Earthquake Early Warning and Realtime Disaster Prevention

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Videos Recorded at the Moment of Earthquake Attack

EEW and Earthquake Disaster Mitigation

Damage of the 2009 L'Aquila Earthquake (Mw 6.3)

- **The Basic Countermeasure is Strengthening the Facilities**
- **EEW is only a Trigger for Quick Response against Quake**
- **It is important for EEW to avoid Overestimation**
- **Late EEW is Unnecessary**
- **Accurate Information is Extremely Important for Quick Response after Quake**

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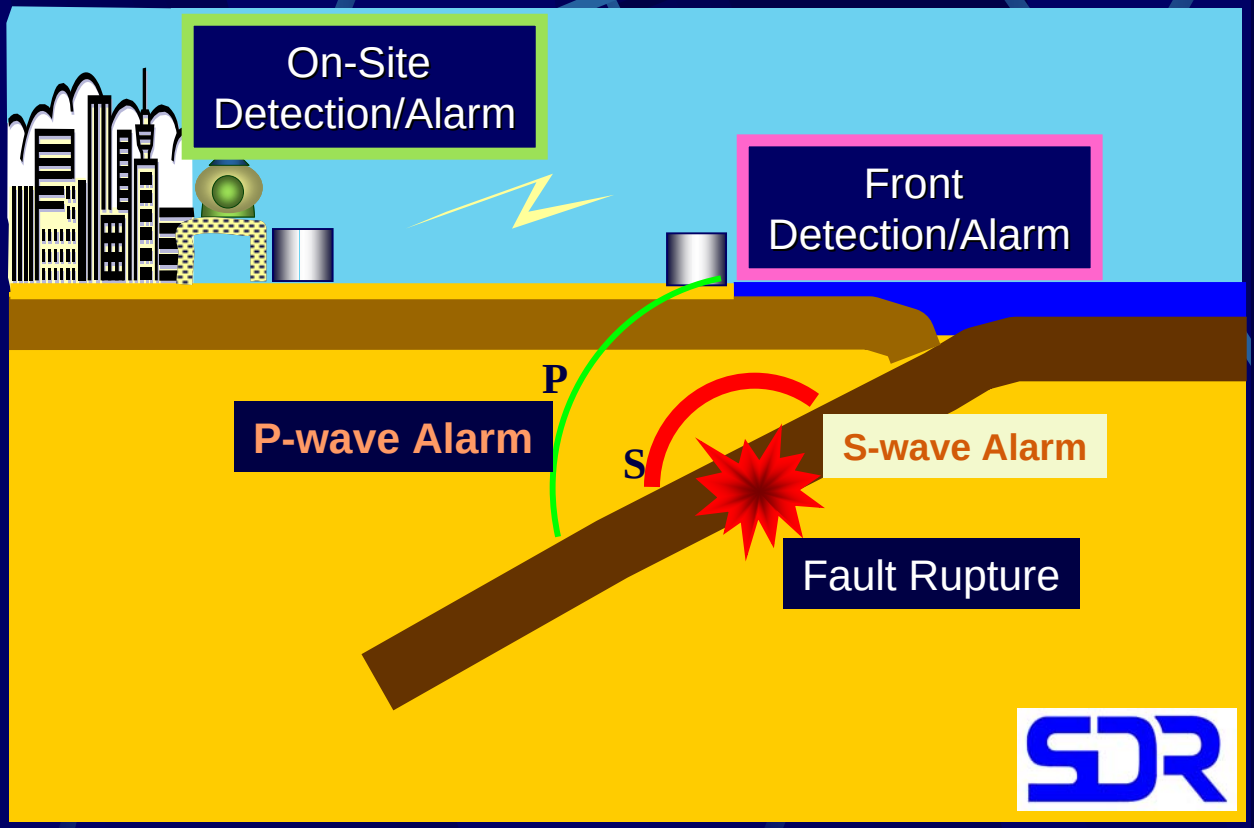
Concept of Earthquake Early Warning



There are two kinds of the earthquake alarm. One is “On-site Alarm” which is the alarm based on the observation at the side of the objects to be warned. The other is “Front Alarm” which is the alarm based on the observation near the epicentral area to warn for the possible damaged area.

