Commercial Trains Check Tracks Daily to Collect Data for Maintenance Planning

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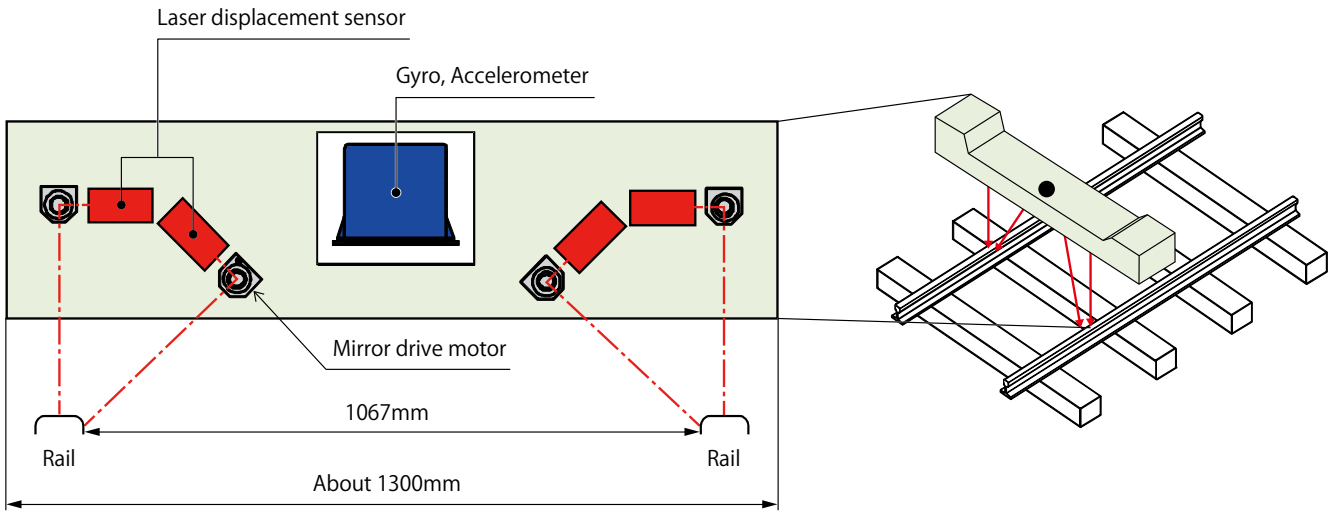
To maintain and improve the running safety and ride comfort of railway vehicles, railway operators regularly measure track geometry (vertical and lateral irregularities, rail surface twist, etc.) using track inspection cars and schedule track maintenance based on the results. Currently, track geometry inspection is conducted about every three months for conventional lines and about every ten days for Shinkansen lines. The data gathered is used for subsequent condition-based maintenance (CBM). Today, with the anticipated reduction in rail transport revenues and shortage of skilled engineers, CBM needs to evolve from the current system of periodic inspection into a more efficient one built on more frequent inspection and higher accuracy. To meet this requirement, RTRI has developed an inertial mid-chord offset track measurement device that can be mounted on commercial trains to enable daily track inspection. RTRI also developed a method for processing the data gathered at high frequency by the device for effective maintenance planning. These developments are outlined below.

Bogie-mounted track measurement device　　Car body-mounted track measurement device

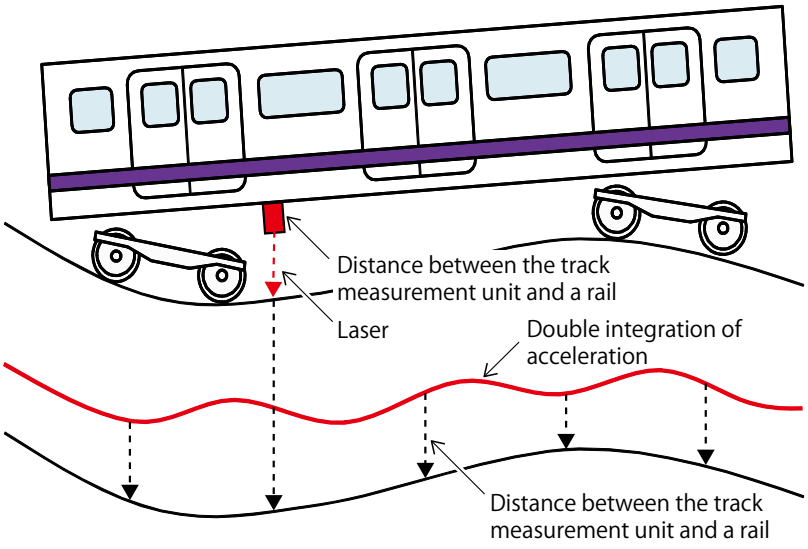
Location of the inertial mid-chord offset track measurement device on the commercial vehicle for each mount type



The location of the track measurement unit above the track is calculated using a gyro and an accelerometer (inertial measurement).

By combining both data, track inspection quality equal to that of the track inspection car can be achieved.

The location of the track measurement unit relative to both rails is measured using laser displacement sensors.



