Brief History of Effective EEW Systems

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A first EEW was proposed by Dr. J. D. Cooper on San Francisco Daily Evening Bulletin dated 3rd November 1868 after a failure of an earthquake prediction. Around 100 years later, Dr. M. Hakuno et al. proposed “A system 10 seconds before a strong motion” for Tokyo metropolitan area in 1972, independently from the concept above. Although many scientific research institutes in Japan tried to realize this without image of effective usage and some research papers were produced, they finally failed for practical use. On the other hand, Japanese National Railways at that time recognized strongly the necessity of EEW for the safety of the high-speed railways with a concrete image of disaster prevention.

The earthquake damage is caused mainly by the earthquake motion more than Ijma 5, JMA intensity, so the conventional instruments was triggered by acceleration corresponding to Ijma 4 to issue before reaching Ijma 5 and to omit unnecessary warning caused by the other vibration. Because of the dilemma that lower alarm to get longer leading time caused increasing over warning, we tried various measures as restricting the observing frequency range or observing the large event at the area close to the occurrence zone.

UrEDAS, Urgent Earthquake Detection and Alarm System, was developed in 1983 and used practically for Tokaido Shinkansen since 1992. UrEDAS detects the initial P-wave motion and estimates the earthquake parameters. Then it estimates the damage area from the parameters and issues proper warning. Because only a basic seismological knowledge is applied for UrEDAS methodology and then the physical meaning is clear. The estimation is done continuously at every 1/100 seconds as sampling time using three components waveform data at a single station. The estimation terminates almost at the same time of the detection, but only the estimation of the initial motion period requires three seconds as one period corresponding to over 10 km of the fault length. And later we confirmed that the initial motion period can be estimated with 1/4 period and can be determined in one second.

At the time of the 1995 Kobe Earthquake, we faced a situation that UrEDAS issued warning properly but it could not reach the damaged area because of communication breakdown. And we recognized strongly a problem for the processing the warning to take three seconds especially for an earthquake just below the epicenter. So we developed Compact UrEDAS in 1997 for the warning at least one second after the detection even for a near earthquake and it was used practically in 1998 for Shinkansens of JR East. It monitors the realtime intensity, defined by us and its maximum value RI is almost same as Ijma, and issues a needed warning by estimated maximum intensity on detecting the initial P-wave. The processing time for warning was shortened to 0.1 seconds from initially one second.

For the 2004 Niigata-Ken-Chuetsu Earthquake, Compact UrEDAS detected it just above the hypocenter and alarmed one second after the P wave detection. The warning made the high-speed running Shinkansen train close to epicenter apply the emergency brakes and succeeded to keep safety of 154 passengers and staffs without injury despite a derailment.

UrEDAS and Compact UrEDAS have been integrated to FREQL, Fast Response Equipment against Quake Load, as the advanced small-sized-portable P-wave warning device in 2004. FREQL has been adopted presently not only for railways but also for a nuclear power plant, stadiums and factories. And it is equipped as an emergency device for hyper-rescue teams.

An on-site FREQL at a hard rock site on foot of Oshika peninsula issued an EEW properly and quickly

with maximum RI 5.5 for the 2011 Tohoku Earthquake. After this, we advanced some technics for more quick and reliable warning.
Finally I'd like to emphasize that EEW is only a supplement for disaster prevention mainly as reinforcement to avoid overvaluations of EEW effect.