For each, there are more two kinds of alarm. One is so-called “S-wave Alarm” or “Triggered Alarm”. And the other is “P-wave Alarm”.

We have developed a prototype system for EEW as UrEDAS in early 1980’s.

Introduction of UrEDAS

UrEDAS, Urgent Earthquake Detection and Alarm System, is the first real time P-wave alarm system over the world in practical use in 1992 for Tokaido Shinkansen.

It is characterized to be able to process digitized waveform step by step without storing waveform.

Amount of procedure is not differ from each other either earthquake occurs or not, so it expected not to be occurred the system down due to the over load.

UrEDAS is able to use not only for the On-site alarm but also for the Front alarm.

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Functions of the UrEDAS

There are two types of UrEDAS; "**UrEDAS**" and "**Compact UrEDAS**".

Function of the **UrEDAS** (1985) is to estimate the magnitude and the location of detected earthquake in **three seconds** after initial P-wave detection and issuing the alarm for expected damage area.

On the other hand, **Compact UrEDAS** (1998) can evaluate whether the earthquake will be destructive or not using Destructive Intensity **DI** and issues alarm **one second** after **P-wave** detection if needed.

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The UrEDAS Technique for Estimation Methods of Location, Depth and Magnitude using a Single Station Data in Realtime

The development of UrEDAS had been almost completed in the middle of 1980's. UrEDAS realized realtime independent process. Although the JMA system intermittingly processes with several seconds, UrEDAS processes in every sampling time. Warning time of UrEDAS can set arbitrary. At first the warning time set to three seconds, but we have found the time is able to set one second without problems at least for M7 class earthquake. For New generation of UrEDAS, FREQL, the warning time is set to one second. I would like to show the potentiality of them instead of explanation the UrEDAS techniques in detail.

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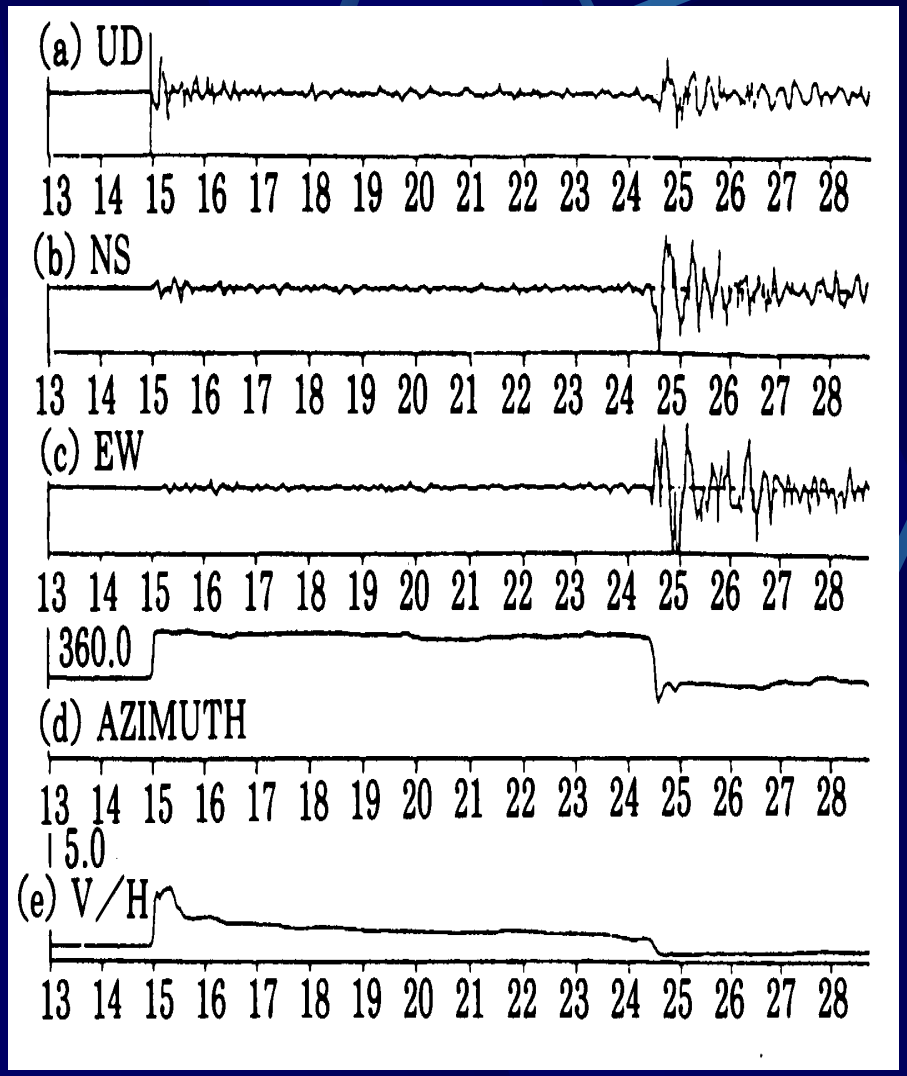
Earthquake of March 29, 1980 : M-4.2 (4.6), Δ/h=55/70 (58/79)km,
θ =355(355)° estimated by Tohoku Univ. (or JMA.)



