Smart Maintenance Highway (SMH) Project

مشروع الصيانة الذكية للطرق السريعة (SMH)

What is SMH?

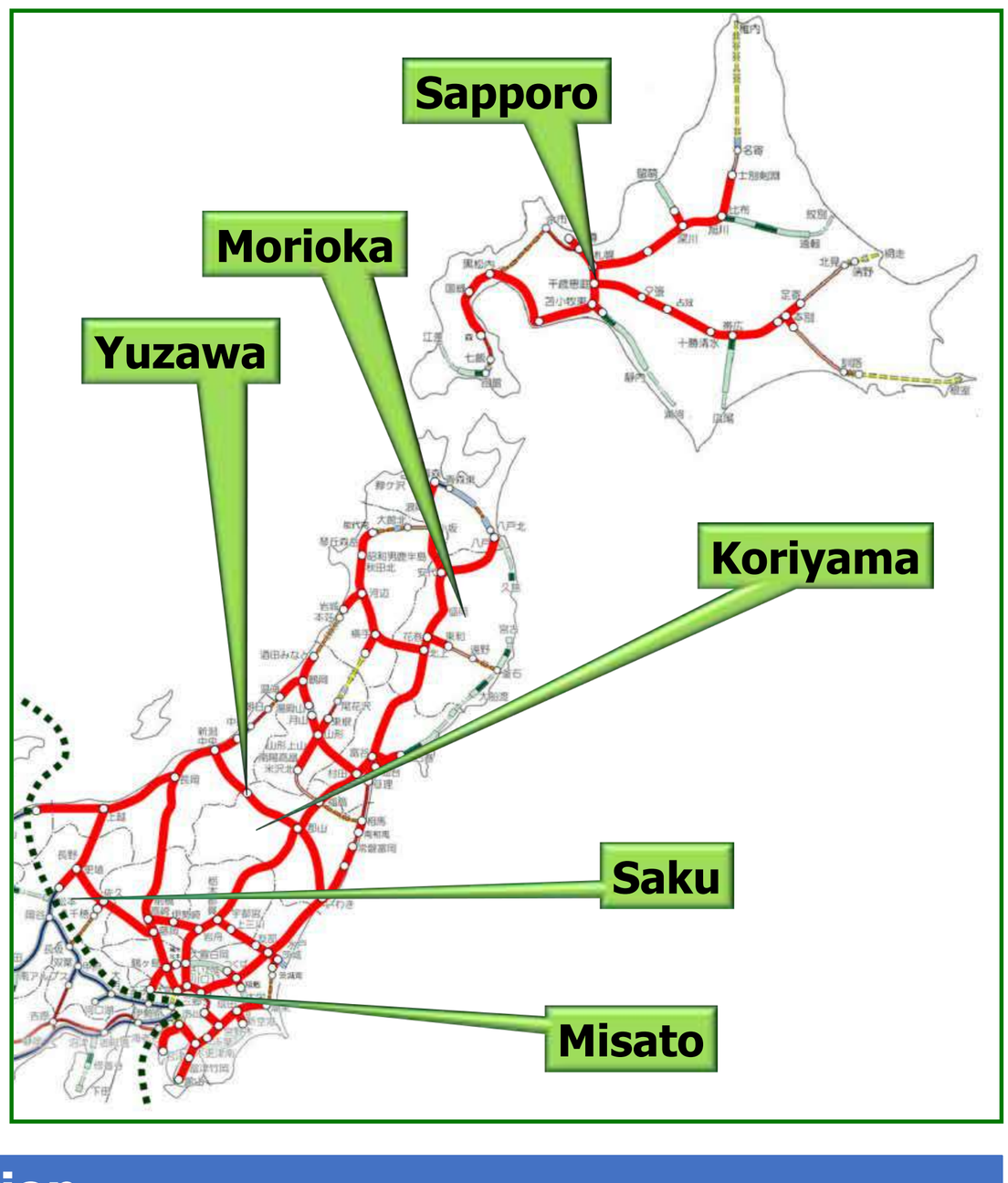
- SMH is company-wide initiative that intends to scrutinize solutions against issues, associated with onsite inspection and maintenance.
- It plans to actively introduce ICT, mechanization, and other innovations. We are setting up a comprehensive maintenance system which all elements are well **harmonized with engineers capability**.
- It aims to secure long-term safety and reliability, leading to easy maintenance, efficient renewal and improvements for expressway infrastructure.

SMH
Smart Maintenance Highway

- The **"safety" which is our invariable mission is expressed by "dark green"** and **"comfort" is expressed by "light green"**. 2 colors are adopted so that they are mixed and harmonized into the corporate color of **NEXCO**.
- The **"letter of" 8 imagines expressway, and means infinity.** This expresses our decision to work together to pursue and secure "safety" and "comfort " permanently.

Promotion of SMH master plan

Progress stage	FY	Study contents
START Planning stage	2013	Announcement of SMH concept
Phase 1 Preparation stage	2014 –2015	Announcement of SMH basic plan & Project Creating SMH Entire Architecture Target setting for technology development and research On-site trial start
Phase 2 Development stage	2016 –2017	Promotion of technology development Expansion of on-site trials System development Data adjustment (RIMS)
Phase 3 Verification stage	2018 –2019	Verification of Infrastructure Management Center Verification and improvement of PDCA cycle Optimization verification of organization, personnel and operations
Deployment stage	2020–	Entire company development of SMH Further development of SMH



Problem of Operation Process and Its Solution

【Problem】

Current RIMS

Taking data from individual system and process it

・Inspection checking system
・Drawing management system
・Bridge Management system etc.

