Pavement Maintenance in Japan

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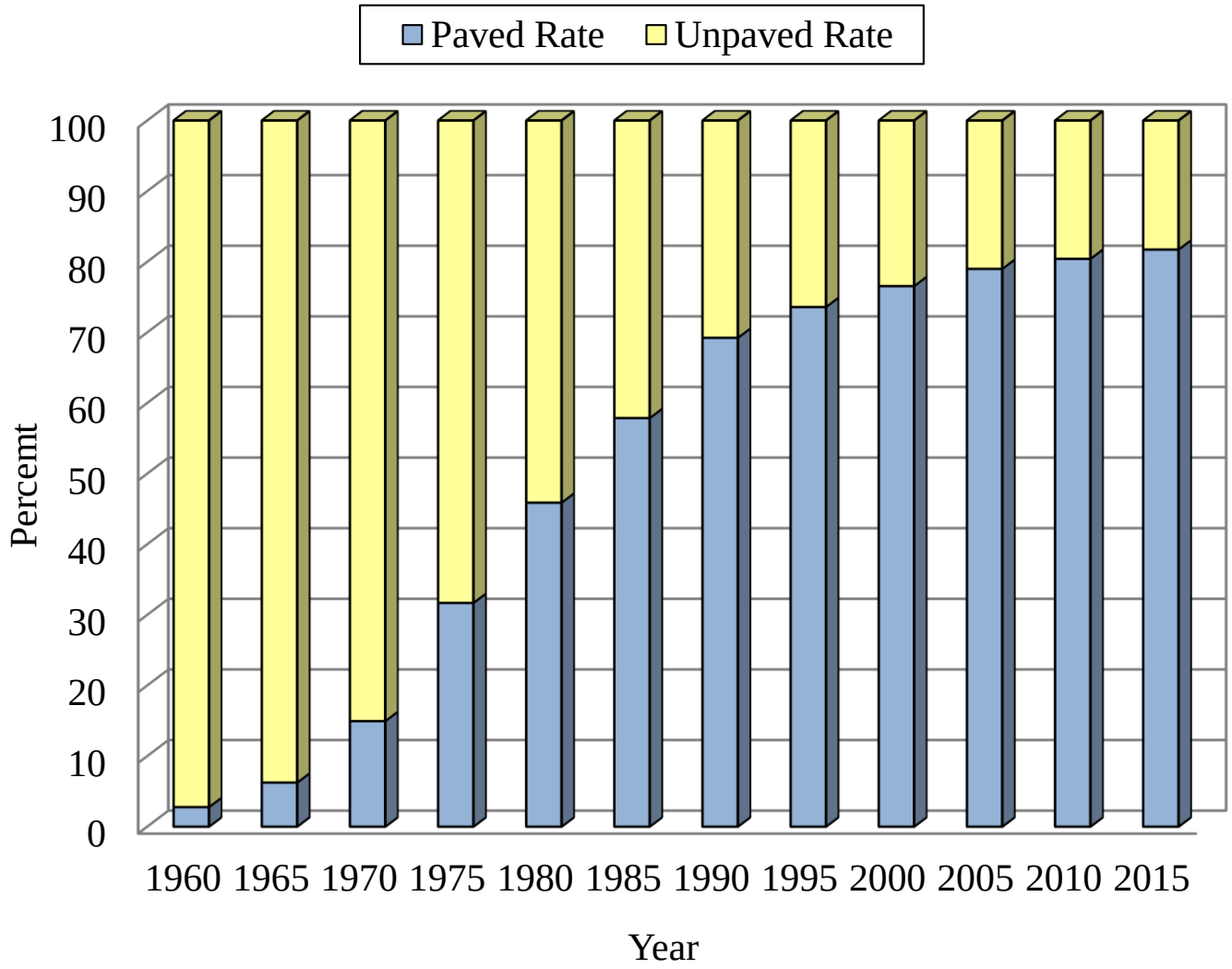
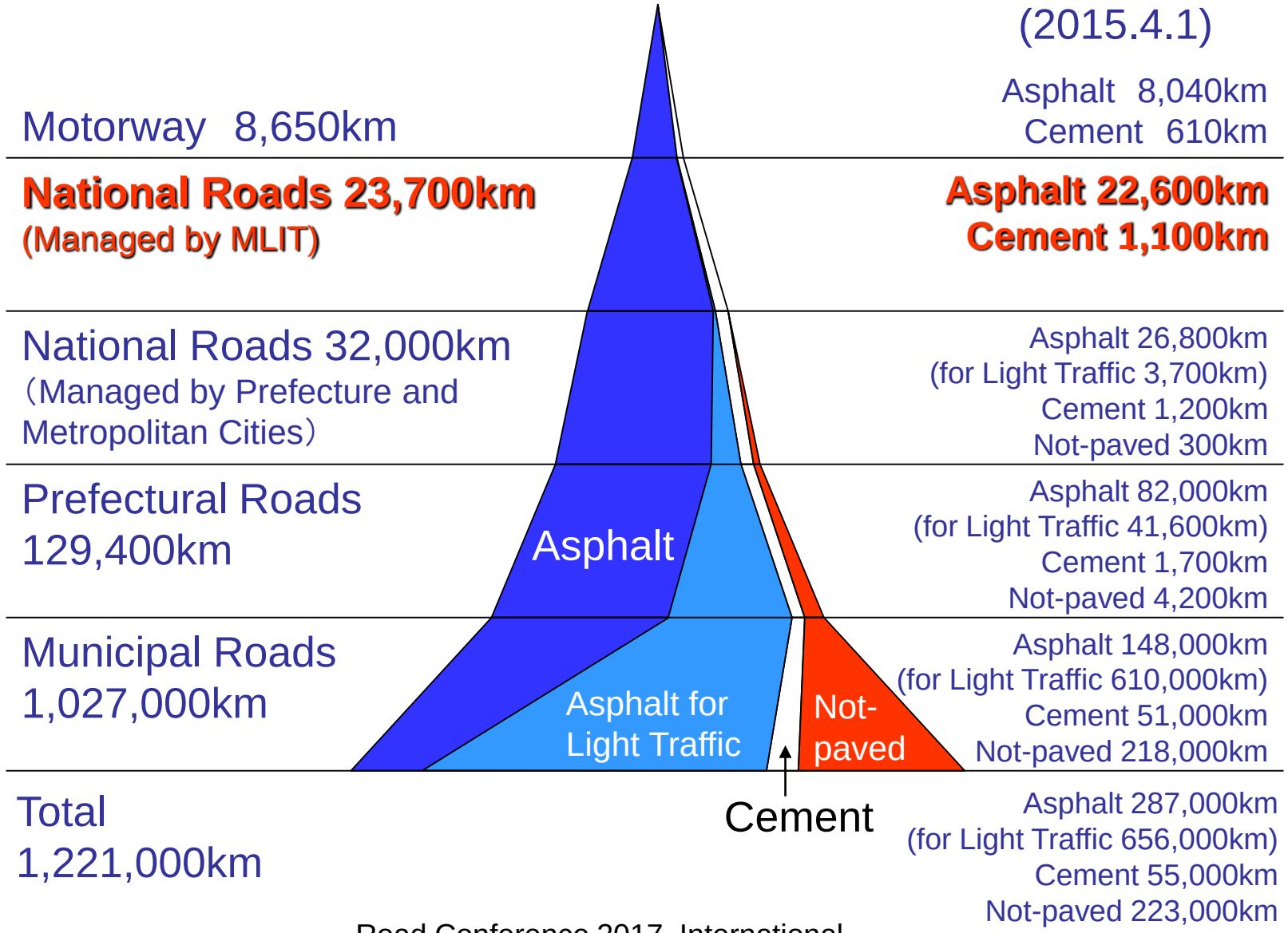
1. Present Status of Roads in Japan - Paved Rate -