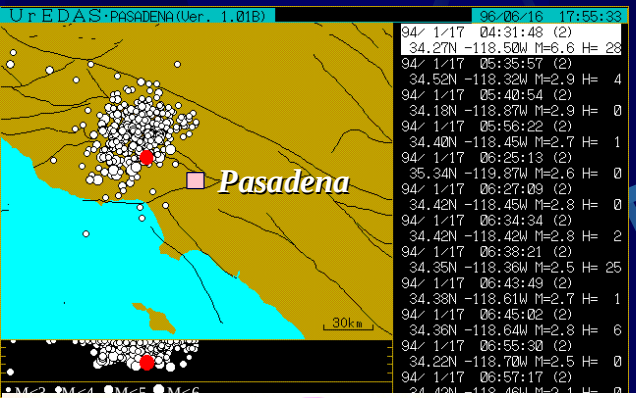
UrEDAS is only true realtime system

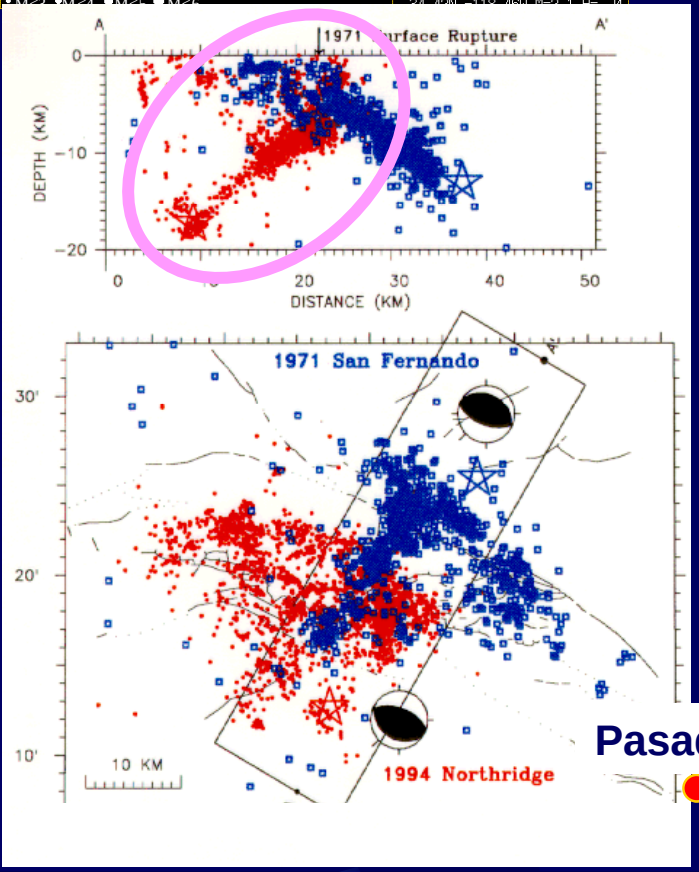
UrEDAS can estimate Epicentral Azimuth, P-wave Incident Angle and etc. in realtime