Schema of inertial mid-chord offset track measurement system

Concept of inertial mid-chord offset method

Track inspection using the inertial mid-chord offset method

Mr. Tsubokawa, senior researcher, working in front of an inertial mid-chord offset track measurement device

Inertial mid-chord offset track measurement device

The inertial mid-chord offset track measurement device consists of a track measurement unit that houses a gyro, an accelerometer, laser displacement sensors and other items, and a control box. It is installed either on the bogie or under the floor of a commercial vehicle to measure the tracks at high frequency, thus it doesn't make track inspection cars indispensable. The device is based on the inertial mid-chord offset method that uses a basic principle of physics, which is: double integration of acceleration is equal to displacement. Applying this principle generally increases the amplification factor in the low-frequency range where the acceleration is low. This prevents accurate geometry measurement of tracks with long wavelengths such as in curve sections.

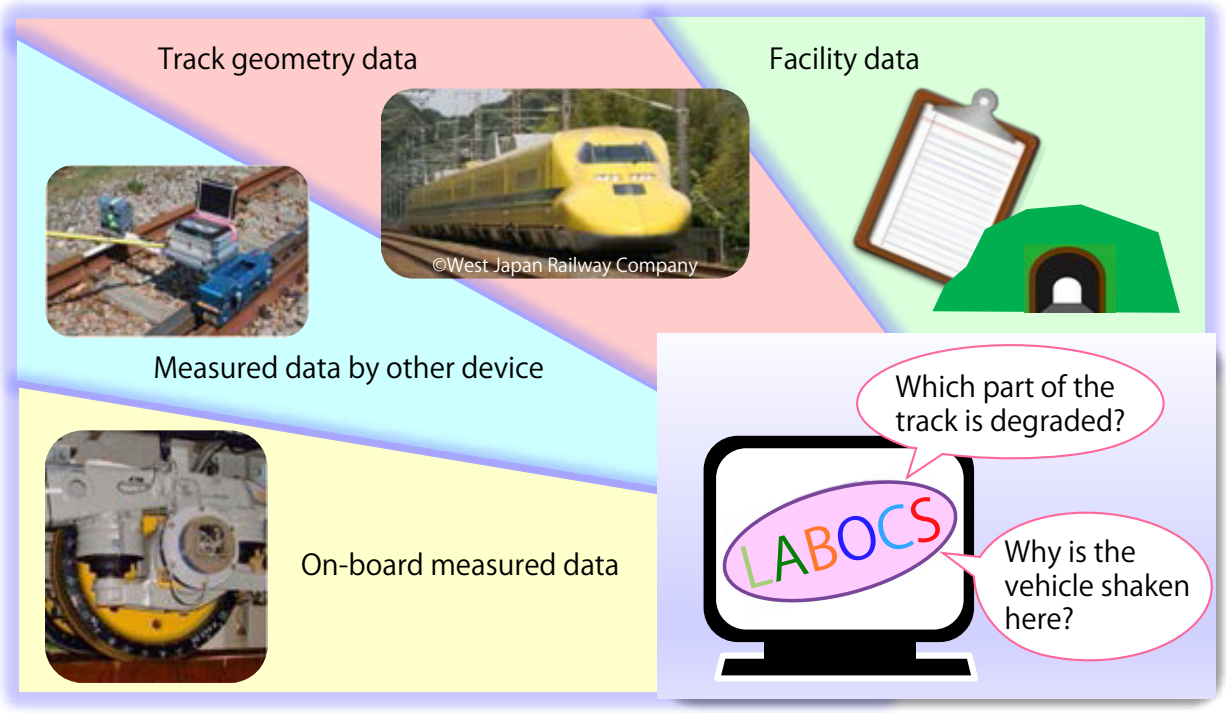
To address that issue, the inertial mid-chord offset method combines its measurement characteristics with those of the 10 m-chord versine method, which is commonly used in Japan for

track irregularity control, to process acceleration and thereby achieve track inspection quality equal to that of conventional methods. The location of the track measurement unit above the track is calculated using the gyro and accelerometer. While at the same time the unit's location relative to both rails is measured using the laser displacement sensors. Then, based on this data, track irregularity is calculated.

Processing of high-frequency track measurement data by LABOCS

LABOCS, a database system developed by RTRI, is designed exclusively to process track measurement data with its extensive signal processing functions. LABOCS analyzes track measurement data for proper track maintenance after putting the data through position synchronization. It is capable of processing not only distance-based track measurement data but also data gathered by various other devices including time-based acceleration due to oscillation and ledger data after converting them into distance-based data. In addition to position synchronization, LABOCS offers a range of distance- and time-based filters.

Currently, a total of 500 LABOCS licenses are owned by more than 25 railway operators and other rail-related companies in Japan and abroad, who have been utilizing the system to secure the running safety and ride comfort of their vehicles

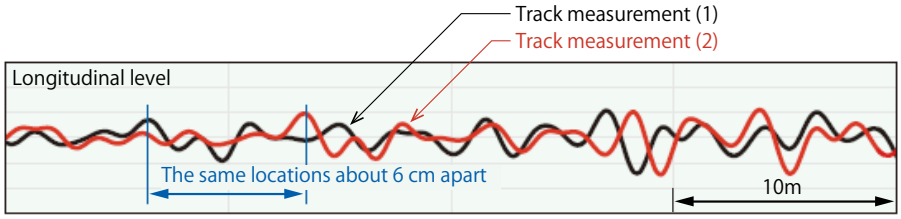


Rendition of LABOCS functions

through proper control of track irregularity. LABOCS is also capable of processing track irregularity waveforms for not only Japan's chord-versine control but also Europe's wavelength band control.