Unpaved

Paved

1. Present Status of Roads in Japan - Pavement Types -



2. Pavement Monitoring - Annual Measurement -

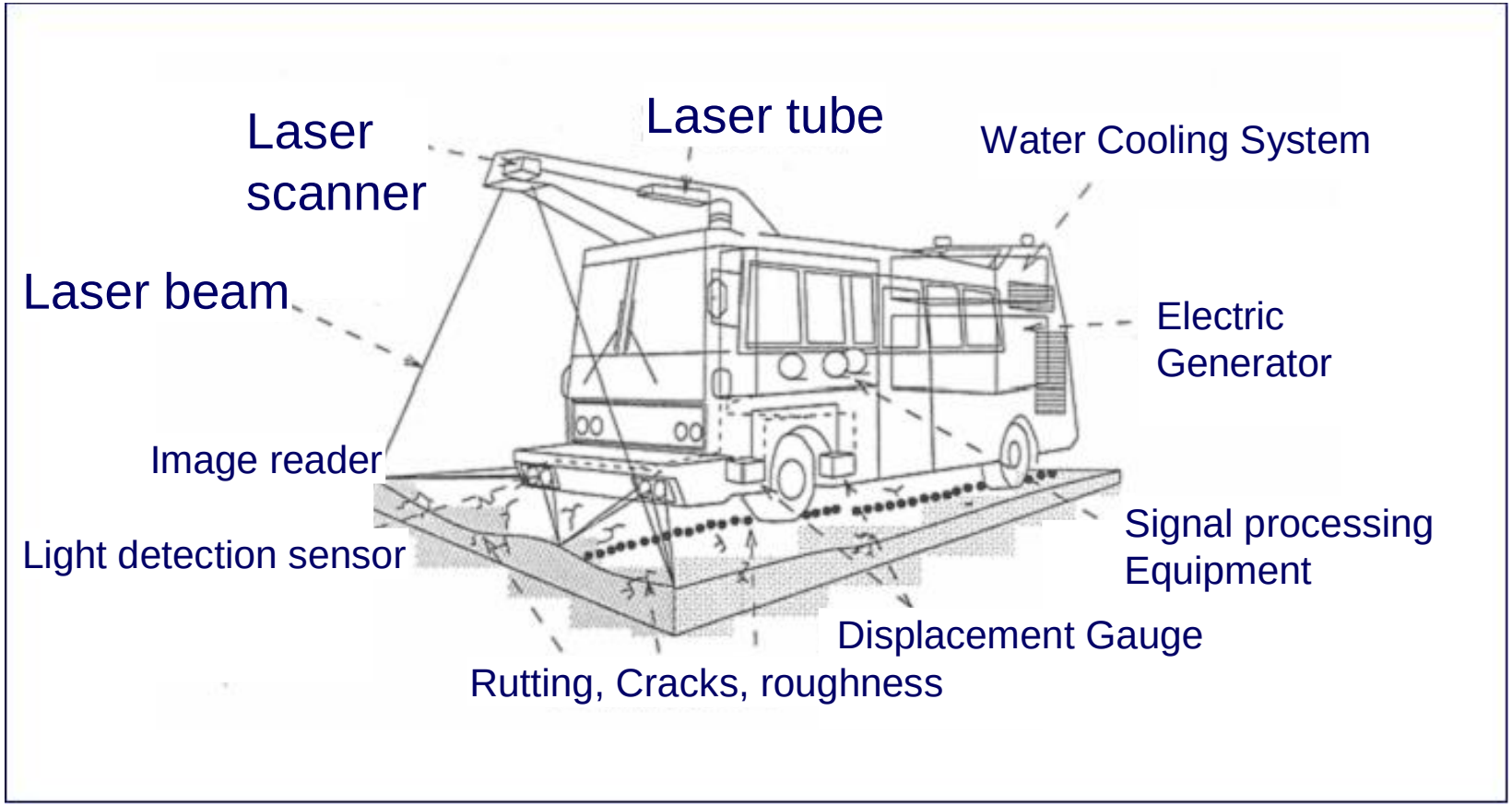
- **Total length (managed by MLIT)**
  about 24,000km

- **Monitoring length (Annually Implemented)**
  about 8,000km/ a year
  → whole network is measured every 3 year

- **Road Surface Measuring Devices**
  Items Measured
  ***Cracking Ratio**
  ***Rutting Depth**
  ***Roughness (IRI)**

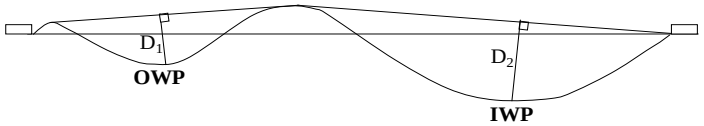
2. Pavement Monitoring - Road Surface Measuring Device -

Now, we are on the way to change this expensive system.



2. Pavement Monitoring - Measured Data -

Rutting ⇒ Rutting Depth (D)



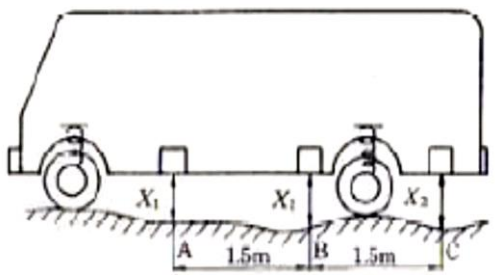
$$D=\max(D_1, D_2)$$

Cracking ⇒ Cracking Ratio (C)

$$C=\frac{\text{Cracking area } (m^2)}{\text{Section area } (m^2)}\times 100$$

Calculation method of cracking area is defined by Manual for Pavement Testing Method (Japan Road Association)