Current RIMS Databases
Individual and Separate Databases

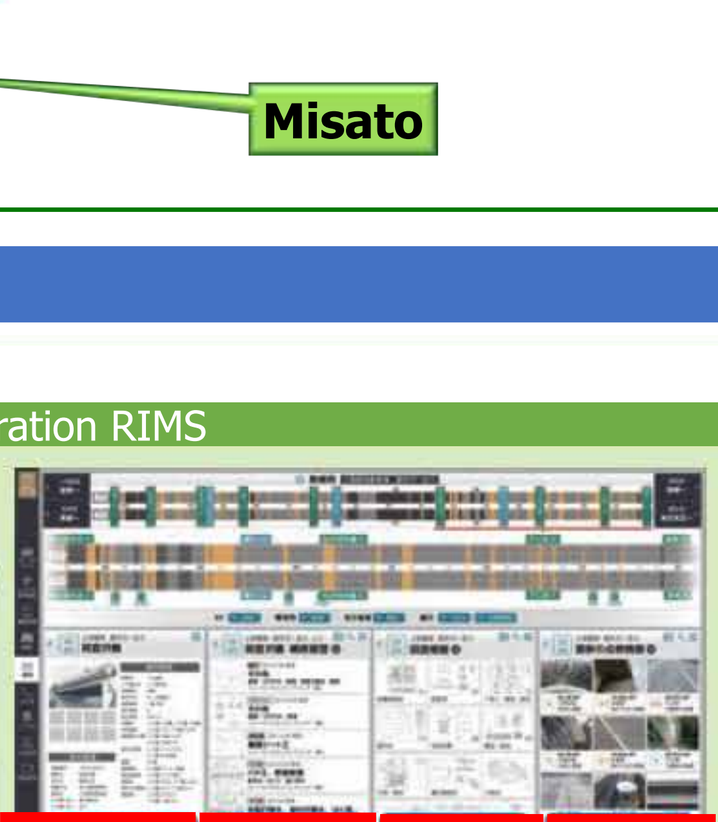
【Solution】

Next Generation RIMS

Access data for analysis in an integrated fashion

Integrated DB
Non-Integrated DB

Next Generation RIMS Databases
Integration of multiple Databases



RIMS: Road Maintenance Information Management System

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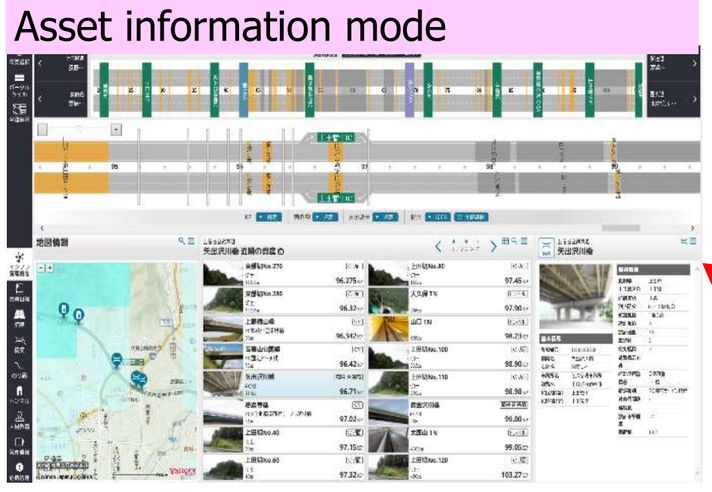
NEXCO EAST

Smart Maintenance Highway (SMH) Project

مشروع الصيانة الذكية للطرق السريعة (SMH)

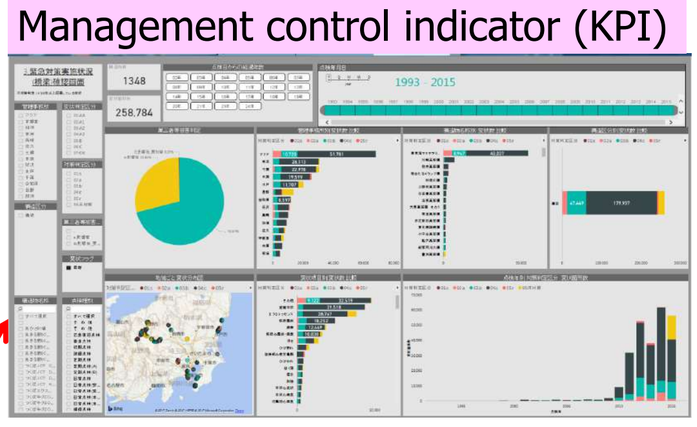
Development of user interface (next-generation RIMS)

Asset information mode



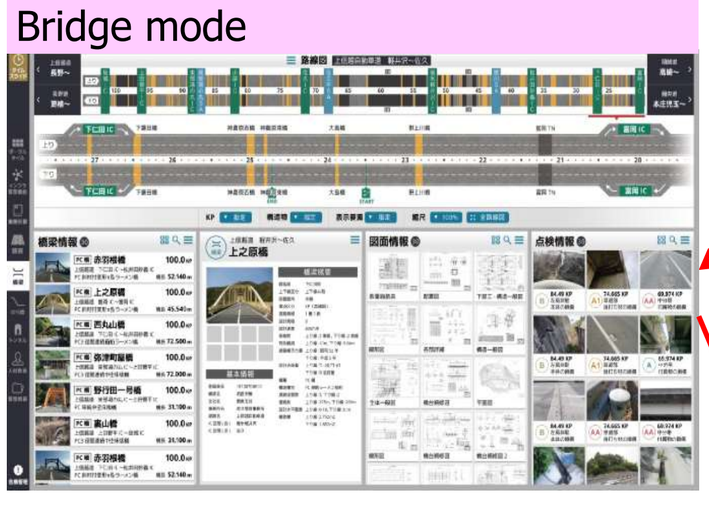
Portal tile

Management control indicator (KPI)

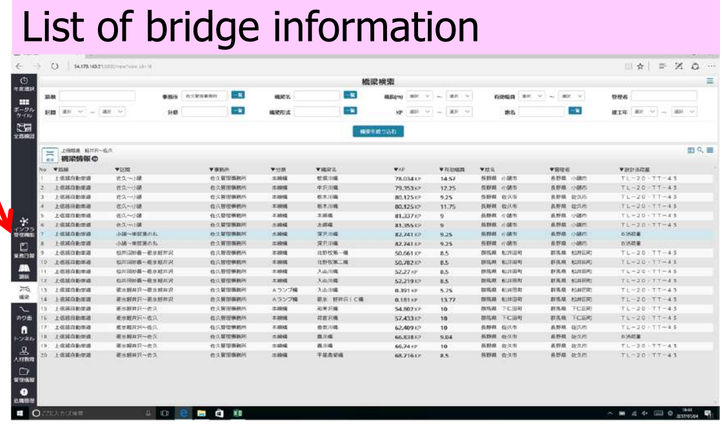


This screen uses Power BI Desktop provided by Microsoft Corporation.

