Historical Survey on Earthquake Early Warning System

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■ Abstract

Earthquake Early Warning System, which is delivered via television, smartphones, and other media immediately after the occurrence of a large earthquake, constitute one form of a system to issue earthquake early warning. Although public dissemination of Earthquake Early Warning Issued by the Japan Meteorological Agency (JMA) began in 2007, the underlying concept dates back as far as an idea proposed in 1868 by a medical doctor in San Francisco. This concept sought to exploit the difference between the propagation speed of seismic waves and that of electrical communication by detecting earthquakes near the epicenter and rapidly transmitting warnings to the distant city of San Francisco. However, the technology available at the time was insufficient to realize this concept.

Approximately 100 years later, a similar concept known as 'A Plan for Strong Earthquake Alarm System 10 Seconds before it Attacks the City of Tokyo' was proposed in Japan. This plan aimed to issue warnings before strong ground motion reached the Tokyo metropolitan area by installing seismometers in Sagami Bay. However, this plan, too, never progressed to a practical stage.

Strongly intrigued by this concept, Japanese National Railways (JNR) initiated research and development on an Earthquake Early Warning System in the 1970s to manage unforeseen events during earthquakes. First, mirroring the earlier concept, a system was deployed on the Tohoku Shinkansen that used seismometers installed near potential epicenters to detect tremors and issue warnings. Subsequently, to enable faster and more precise alerts, JNR developed the UrEDAS (Urgent Earthquake Detection and Alarm System). This advanced system estimates seismic parameters from the primary wave (P-wave) and issues warnings based on expected damage, calculated from the relationship between an earthquake's magnitude and its distance from the epicenter. Launched in 1992 alongside the debut of the Nozomi service on the Tokaido Shinkansen, UrEDAS was the world's first operational Earthquake Early Warning System to issue alarms triggered by the initial detection of P-waves.

The successful implementation of UrEDAS was followed by the development of new Earthquake Early Warning Systems, informed by the experiences of major disasters such as the 1995 Southern Hyogo Prefecture Earthquake (Great Hanshin-Awaji Earthquake) and the 2004 Mid Niigata prefecture Earthquake. Then, in 2007, an Earthquake Early Warning System, which had been utilized mainly for railway operation control, was launched for public use as the Earthquake Early Warning Issued by JMA. This shift played a significant role in raising public awareness and engagement with earthquake disaster prevention.

Looking abroad, Earthquake Early Warning Systems were first implemented practically in Mexico and the United States during the 1990s. Development has since progressed in numerous other countries and regions in anticipation of major seismic events. Furthermore, a service rolled out by global technology giant has expanded worldwide, rapidly accelerating the global adoption of these Early Warning Systems.

This historical survey traces how Earthquake Early Warning Systems emerged and evolved over time. In particular, it focuses on the circumstances leading to the birth of UrEDAS, the world's first practically implemented Earthquake Early Warning System, the underlying concepts and philosophies that shaped its development, and its subsequent evolution. This survey also provides an overview of the history of research related to seismometers, seismic observation, and earthquakes proper.