Roughness ⇒ σ



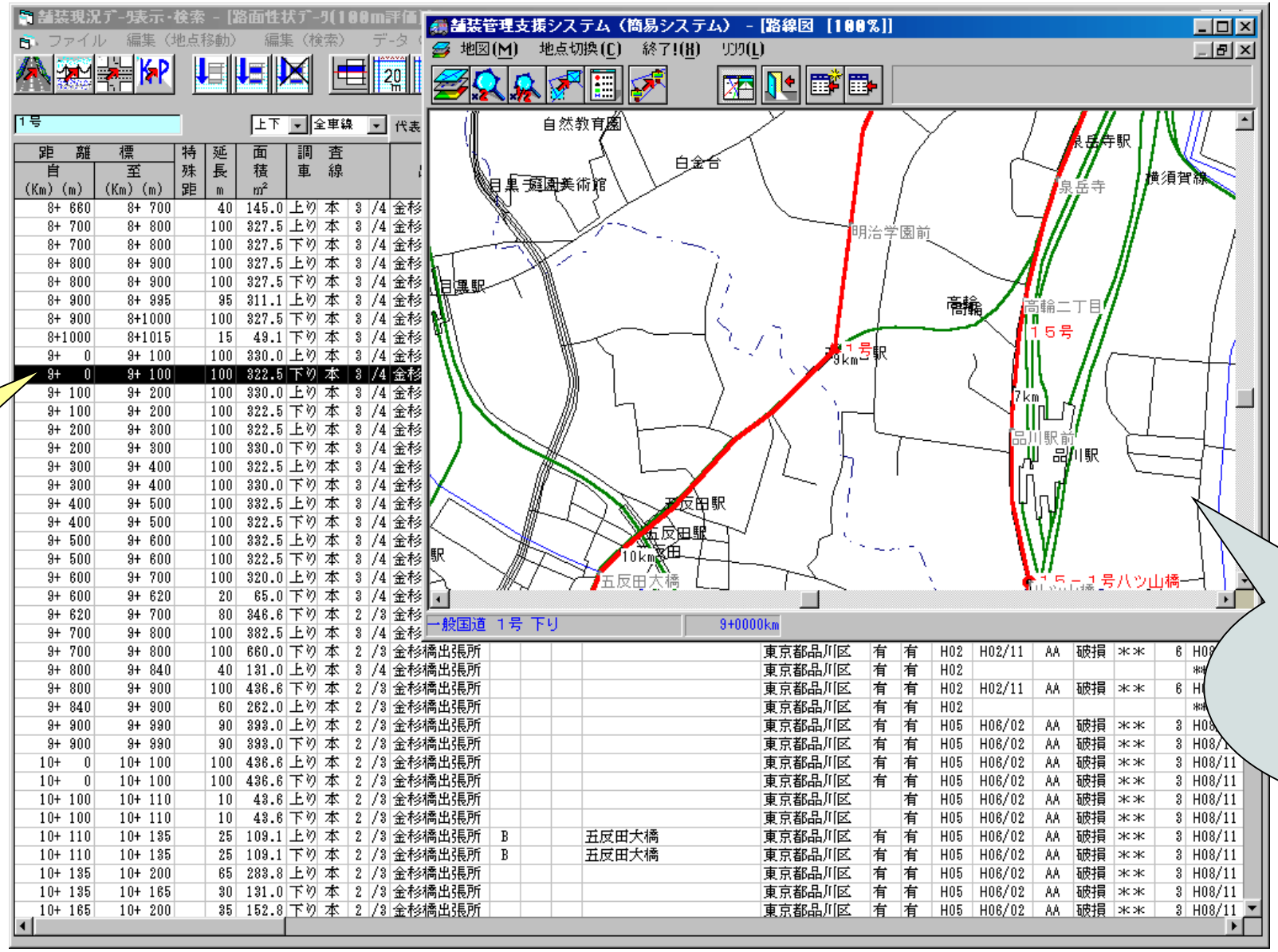
$$\sigma = \sqrt{\{\Sigma d^2 - (\Sigma d)^2/n\}/(n-1)}$$

$$d=(X_1+X_3)/2-X_2$$

n = number of data

IRI can be conversed from σ

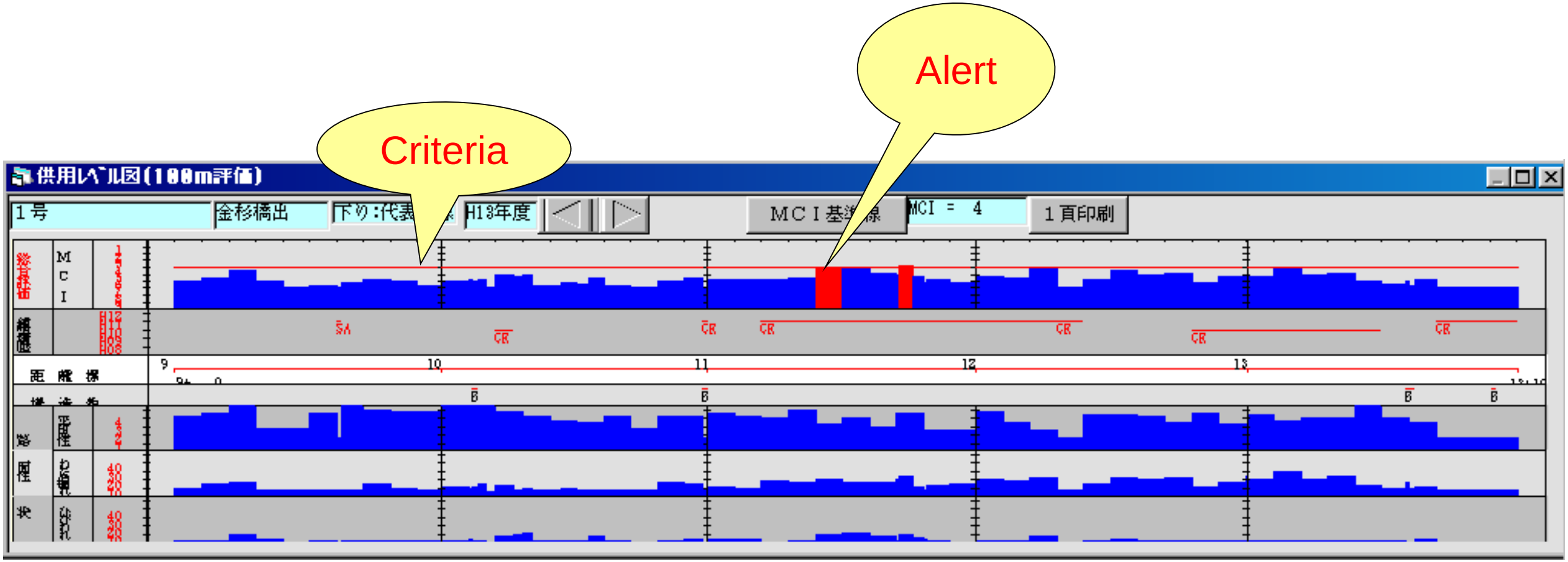
3. Pavement Database - Display Map -



Click Here

Map will be Displayed

3. Pavement Database - Service Level Check for each Section -



Display MCI(=distress level of each pavement), Cracking Ratio, Rutting Depth, and Roughness