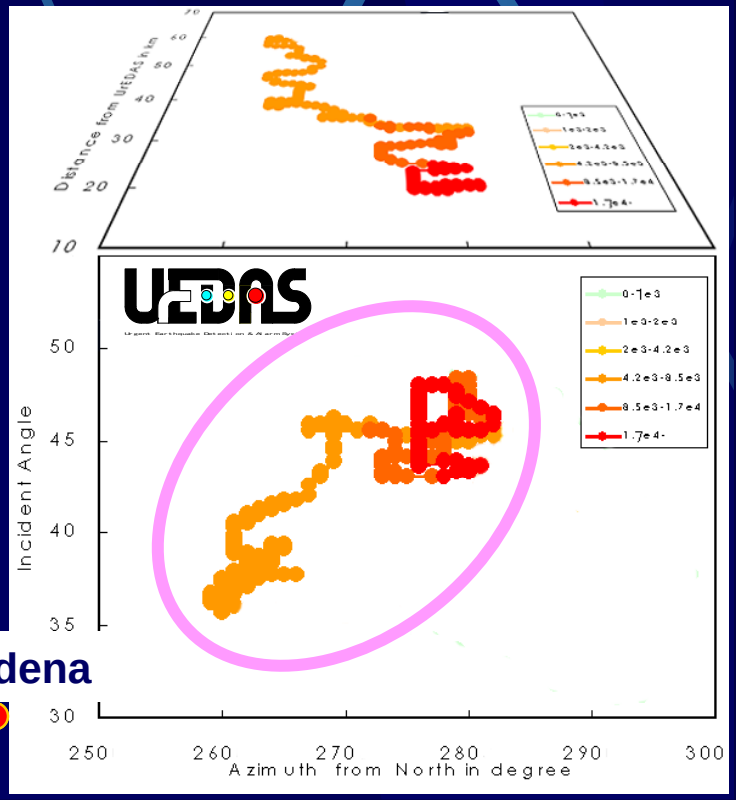
I would like to show the potentiality of UrEDAS; Rupture Trace for Real Event in realtime using one UrEDAS station

UrEDAS Application to Rupture Process Estimation in Realtime

In case of the 1994 Northridge Eq. (after Nakamura 2001)







This is an example of rupture process tracing in realtime using the data of Pasadena UrEDAS station. The plane between back azimuth and incident angle is correspond to left upper cross-section. Rupture can be seen to go to surface from hypocenter.

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Estimation Destructivity and Warning Methods of Compact UrEDAS

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Captured Photos at the time of the 1995 Kobe Earthquake

Motivation of Compact UrEDAS development is the Kobe Earthquake. On the VTR, they noticed the initial P wave motion as something happen, and then the severe motion attacked them after a few seconds. Although there was only a few seconds between something happen and recognition of earthquake, it was anxiousness and fearful because they could not understand what happened and felt relieved after recognition of the earthquake occurrence. As the counter of this kind of feeling, the earlier earthquake alarm is required and I developed the Compact UrEDAS to make the alarm within one second after P wave arrival.