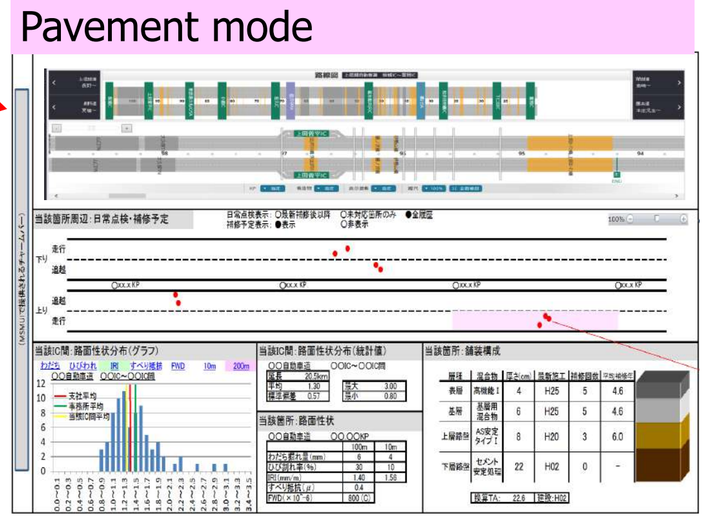
Bridge mode



List of bridge information

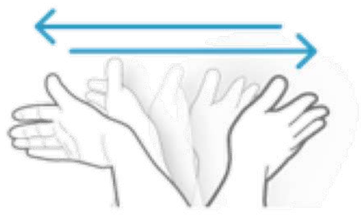


Pavement mode

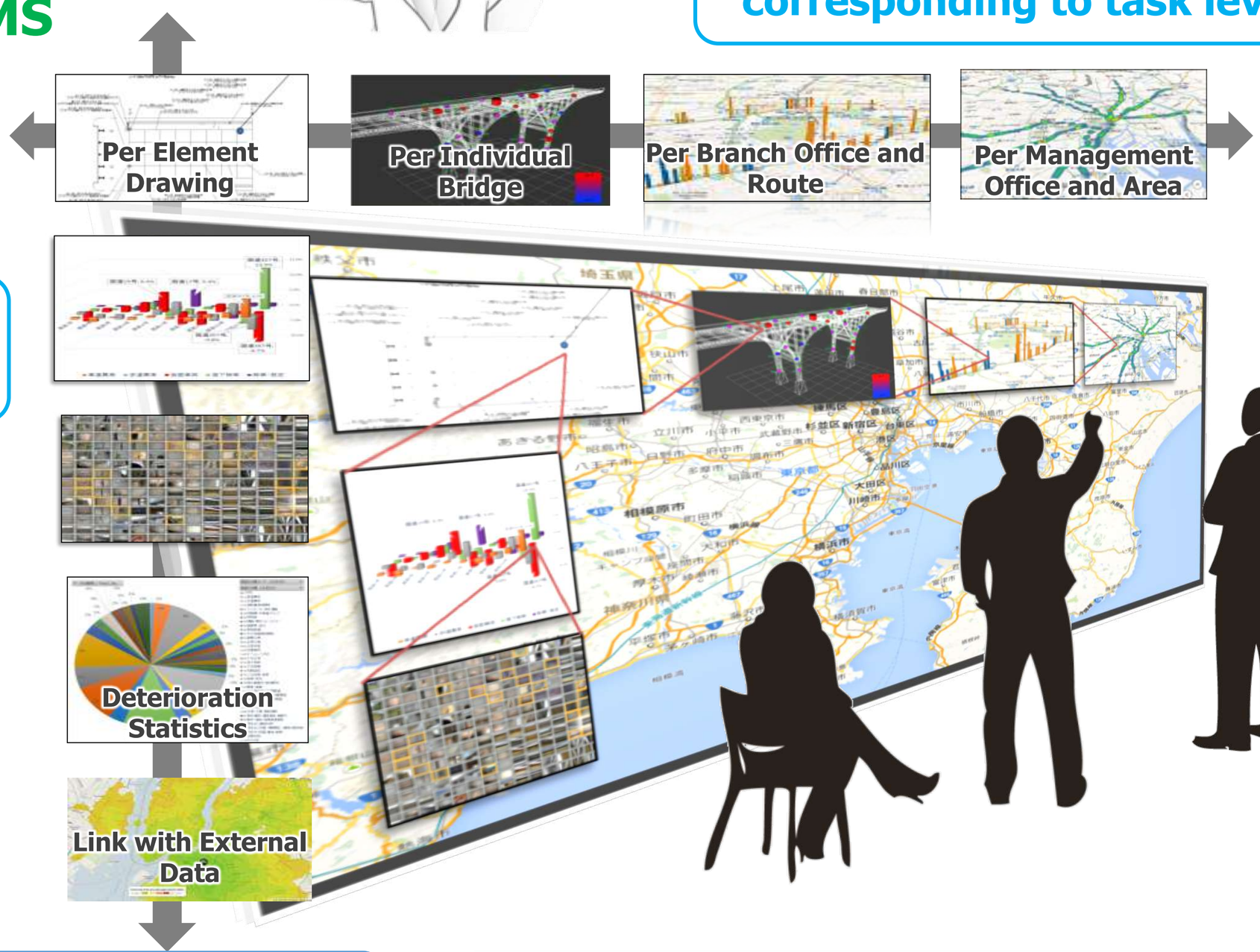


User-friendliness for Business Use

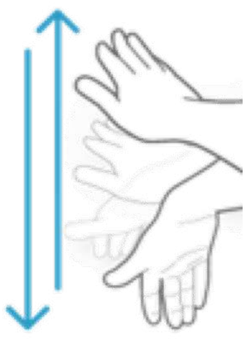
Operation of next-generation RIMS



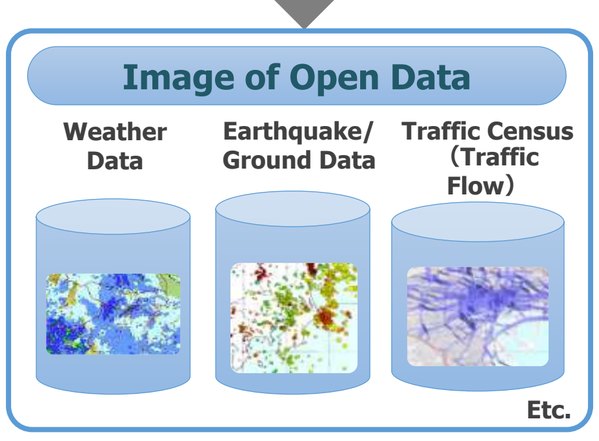
Provides multi-scaled UI corresponding to task level