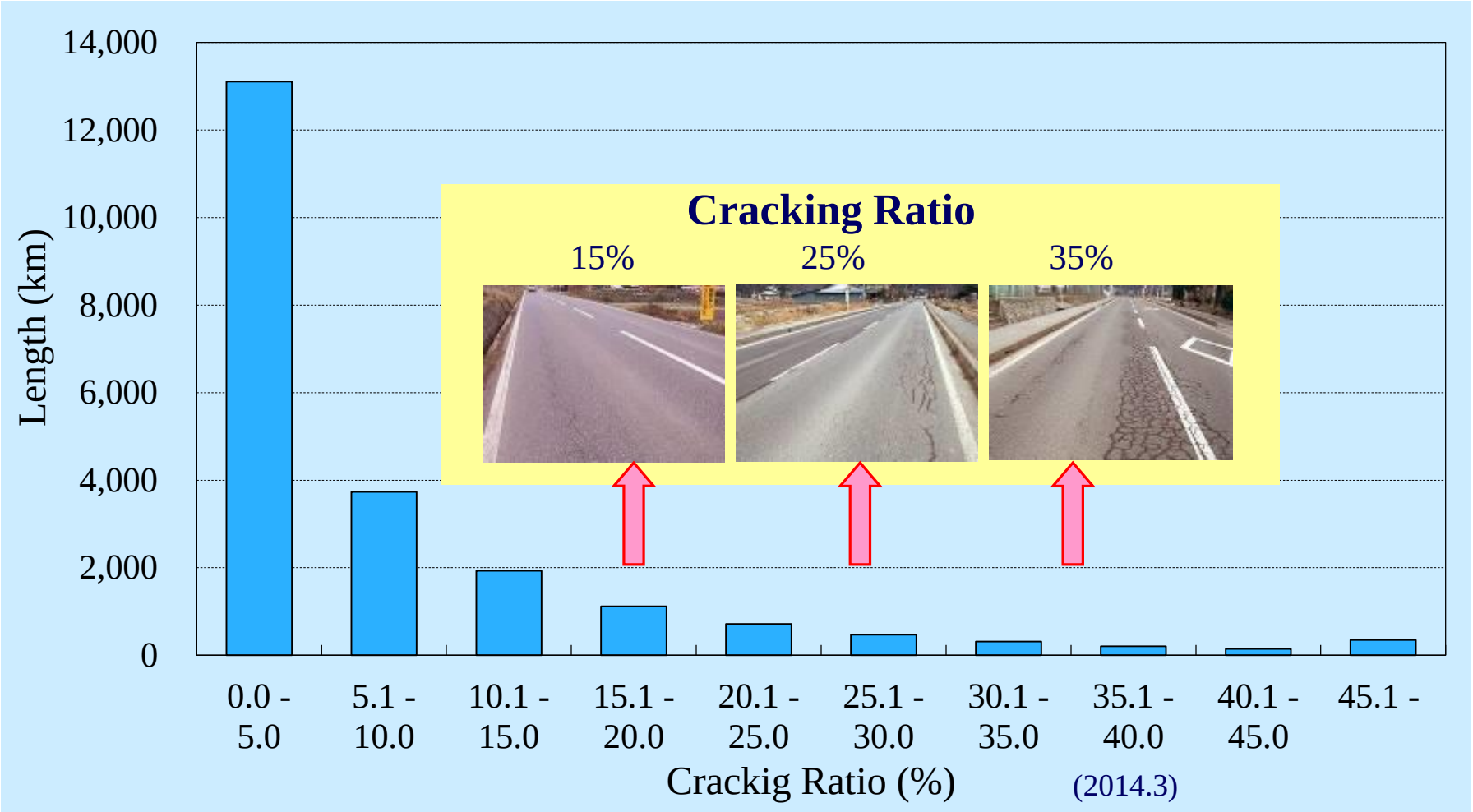
$$MCI=10 - 1.48C^{0.3} - 0.29D^{0.7} - 0.47\sigma^{0.2}$$

C: Cracking Ratio (%)
D: Rutting Depth (mm)
σ: Roughness (mm)

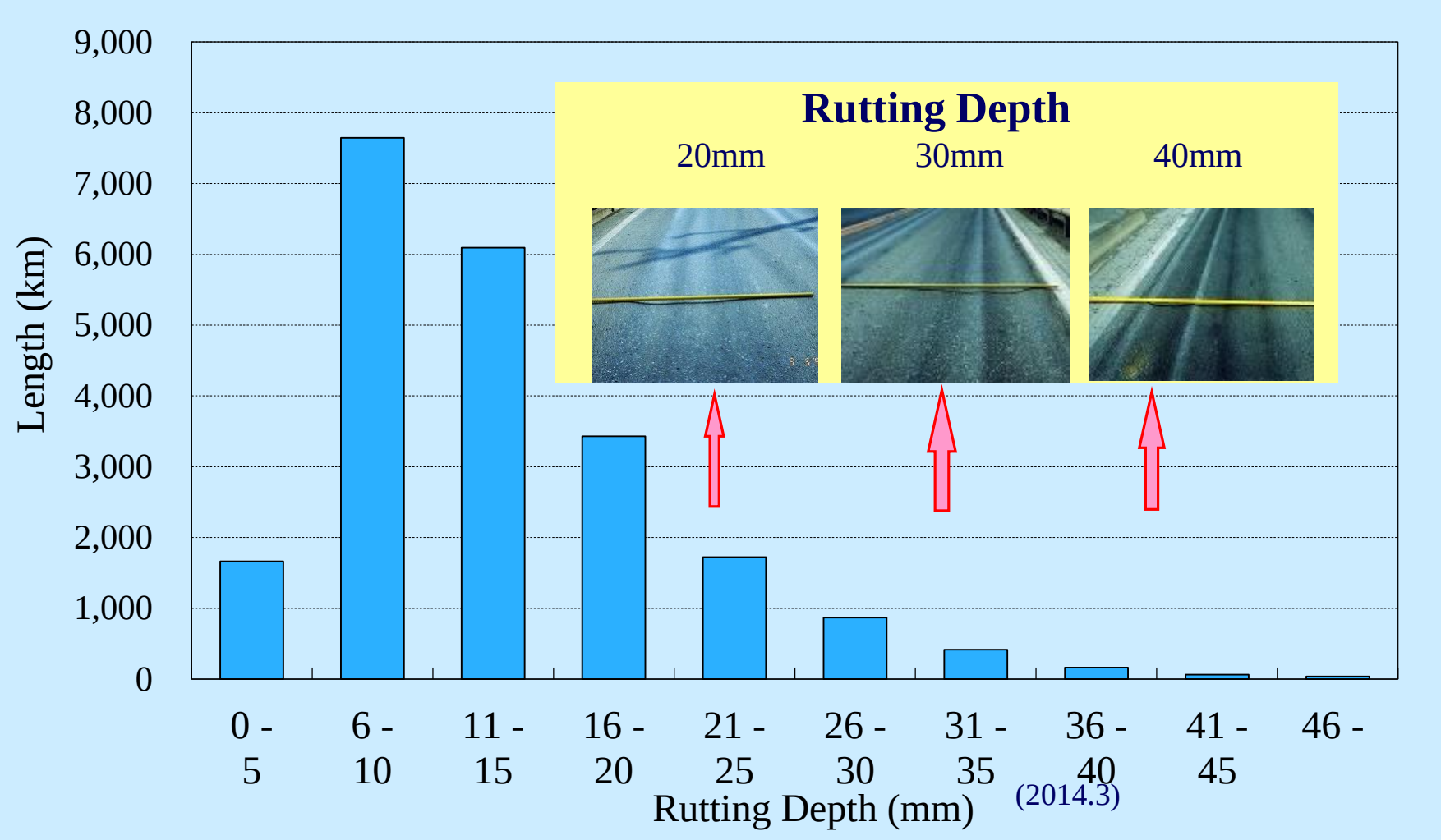
Concept is very close to PSI in USA

- Fullmark=10points
- MCI had been used by MLIT as an index for the pavement management until 2005.
- At present , MLIT uses Cracking Ratio and Rutting Depth as the important Indices for judgment of repair pavement.