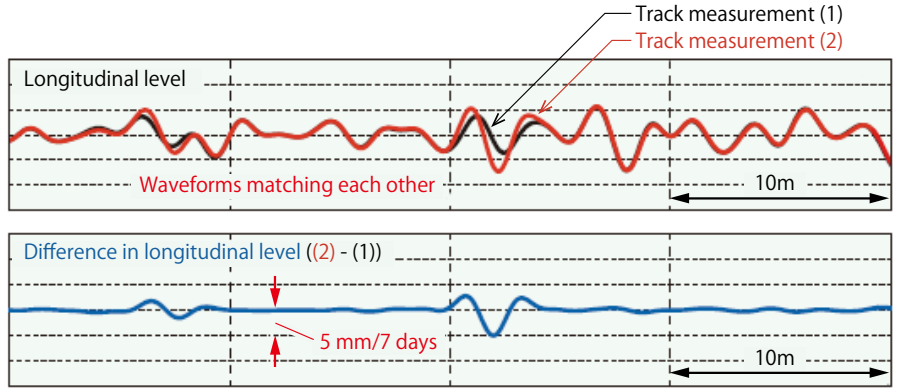
Track inspection cars run over the same section regularly, and it can be extremely difficult to synchronize the section's cumulative data with that measured in past runs. This is because the car's steel wheels can slip and slide on the steel rails on which they run. Similarly, for high-frequency track measurement by commercial trains, which often run the same section many times daily, to yield useful data for track maintenance, automated and highly accurate data synchronization is a must. All this suggests that, if a highly accurate synchronization system was available, it would be possible to automatically spot where on the tracks irregularity were growing rapidly.

For these reasons, RTRI developed a waveform matching technology and incorporated it into LABOCS. As a result, LABOCS is now capable of automatically spotting locations of rapid growth in track



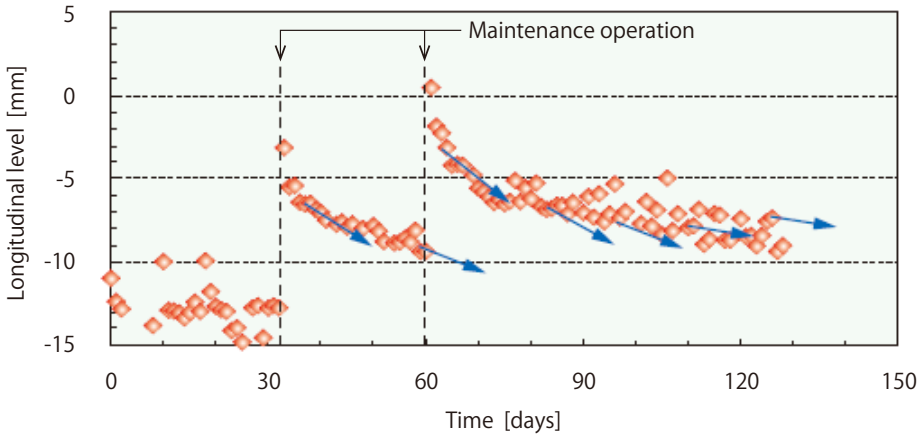
Note: Positional difference preventing the calculation of progress in track irregularity

Example of out-of-sync track irregularity waveforms obtained by conventional methods



Note: Automatically spotting the location and progress

Highly accurate synchronization of track irregularity waveforms and calculation of irregularity progress based on the new (cross correlation) method



Example of Bayesian estimation of progress in track irregularity

Mr. Tanaka, senior researcher, viewing LABOCS charts on a PC

irregularities. Also being developed is a method for predicting the growth in track irregularity over the short term based on data measured daily and updated regularly. Each arrow in the figure shows predicted growth in track irregularity based on the data measured and updated up to that point in time. These methods for spotting and predicting locations of rapid growth in track irregularity are already being used by JR East to plan track maintenance on its conventional lines. Armed with these features, the system enable
s the maintenance staff to predict when and where track irregularity will reach the target or standard value and thereby to plan and execute track maintenance accordingly. Using the system, it is also possible to check the quality and effect of the track maintenance done, bringing us closer than ever to highly accurate CBM of track irregularity.

Future plans

In Japan, track measurement is still mostly conducted on a regular basis using inspection cars. For more efficient track maintenance going forward however, commercial trains are expected to replace inspection cars as the main means of track measurement. Accordingly, RTRI will continue to enthusiastically develop track inspection and related data processing technologies to help further upgrade track maintenance operation. Through these R&D efforts, RTRI will support railway operators in transforming the current track maintenance into a highly accurate system based on CBM.