See detailed info. By drilling down



Plane view using similarities of multi-media



『 Enhance collaboration among engineers, instead of working separately』

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Measures against snow and ice

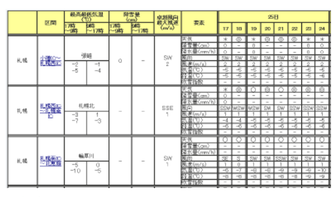
تدابير مضادة للثلج والصقيع

Artificial intelligence-based decision-making assistance system for snow and ice mitigation

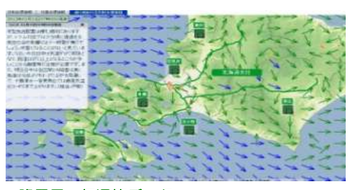
This system assists decision-making by people who are involved in snow and ice mitigation efforts. The system employs an artificial intelligence supported by cumulative knowledge from snow and ice mitigation experience in the past and also by various pieces of real-time information including weather forecast, current weather, road surface condition and snow and ice management readiness.

Big data

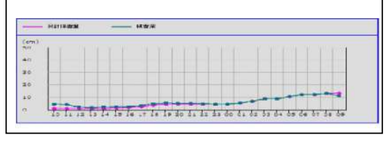
Climate data



気象状況



降雪量、気温等データ



Work situation data

Work readiness data

Traffic data

Road surface condition data

道路巡回の情報

Related organizational readiness data

input

Artificial intelligence (AI)

Assistance system with AI and other supporting technologies

- A systematized wisdom and knowledge based on the expertise of best trained personnel
- Cumulative snow and ice mitigation records and information from various sources

Decision making about whether or not, when and how to remove snow or to apply antifreezing agents

Work instructions

Snow and ice mitigation work

Antifreezing agent application

Snow remova

[AI development process]

Work instructions from a controller person at NMH (regional control center).

⟷ **Gap**

Work-related decisions made by artificial intelligence (AI)

Analyze the difference in the decisions made

[Learn]
Aim to achieve the decision-making capability as close to that of an experienced human controller as possible

Anticipated effects:
① Accumulation of wisdom and knowledge related to snow and ice mitigation efforts
② Support for less-experienced control center personnel in making snow/ice mitigation effort decisions.
③ High-quality and consistent wintertime road surface management service
④ Retention and transfer of the expertise possessed by best trained personnel

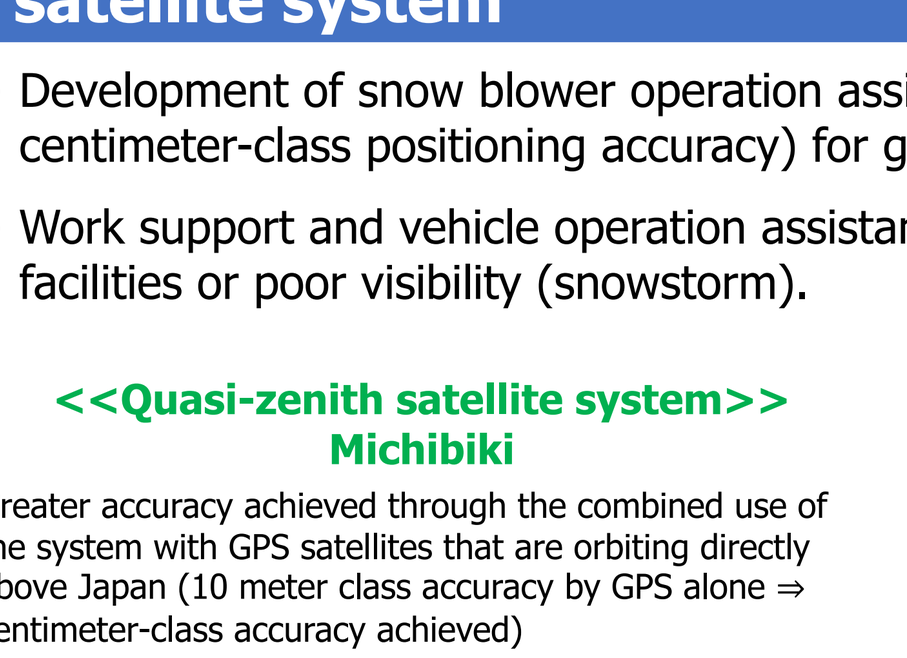
Ice and snow mitigation vehicle operation support by a quasi-zenith satellite system

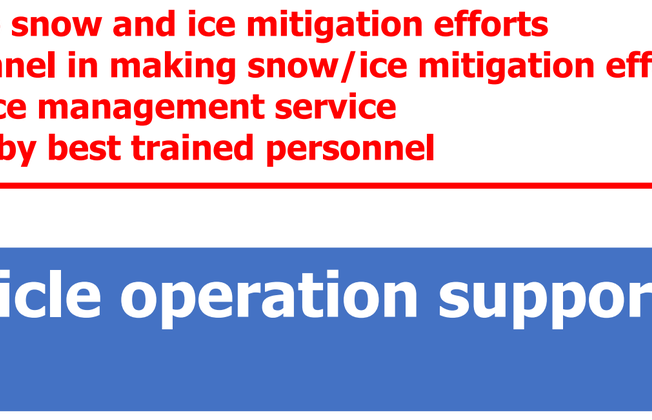
- Development of snow blower operation assistance system supported by a quasi-zenith satellite system (with a centimeter-class positioning accuracy) for greater snow removal safety and efficiency
- Work support and vehicle operation assistance in adverse conditions such as roadside snow piles covering road facilities or poor visibility (snowstorm).