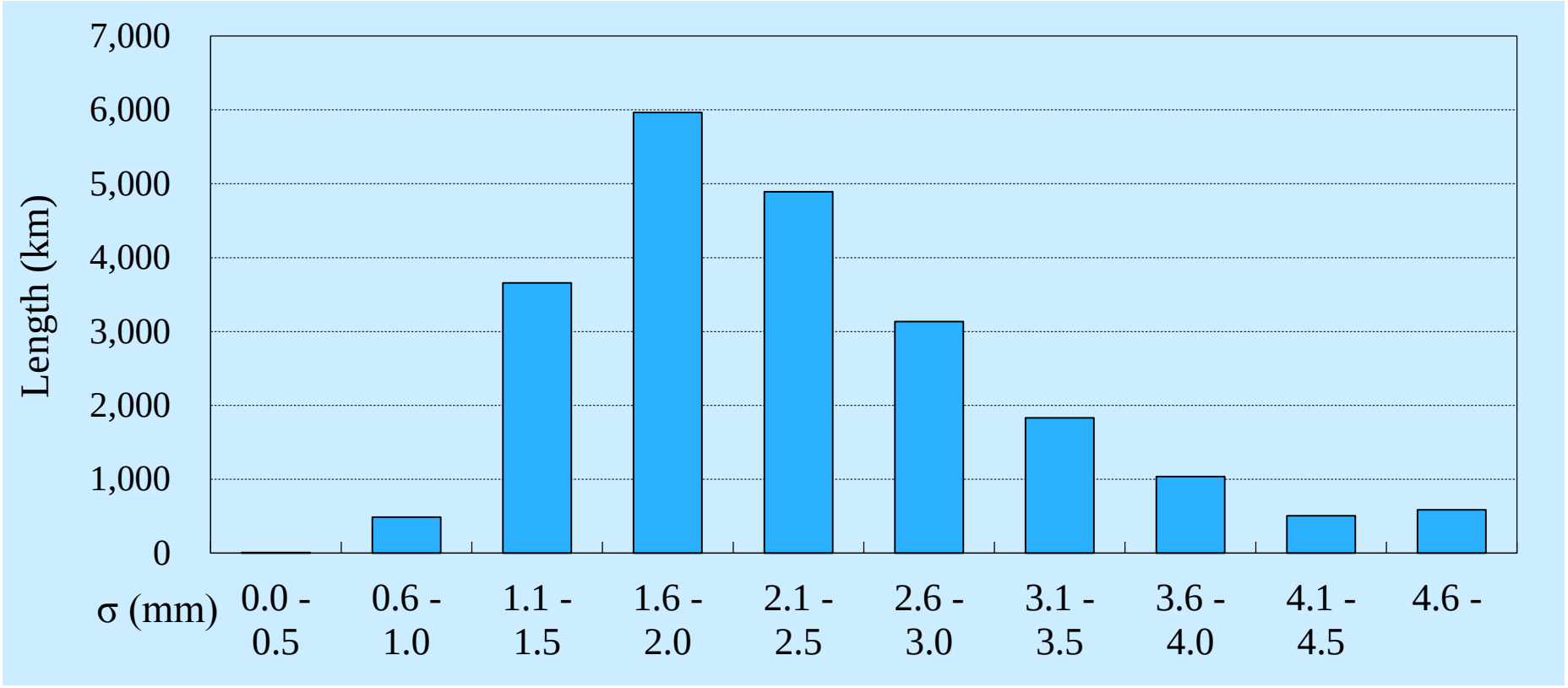
4. Pavement Condition in National Highways -Cracking Ratio -



4. Pavement Condition in National Highways -Rutting Depth -



4. Pavement Condition in National Highways -Roughness σ-



$IRI = 1.2054\ \sigma + 0.123\ (R^2 = 0.92)$ by PIARC EVEN Project in 1998.

(2014.3)

5. Major Point for Pavement Maintenance - New Policy -

For heavy traffic (trunk) roads,

- Difference in pavement life (repair cycle) between heavy and light traffic road
  - ➢ Classify road network by heavy traffic Level
- Financial and human resource problem especially in local gov.
  - ➢ Minimize LCC with efficient management
- There seem some cases of long life pavement without frequent repair work
  - ➢ How to extend repair cycle

As with bridges and tunnels, the Maintenance Cycle shall be established to extend the life of pavement and reduce LCC*1.

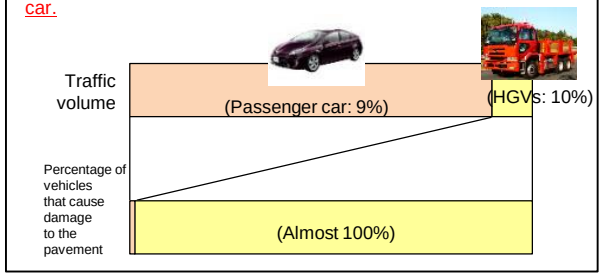
*1: Life Cycle Cost

- Durability of pavement is mostly affected by heavy goods vehicles (HGVs) ➔ the more HGVs that are on the roads, the more rapidly pavement deterioration occurs
- It is important to make sure the layers underneath the roadbed are in a good condition by repairing the surface as needed, in order to reduce LCC.
- Although the National Government and Expressway Companies (NEXCOs), as well as 80% of all prefectures and 20% of all municipalities, have implemented road inspections, standardized data collection and appropriate preventive maintenance/repair has not been sufficiently implemented.

■ Damaging Factors To Pavement

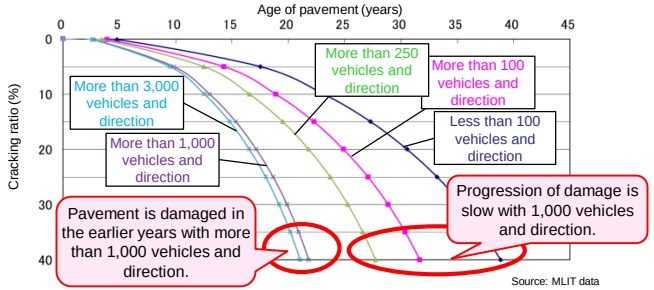
■ Damage to pavement increases with the axle load to the power of four. (Figure 1)

If the vehicle is 20 tons, the axle load is 20 times higher than that of a typical passenger car and the damage to the pavement by the 20-t truck is 16 million times greater than that of a passenger car.

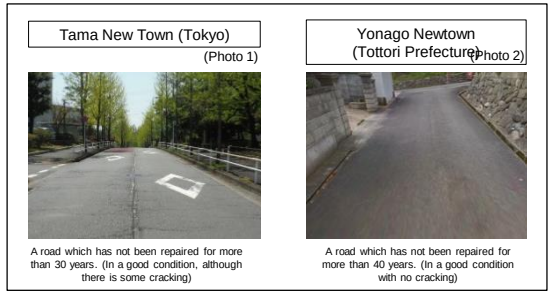


■ The more HGVs that are on the road, the more rapidly the asphalt pavement becomes damaged.