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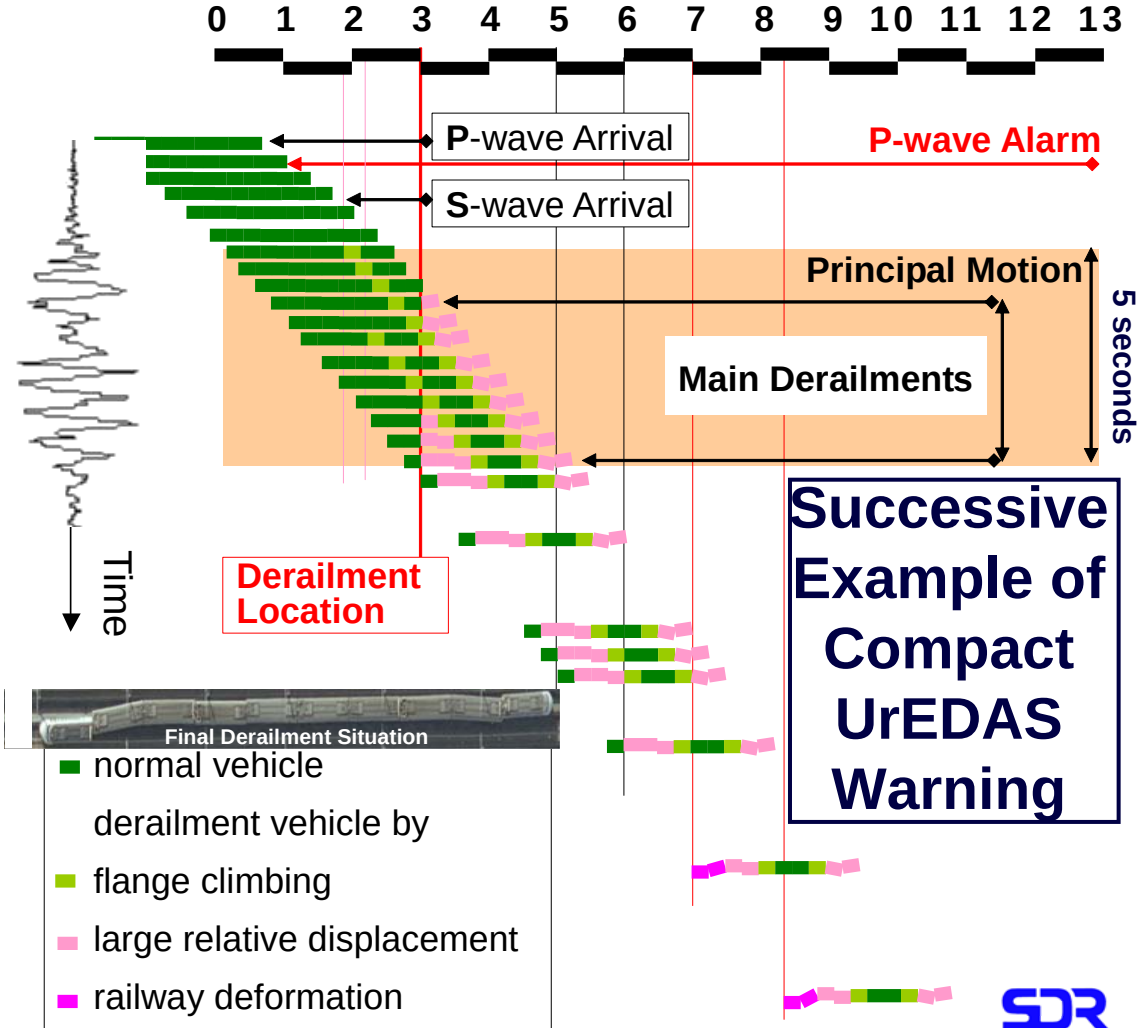
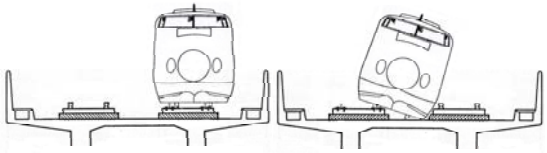
The P wave alarm of Compact UrEDAS demonstrates the effectiveness as making the derailment not catastrophe

2009/04/22



Successive Example of Compact UrEDAS Warning

Vehicle ②:
You can see derailment situation and contact situation between body and railroad,