<<Quasi-zenith satellite system>> Michibiki

Greater accuracy achieved through the combined use of the system with GPS satellites that are orbiting directly above Japan (10 meter class accuracy by GPS alone ⇒ centimeter-class accuracy achieved)

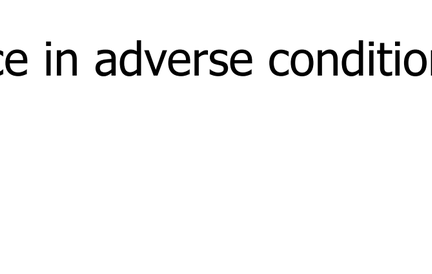
- 24-hour 4-sattelite service capability established in October 2017
- Full service commenced in April 2018



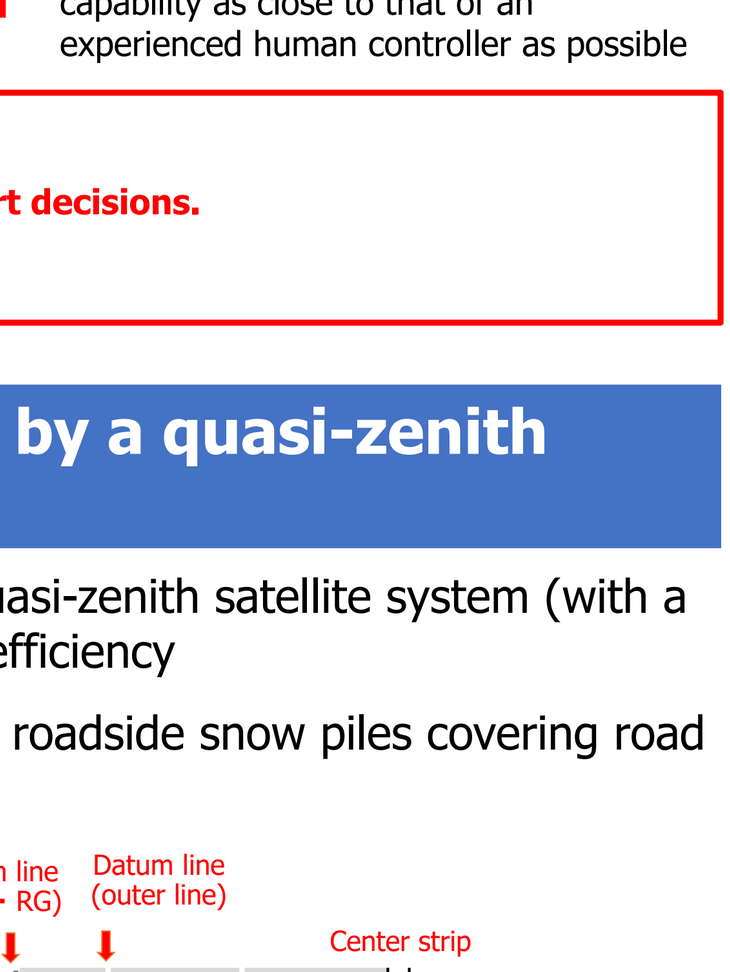


Quasi-zenith satellite receiver antenna

Roadside snow pile (road facilities such as guardrails and asphalt curbs are buried underneath)



Quasi-zenith satellite receiver



[Vehicle location, distance from nearby objects (asphalt curb etc.) and steering wheel angle are displayed.]

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Measures against snow and ice

تدابير مضادة للثلج والصقيع

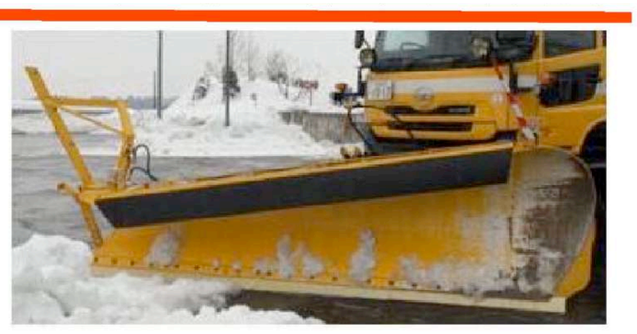
Single-touch centralized control of snow/ice mitigation vehicle

- The cabin of a snow/ice mitigation vehicle is usually cluttered with controls for various devices such as the plow (snow remover), the antifreezing agent applicator and the signaling device. To facilitate the simultaneous operation of these devices, a highly centralized single-touch control system has been developed.

Controls for antifreezing agent applicator

Signaling device controller

Plow (snow remover) controller



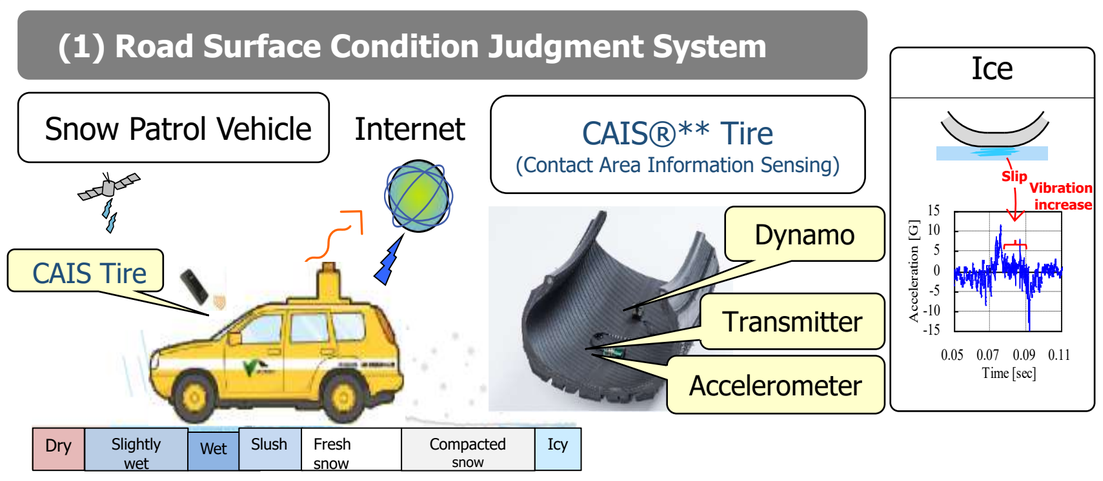
Various operations and maneuvers integrated into a number of patterned, streamlined sequences.