Relationship Between HGV Traffic Volume and Pavement Damage (Figure 2)



(FYI)
Residential streets remain healthier when they have less HGV traffic, unless the street is dug over.

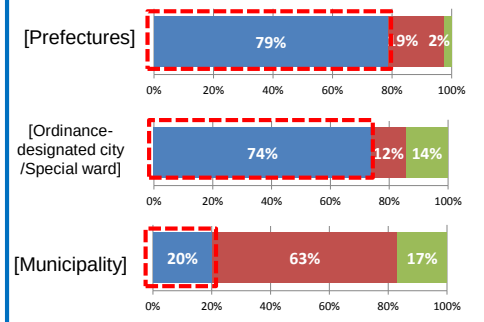


■ Ensuring the Soundness of Roadbeds Is Important To Reduce LCC

(1) Rain water, which penetrates roadbeds due to damaged surfaces, will ultimately reduce the roadbed's support and cause damage to the entire pavement structure.
(2) Repairing roadbeds costs 3 times more than repairing surfaces and takes 4 times more work.
(3) If the roadbed is already compromised, then repairing only the surfaces may result in more damage to the surface in a shorter period of time than normal.
(4) Due to the above factors, it is important to keep roadbeds sound. Repairing surfaces and other structures in a timely manner is required.

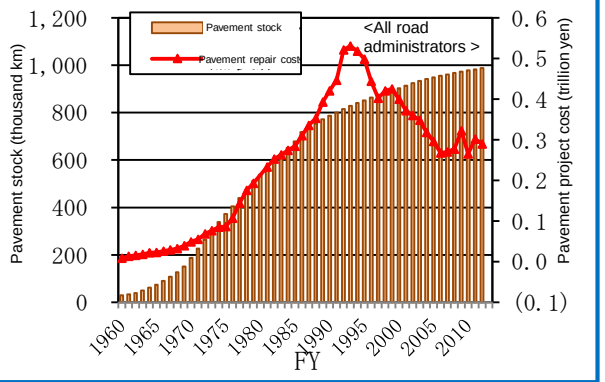
■ Pavement Management Today

■ About 80% of all prefectures and ordinance-designated cities, and about 20% of all municipalities, have implement pavement inspection. (Figure 3)



(1) Inspections carried out.
(2) The only time inspections were carried out were when the Comprehensive Road Stock Inspection was carried out.
(3) Inspection has never been carried out.

■ The budget is decreasing and the appropriate preventive maintenance and repairs are insufficient. (Figure 4)



5.Major Point for Pavement Maintenance -Settlement of Target Service Life-

- Set Target Lifetime

➢ Pay more attention to shorter lifetime pavement
➢ Recommend preservation or reconstruction rather than repair work such as cut & overlay
➢ Monitor pavement condition every five years or longer
➢ Visual observation or equipment-aided

■ **Roads with Rapid Progression of Damage**

- In order to protect roadbeds, surfaces must be efficiently repaired in a timely manner.
- Management is required to increase the life of roads, this can be achieved by creating a targeted lifetime for the pavement.
- An inspection at least once every 5 years is prescribed.
- Use of 3 stages for evaluation is recommended.

6. Inspection of Asphalt Pavement
6-1. Roads with rapid progression of damage (Type A and B)
(1) Inspection Methods

- Setting the pavement life
The road administrator shall appropriately set the targeted lifetime for the pavement, according to the repair work history in the same area and HGV traffic volume classification.

- Frequency of inspection
The road administrator shall appropriately set a frequency of inspection, while taking into consideration that a frequency of once every five years is recommended.

- Inspection method
In light of the characteristics of each road, the road administrator shall set the standard for proper management to understand the pavement condition through appropriate methods including visual observation and equipment-aided observation.

* targeted lifetime for the pavement
Number of years set as a targeted lifetime for the pavement. The intention is to extend the life of pavement through granular control, including removal of severely damaged sections in the early years and implementation of appropriate actions depending on the service years and damage level of the asphalt pavement, which has a wide variety in deterioration levels.

5. Major Point for Pavement Maintenance -Identify Damage Level-

Longer life

Sound or average condition:
No need to consider structural re-design

Shorter life

Undesirable condition:
Need to consider structural re-design

(2) Evaluation of Soundness

In the light of the criteria set by the road administrator, pavement shall be appropriately evaluated using information from the inspection (e.g. cracking ratio, rutting depth and IRI).

* Use of 3 stages for evaluation is recommended.

Type		Condition
I	Good	Damage level: low: In the light of the criteria, the deterioration level is low and the pavement surface is in a good condition.
II	Phase to keep surface functioning	Damage level: medium: In the light of the criteria, the deterioration level is medium.
III	Repair phase	Damage level: high: In the light of the criteria, the deterioration level is high and (expected to be) beyond the permissible level (soon).
	(III-1: Surface repair)	Service years of the surface exceed the targeted lifetime for the pavement (i.e. layers under the roadbed are thought to be in a good condition).
	(III- 2: Replacement of roadbed)	Service years of the surface do not exceed the targeted lifetime for the pavement (i.e. layers under the roadbed are thought to be damaged).

* Recommended management standards are provided.
-Type A road: cracking ratio of 15-20%, rutting depth of 20-25 mm, IRI of 3.5 mm.
-Type B road: cracking ratio of 20-40%, rutting depth of 20-40 mm, IRI of 8 mm.

(3) Actions

Based on the evaluation results, the necessary actions shall be taken to implement the pavement repair in an efficient manner.

* Actions shall be taken based on proper repair design by comparing several LCC scenarios, including a change to concrete/composite pavement and reinforced roadbed by cement stabilization.

(4) Records

Results of the inspection, evaluation, and actions shall be recorded and kept as long as the pavement is in service.

For type A roads, appropriate methods may be used depending on the road characteristics at each phase of inspection, evaluation, action, and recording, considering the required service level for high-speed running roads.

5. Major Point for Pavement Maintenance -Case of Local Road-

For low volume (local) roads

“broken, then repair”
Less need for monitoring or efficient management of pavement conditions

For more efficient pavement management,

“ready for future repair”
Budget plan for repairment is Recommended to be laid by local gov.

■ **Roads with Slow Progression of Damage**

- Development and implementation of an inspection plan are prescribed.
- Use of 3 stages for evaluation is recommended.

6. Inspection of Asphalt Pavement
6-2 Roads with slow progression of damage (Type C and D)
(1) Inspection Methods

-Development of an inspection plan
The road administrator shall appropriately develop an inspection plan considering the total road length, replacement timing, and local characteristics.

- Inspection method
In light of the characteristics of each road, the road administrator shall set the standard for proper management to understand the pavement condition through appropriate methods including visual observation and equipment-aided observation.

* For reference of inspection planning, the deterioration curve for roads with slow progression of damage is provided in the appendix.

*If intervals between inspections becomes too long, it is recommended that information from regular patrols is used to complement the inspection.

5. Major Point for Pavement Maintenance - Patrol and Treatment -

Pavement is thinner and more simple than trunk roads
There is less difference between surface and structural repair

(2) Evaluation of Soundness

In the light of the criteria defined by the road administrator, pavement shall be appropriately evaluated based on the information obtained from the inspection.

* Use of 3 stages for evaluation is recommended.

