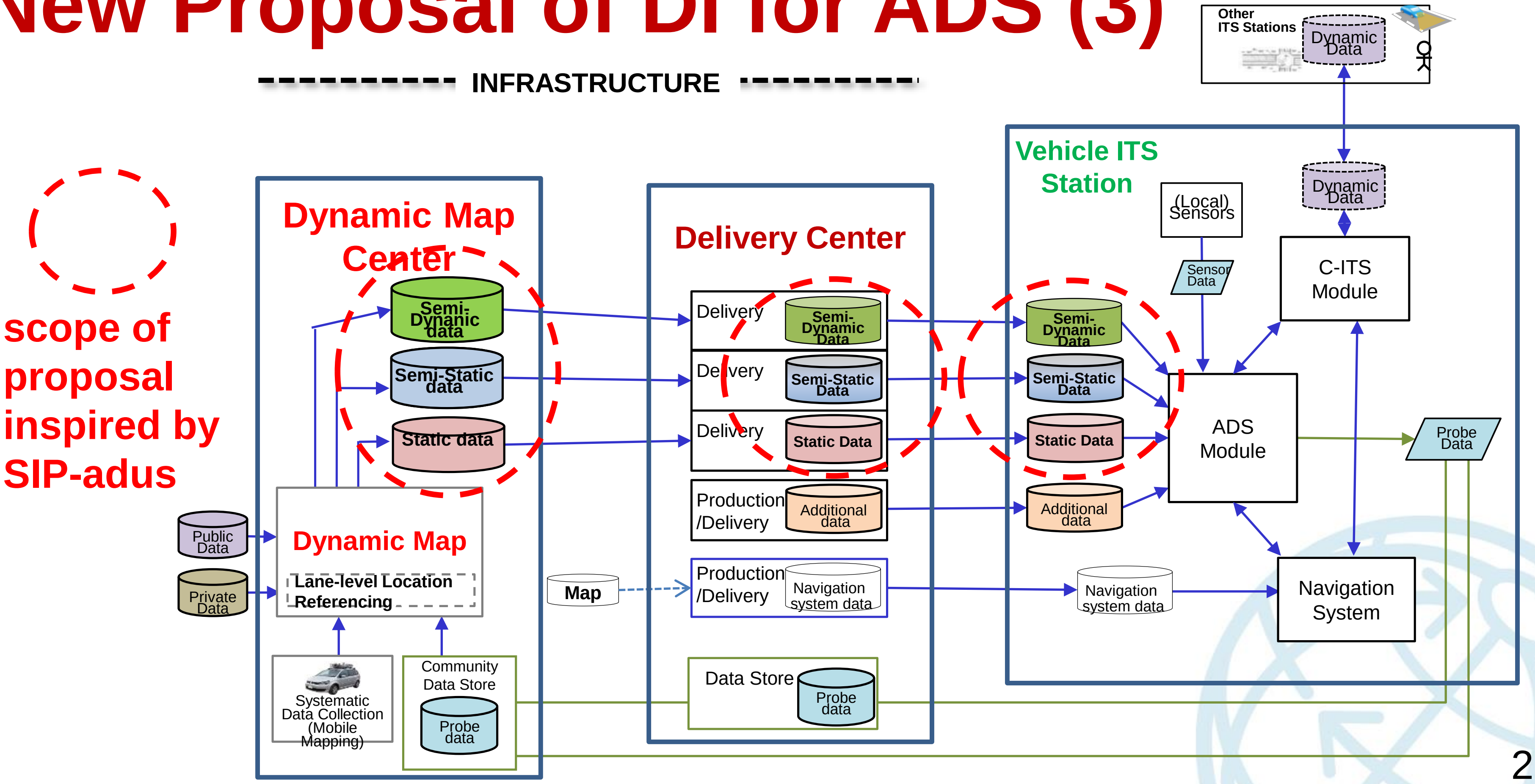
- ✓PWI 22726 approved in April 2017

  (PWI = Preliminary Work Item)
- ✓Title: Dynamic events and map database specifications for applications of ADS, C-ITS, and advanced road/traffic management systems

New Proposal of DI for ADS (2)