Single-touch operations

Automatic Salting-control System using the Tire Sensing a Road Surface Condition (ISCOS*)

*ISCOS: Intelligent Salting Control Optimization System

(1) Road Surface Condition Judgment System



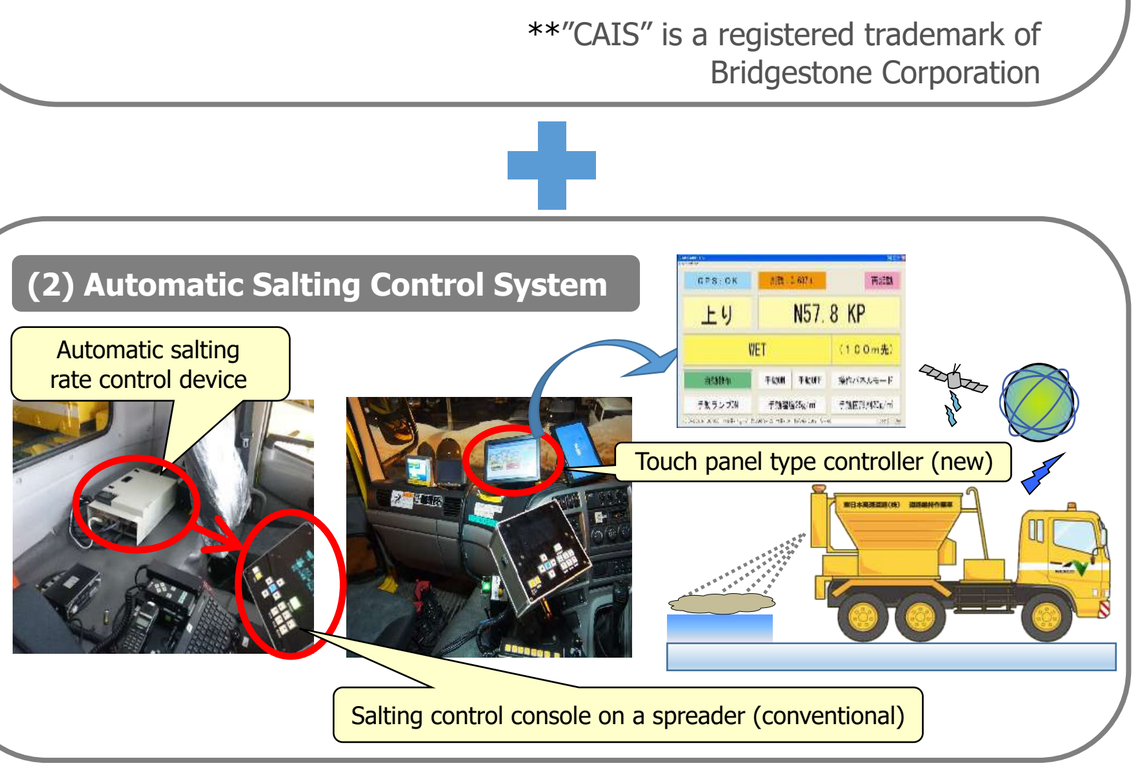
**"CAIS" is a registered trademark of Bridgestone Corporation

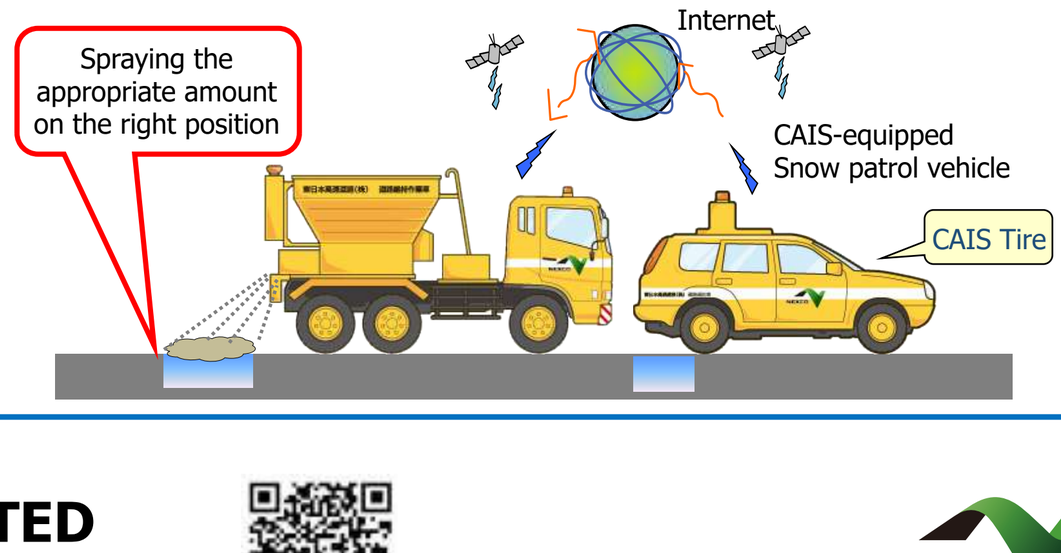
(1) CAIS-equipped snow patrol vehicle makes a presalting trip to grasp road surface conditions
⇒ Web-based real-time database development

The salting rate every 100m is calculated based on the database
⇒ Loading only the necessary amount of salt through the measurable hopper

(2) Automatic salting rate control device on the spreader communicates with the web-based database
Automatic salting in which salting rate changes every 100m depending on the vehicle location
⇒ Appropriate salting amount to meet the road surface condition
Approximately 10 % of salt was reduced in 2015-17