Type		Condition
I	Good	Damage level: low: In the light of the criteria, the deterioration level is low and the pavement surface is in a good condition.
II	Phase to keep surface function	Damage level: medium: In the light of the criteria, the deterioration level is medium.
III	Repair phase	Damage level: high: In the light of the criteria, the deterioration level is high and (expected to be) beyond the permissible level (soon).

* Recommended management standards are provided.
Roads with slow progression of damage: Cracking ratio (20% to 40%), rutting depth (20 mm to 40 mm)

(3) Actions

Based on the evaluation results, necessary actions shall be taken to implement the pavement repair in an efficient manner.

(4) Record

Results of the inspection, evaluation, and actions shall be recorded and kept as long as the pavement is in service.

For type D roads, regular patrols may be deemed as proper inspections in order to identify surface damage, take actions, and record the log.

6. Trials to Reduce LCC - Performance-Based Contract for Asphalt Pavement Work -

- Both the administrator and the contractor shall identify challenges and explore solutions to assure the long-term quality of the infrastructure.
- To this end, the administrator should require the contractor to assure a level of performance of the infrastructure for a certain period of time even after the completion of the work, in order to encourage the contractor to do the work carefully. In this way, road pavement will become more durable and last longer.

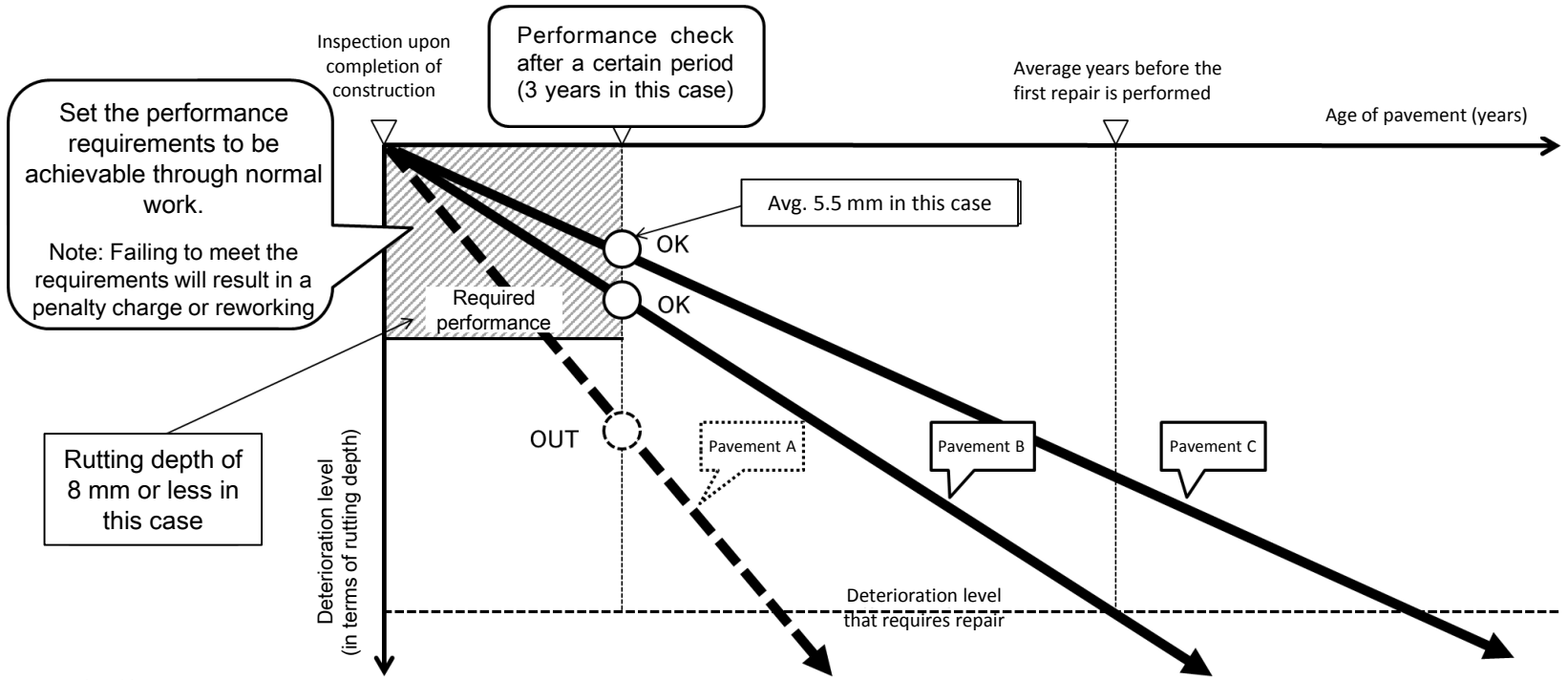
<An Illustration of Long-term Performance Assurance>

- Currently, an inspection is carried out upon completion of work before the infrastructure is put into use. However, some infrastructure deteriorates faster than others over time, thus requiring proper repair regardless of the time period after delivery.
- With a long-term performance assurance, rapid deterioration of pavement, as shown “Pavement A” in the figure below, can be prevented. This will help extend the life of the pavement.

Desirable
C>B>A

<u>Under previous and manner,</u>
condition just after construction would be checked, and found no difference among A, B and C

<u>Under performance-based contract,</u>
It will become possible to evaluate
C>B>A

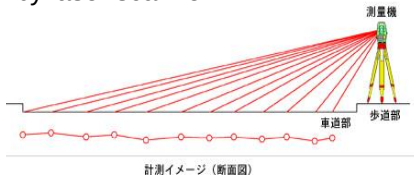


“Better construction work for longer life”

ICT (Information and Communications Technology in the Pavement Field)

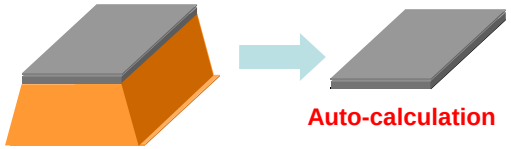
- To increase productivity, “ICT Pavement” (ICT-enabled paving work) has been introduced in FY2017.
- Necessary technical standards and estimation standards were developed in FY2015 and came into effect in April 2017.

(1) **Pre-measurement** by laser scanner



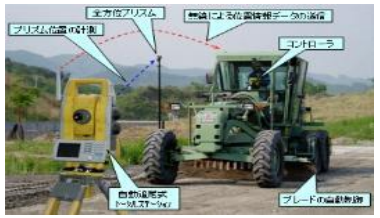
Laser scanner allows an area-based (high-density) 3D measurement in a short period of time.

(2) **Designing and planing of construction** based on ICT-enabled 3D measurement



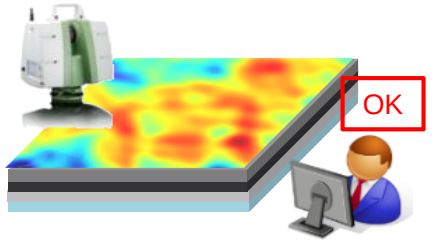
From the difference between 3D measurement-based design data and pre-measurement data, the actual amount of work necessary is automatically estimated.