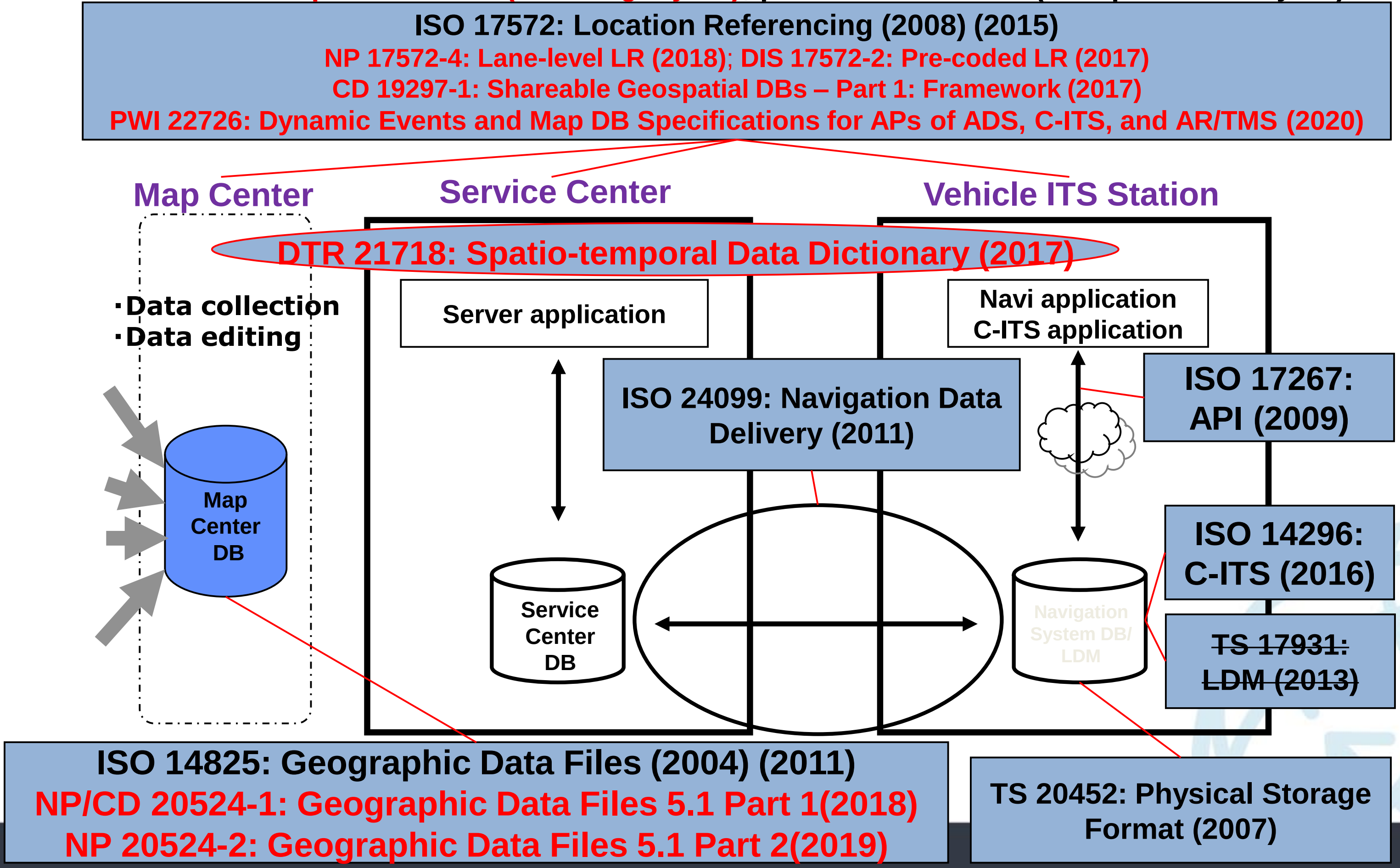
- ✓To standardize static, semi-static, and semi-dynamic map data elements and their logical data model used in maps for ADS, C-ITS, and advanced road/traffic management systems
- ✓Targeting international standard
- ✓Publication expected in 2020

New Proposal of DI for ADS (3)



FYR: Full Set of WG3 Work Items (as of June 2017)

under development=in red (with target year); published=in black (with publication year)



Any questions?

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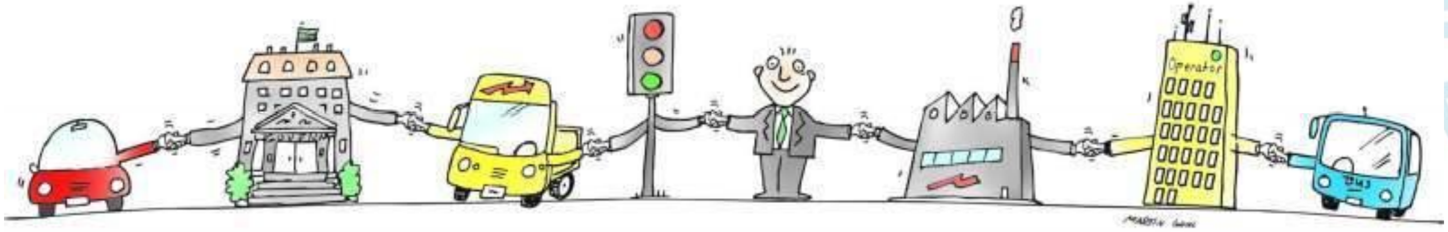

***Source: ERTICO**

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