(2) Automatic Salting Control System





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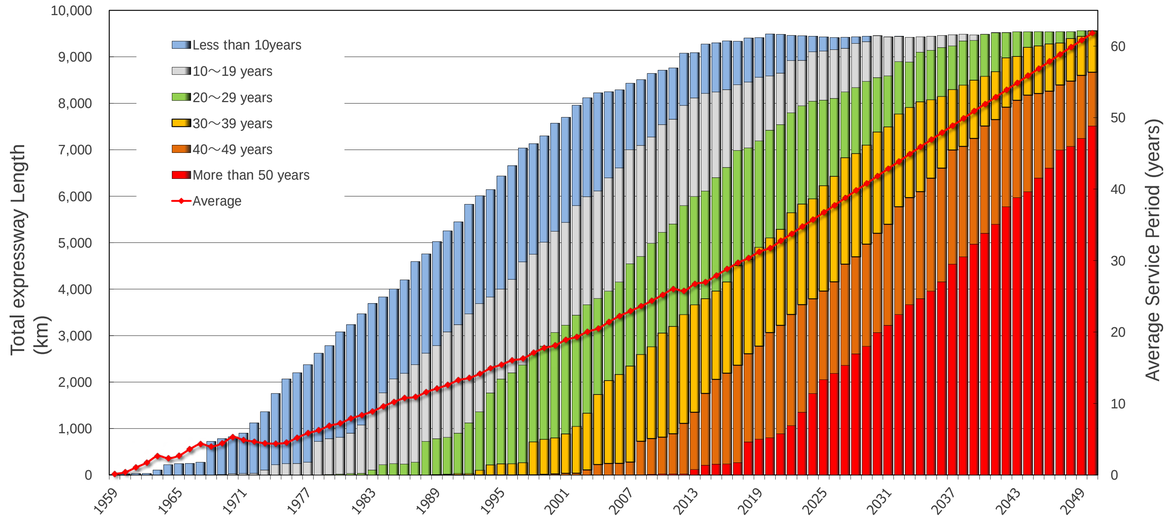
NEXCO EAST

Ageing Road Assets

متقادم

Current situation and problem of expressways

- At least 40% of the total expressways-length has been operated for more than 30 years and because of this, the expressways are seriously deteriorated.
- At least 40% of the total bridge-length and 20% of total tunnel-length were also constructed more than 30 years ago and they are facing increased risk by the aged deterioration.
- The total vehicle weight is increasing with the increase in the number of large-scale vehicle on the expressways. The expressways are under severe conditions such as increasing in the usage of anti-freezing agent (NaCl) and the increase in the amount of extreme rainfall for a short time.



Elapsed years of the expressway transition

Severe environment in snow region

Concrete cracks and float

Concrete free lime

Damaged Condition

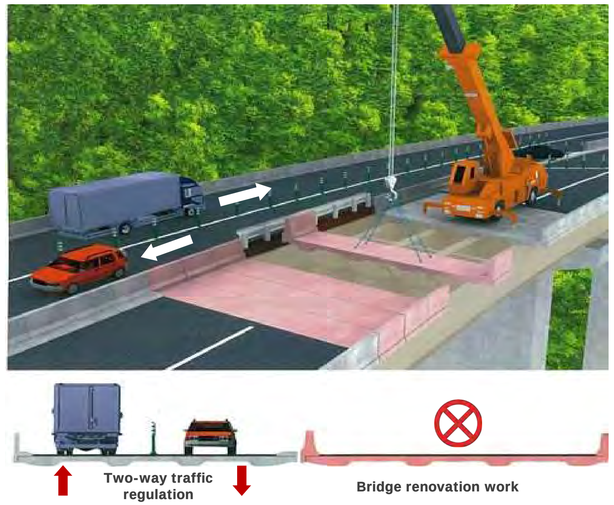
Expressway Renewal Project

التجديد

Severe deterioration on slab lower surface

Large-scale renovation for bridges

e.g. Replacement of RC concrete slab with PC precast slab



Open to Traffic (1963)

Deteriorated Structure (2014)

Undergoing Renewal Works (2019)

Renewed Segment (planed in 2026)

Expressway Inspection & Diagnosis

التفتيش والتشخيص

Road Surface

One of unique road surface inspection vhiecles, not only can measure rutting, cracking, and flatness (σ10ft, IRI) but also longitudinal and transverse pavement measurements without making contact with the pavement.
It can smoothly and safely perform all 6 functions at 100km/h without impacting the flow of other traffic.

High-Speed Road Surface Measuring Vehicle (Road Tiger)

Tunnel Liner

Inspection vehicle

Filming in a tunnel

Crack analysis (minimum 0.2mm in width)

Tunnel liner inspection vehicle:

It is now possible to obtain a clearer image at a speed of 100km/h by adopting the line sensor camera instead of the conventional video camera. In addition, because the photographing illumination using LED infrared illumination is not visible to the naked eye, it no longer influences on the passing vehicles on the opposite direction. Moreover, this vehicle automatically identifies the cracks by the captured image.

Bridge

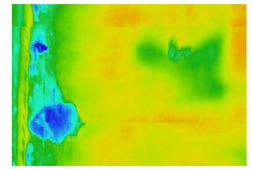
Digital camera/video camera system - Crack inspection:

High definition images taken by digital camera or video camera makes it possible to inspect the surface of a structure in the same way as the close visual inspection. Through a computer analysis of the images, the clacks are automatically detected.

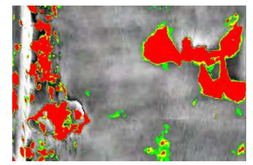
Infrared Camera System – Delaminations /spill inspection:

The infrared camera system takes images which is analyzed automatically and displays the damage level in three stages. Because damages are objectively analyzed by software, bias or oversight in measuring caused by skill difference can be prevented. In addition, this system helps to create a research report since the detected results are easily captured on spreadsheets or word processing software. This system has gotten track records in the U.S.