(3) **Work** using ICT-enabled grader

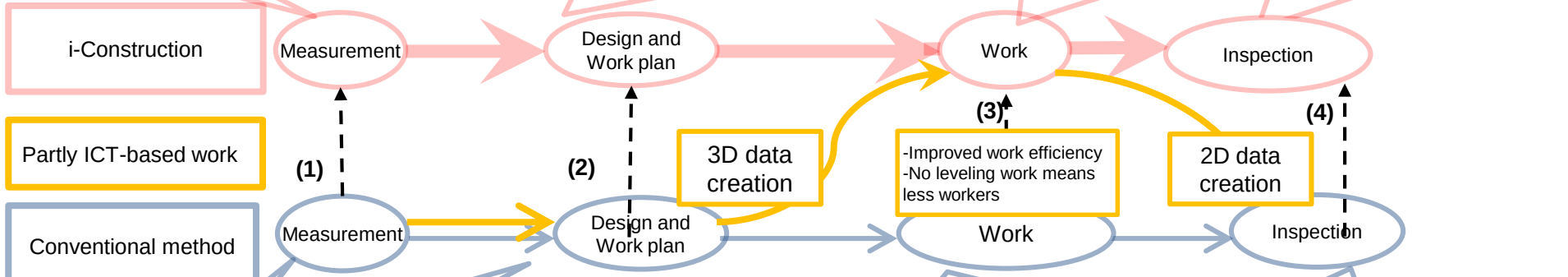


ICT-enabled construction equipment is self-operated using 3D design data.

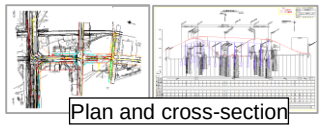
(4) Labor-saving in **inspection**



Laser scanner data-based inspection reduces documentation work by half.



Manual measurement



Amount of work is estimated from paper-based drawings

Leveling string is set

Work based on the leveling

Repeated measuring and work until it is shaped

Inspection by drilling

ICT (Information and Communications Technology) in the Pavement Field

- ICT is introduced in a phased manner depending on the project phases (from construction to maintenance/management) and purposes (from streamlining to quality enhancements).

[Purpose]

[Phase 1 (from 2017 onward)]

[Phase 2]

[Phase 3]

Improved work efficiency (Construction)

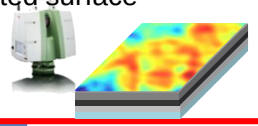
Roadbed work (Introduction of MC grader)

Consider expansion of ICT-enabled work including asphalt paving and cutting overlays (Introduction of MC finisher, MC cutting machines)

Improved work efficiency (Work management)

Management of completed surface (Laser scanner)

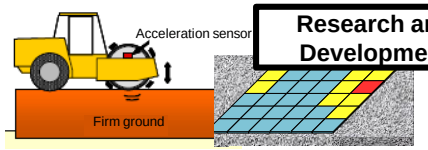
Area-based management of completed surface



ICT pavement
Effects: construction period and labor are reduced

Quality Control (density) Non-destructive technology

Management of compaction by ICT-enabled roller

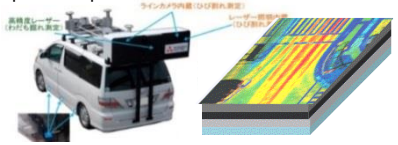


Improved management level (maintenance / management)

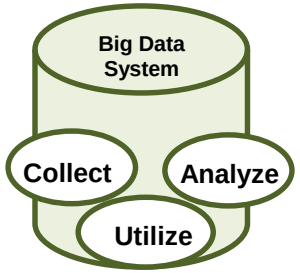
Stored point cloud data

Management of long-term performance (Laser scanner)

Measurement of surface characteristics after the road is opened to public



Quality control by ICT
Effects: Unevenness of quality is addressed and labor-saving in quality control



Quality Improvement (Work / work management)

Stored quality data

Consideration toward ideal work/work management to improve long-term performance

Analysis on the long-term fluctuation of face shape data obtained from i-Construction

What is expected results of applying ICT in the Pavement Field?

[Beneficial Effects for Long-term Performance Assurance System]

- Laser scanner improves measurement of completed surface, helping to address issues concerning the long-term performance evaluation system.
- Area-based quality control will help address unevenness of quality, extend the life of the pavement and reduce the costs, which are what the long-term performance assurance system aims to do.

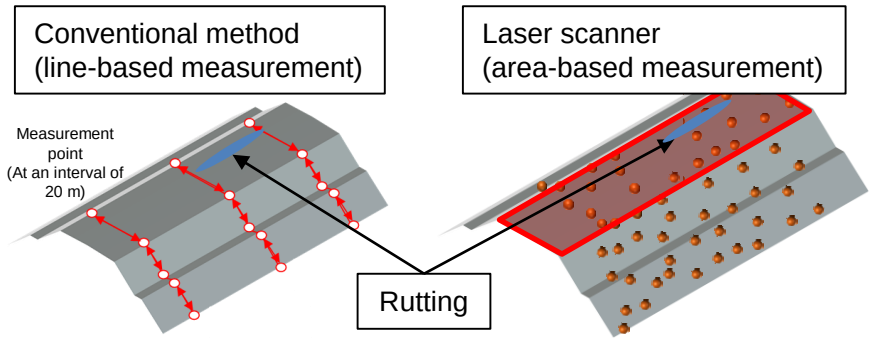
Measurement of completed surface by laser scanner

[Challenges]

-Measurement of completed surfaces just after the construction (initial setting) does not necessarily cover all the sections that need to be evaluated for long-term performance assurance work.
-Initial measurement points may not be accurately identified in some cases.

[Solution]

-It is possible to obtain initial values wherever the rutting occurs by using a laser scanner to carry out an area-based measurement just after the completion of the work.
-Accurate location of the initial measurement points can be obtained by using point cloud coordinates.



Quality control by ICT

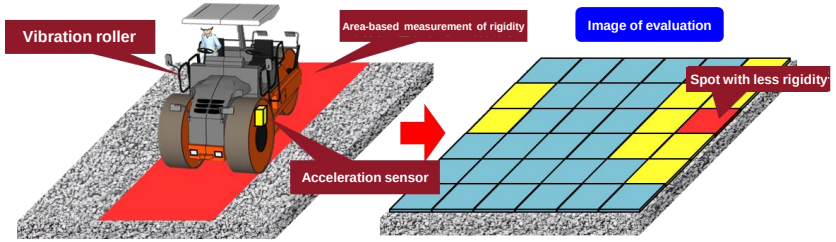
-Area-based quality control using acceleration sensors will help address unevenness of quality between constructors, extend the life of pavement, and reduce the costs.

[Conventional Method]

The existing quality control criteria requires the digging of a given spot to evaluate the density by the sand replacement method, which may cause unevenness in the quality of the pavement.

[i-Con]

Acceleration sensor-based quality control may identify locations with a relatively lower rigidity. By applying another rolling compaction, the quality of pavement will be improved and unevenness can be addressed immediately and without additional damage.



ICT is effective,

- not only for good construction
- but also for 2D or 3D construction data

For performance-based contract, 2D or 3D construction data is very effective to understand the reason of their performance, such as local insufficient compaction or uneven material

ICT will encourage and assist performance-based contract and finally contribute to extend pavement life

Thank you for your attention!