Earthquake Early Warning Systems for Railways in Japan

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It is obvious that railways in Japan, as well as other infrastructure systems, are highly exposed to earthquake risk. According to the JMA earthquake catalogues, over 100 thousand events have been recorded in every year, which roughly means that we have about 300 earthquakes per day in Japan. Therefore mitigation of earthquake damage is essential tasks for railway companies in Japan.

In order to stop Shinkansen (high-speed train) trains during earthquake as soon as possible, various types of systems have been utilized since 1964 when Tokaido Shinkansen began its operation (see Fig.1). Each system directly stops power supply to Shinkansen

1) The first generation was the railside S-wave detection system which stops power supply to Shinkansen when amplitude of acceleration simply exceeds predefined threshold. This approach is thought to be a basis of earthquake damage mitigation for Shinkansen, and still in use in the recent system, however this system provides no leading time.

2) The second generation was the coastline S-wave detection system which detects S-wave at the coastline far from the rail and transmits control signals to sub-stations without estimating magnitude or epicenter. The target area was limited, but this is the first practical EEW system in Japan.

3) The third generation was a very progressive system, known as UrEDAS, which estimates magnitude and epicenter using the first few seconds of P-wave data and transmits control signals judging railway damage. This system provides longer leading time than the second generation system.

4) The fourth generation has a completely new algorithm, called “the B-⊿ method ”, to estimate epicentral distance within 1-2 seconds using P-wave. Since this system monitors growing magnitude in every sample, estimation of magnitude is expected to be more reliable for large earthquakes than UrDAS which calculates magnitude once after P-wave detection. Hardware and software of this system are improved so as to keep working stable in noisy environments. Recently about 200 seismometers for the fourth generation system are installed for Shinkansen. The B-⊿ method was originally developed by RTRI and JMA and is also used in the JMA EEW system.

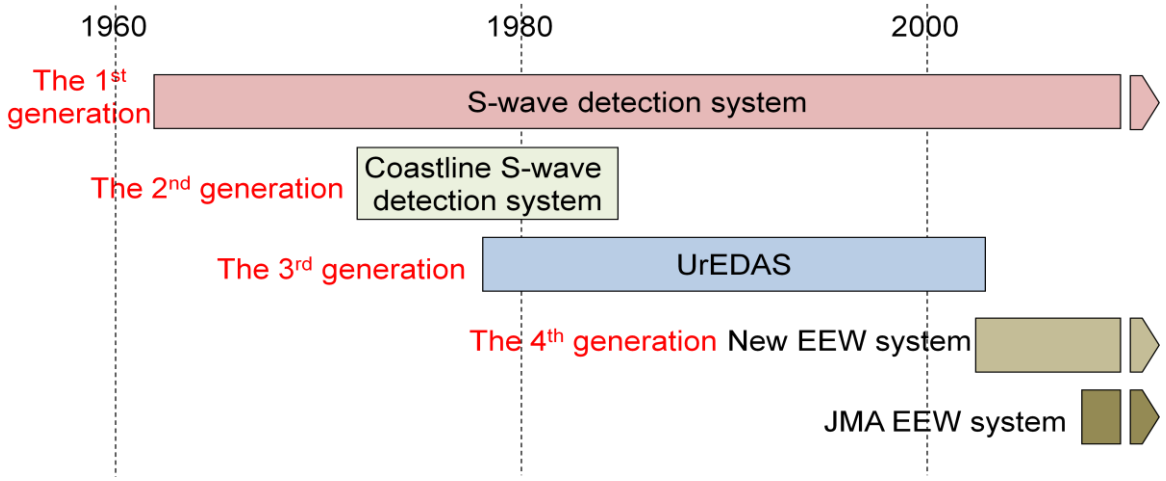

Fig.1 History of EEW systems for Shinkansen

After starting operation of the JMA EEW system, more than 30 railway companies begin to use the JMA EEW information for mitigating earthquake damage. Most of them receive the information via leased line and/or satellite communication line at traffic control centers and transmit control signals to trains. Some companies uses the JMA EEW combined with information of their own EEW systems to improve the system reliability (see Fig.2).

Various studies for the next generation EEW system are now in underway to increase leading time and accuracy of estimation.

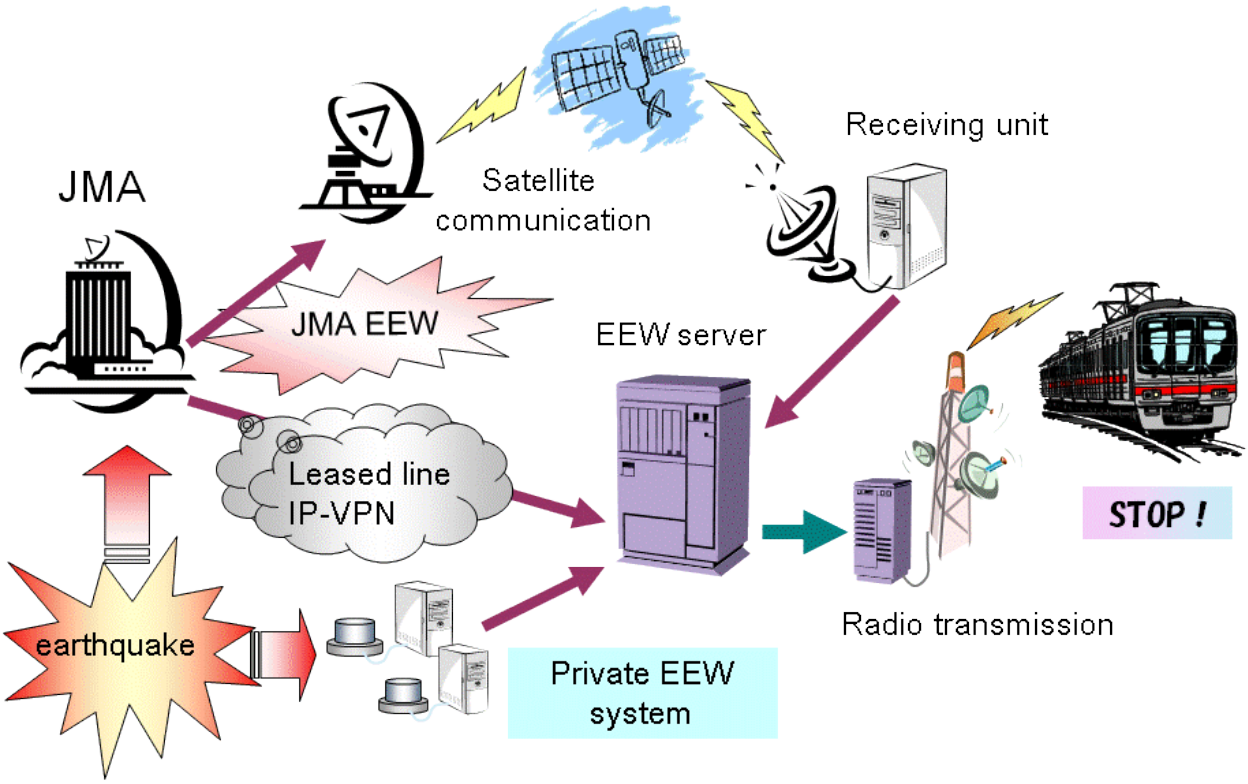

Fig.2 An example of EEW system for railways