Bridge inspection using Infrared Camera System

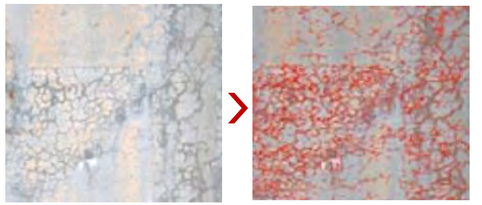


Infrared thermal image



Damage is detected by computer analysis

Bridge inspection using Digital Camera System



Automatic crack-analysis by computer

Video Camera System

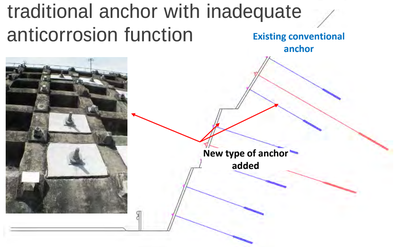
Disaster Management
الوقاية من الكوارث

Disaster Prevention

Disaster caused by extreme rainfall for a short time

◆ Ground anchor

New type of anchor installation filling up traditional anchor with inadequate anticorrosion function



◆ Slope Protection Work

Measures against land slide

The recovery of the Tomei expressway in Makinohara area

Immediately after the Surugawan earthquake, NEXCO-Central started emergency checkup and stopgap recovery, and 4 days later, finished temporary recovery for general traffic.

Aug. 11th 2009

Aug. 15th 2009 (4 days later)

Earthquake Museum for educational assistance on disaster prevention

Great Hanshin-Awaji Earthquake occurred in January 1995, took precious lives and destroyed cherished livings of local communities. Earthquake Museum conveys how Hanshin Expressway responded in the 623 days to complete the restoration of the expressway system. It displays damaged structures and introduces new technologies and various activities which put into practice based on the lessons including disaster management support and educational assistance for disaster prevention.

Use of rest areas as disaster-management bases

In the Great East Japan Earthquake, the Self-Defense Forces and firefighters heading to stricken areas used expressway rest areas as relay and support bases. Based on this experience and various issues, authorities are bolstering their disaster-response capabilities across Japan to respond effectively and efficiently to emergencies, using Moriya SA on the Joban Expressway as their model.

◆ Moriya Service Area (Southbound) on Joban Expressway, as a disaster management base

Disaster-response warehouse
Inflatable tents for outdoor use, emergency food and rations, relief supplies, traffic regulation equipment and other suppliers are store at this Disaster-response warehouse

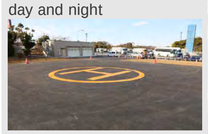
Emergency vehicle entrance/exit
Used by emergency vehicles to enter and exit outside of expressway in times of disaster

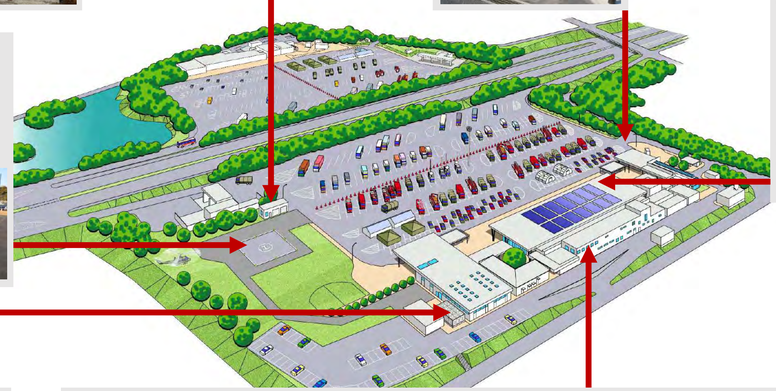
Generators and rooftop solar-power generation facilities

Solar-power generation panels on the roofs of commercial facilities

Generators enable continuous use for 72 hours

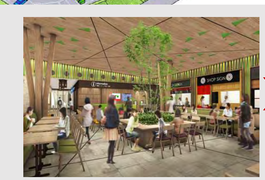
Heliport for mid-size Helicopters
Nighttime illumination and a helicopter office have been installed, enabling safe landing and take-off day and night



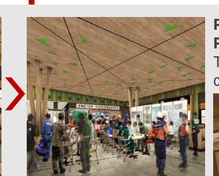


Well
A well has been dug in case of interruption of water supply

The food court is used as a disaster management office (1st Floor)
The food court layout can be rearrange for use as a disaster management office, under disaster situations
- Electrical power outlets and TV antenna terminals are installed
- Large monitors and whiteboards are installed



General situation



Emergency situation

First-aid space (2nd Floor)
The employee break lounge can be used as a first-aid

Expressway Network in Japan

شبكة الطرق السريعة في اليابان

Japan's Expressways are built and operated by six companies.
The total length in operation is 10,351km, and 331 km is under construction.

NEXCO WEST

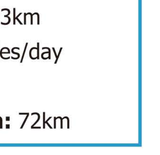
Company Name:
West Nippon Expressway Company Limited
Head Office: Osaka
Expressways in Operation: 3,533km
Traffic Volume: 2.95million vehicles/day
Toll Revenue: US$ 7.1billion
Expressway under construction: 72km

Hanshin Expressway

Company Name:
Hanshin Expressway Company Limited
Head Office: Osaka
Expressway in Operation: 250.4km
Traffic Volume: 0.72million vehicles/day
Toll Revenue: US$ 1.7billion
Expressway under Construction: 34.2km

Honshu-Shikoku Bridge Expressway

Company Name:
Honshu-shikoku Bridge Expressway Company Limited
Head Office: Kobe
Expressway in Operation: 172.9km
Traffic Volume: 0.12million vehicles/day
Toll Revenue: US$ 0.6billion



NEXCO EAST

Company Name:
East Nippon Expressway Company Limited
Head Office: Tokyo
Expressway in Operation: 3,943km
Traffic Volume: 2.95million vehicles/day
Toll Revenue: US$ 7.82billion
Expressway under Construction: 75km

NEXCO CENTRAL

Company Name:
Central Nippon Expressway Company Limited
Head Office: Nagoya
Expressway in Operation: 2,132km
Traffic Volume: 1.98million vehicles/day
Toll Revenue: US$ 6.30billion
Expressway under Construction: 132km

shutoko

Company Name:
Metropolitan Expressway Company Limited
Head Office: Tokyo
Expressway in Operation: 320.1km
Traffic Volume: 1.02million vehicles/day
Toll Revenue: US$ 2.4billion
Expressway under Construction: 17.5km

In operation
Under construction

As of JULY 1st, 2019
Note: Revenue is for year ended March 31, 2019 and calculated by the exchange rate of 110 JPY for 1 US$