Front ⑩ **Rear ①**

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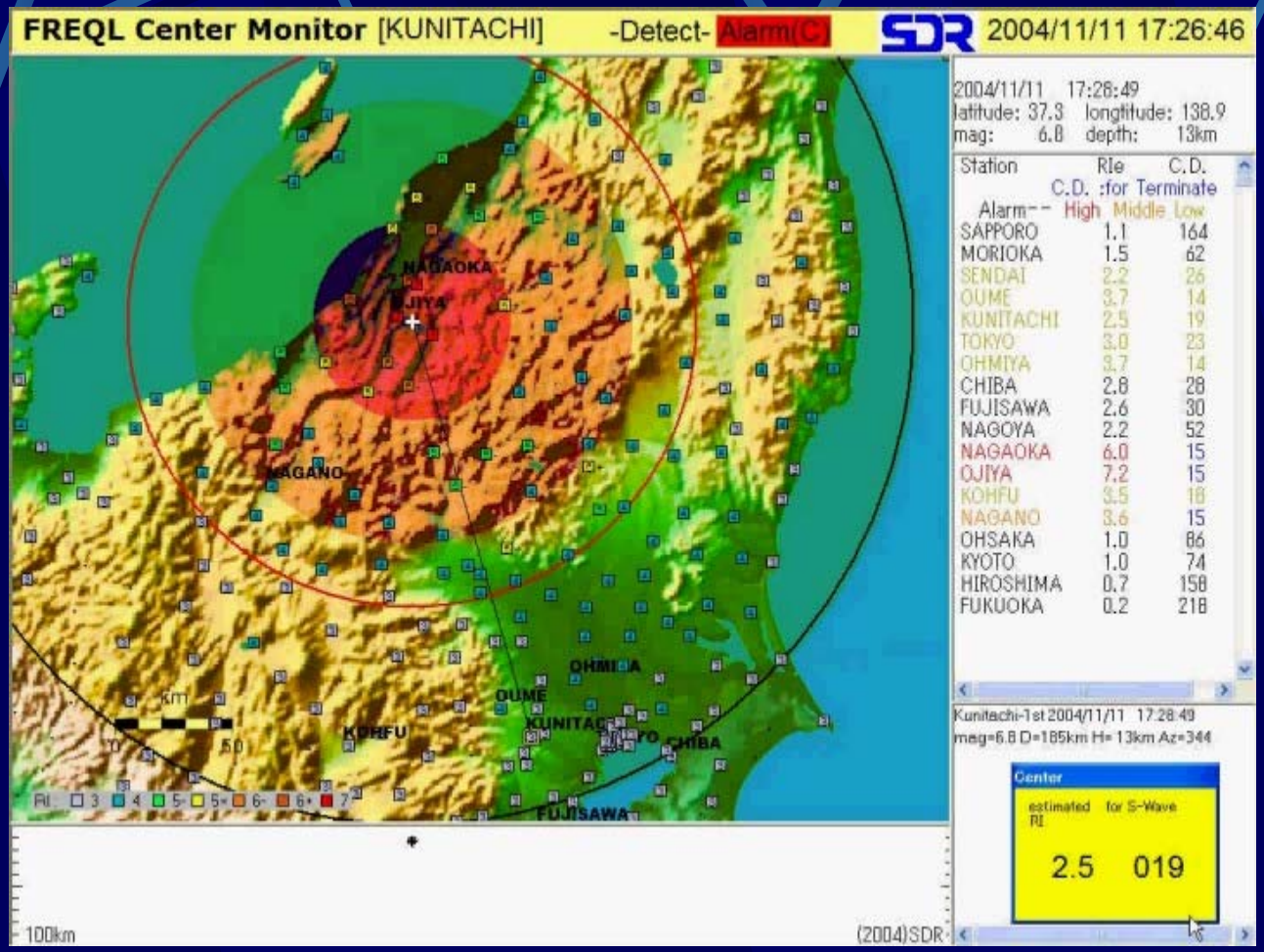
Ultimate Earthquake Early Warning System FREQL series and AcCo - PS



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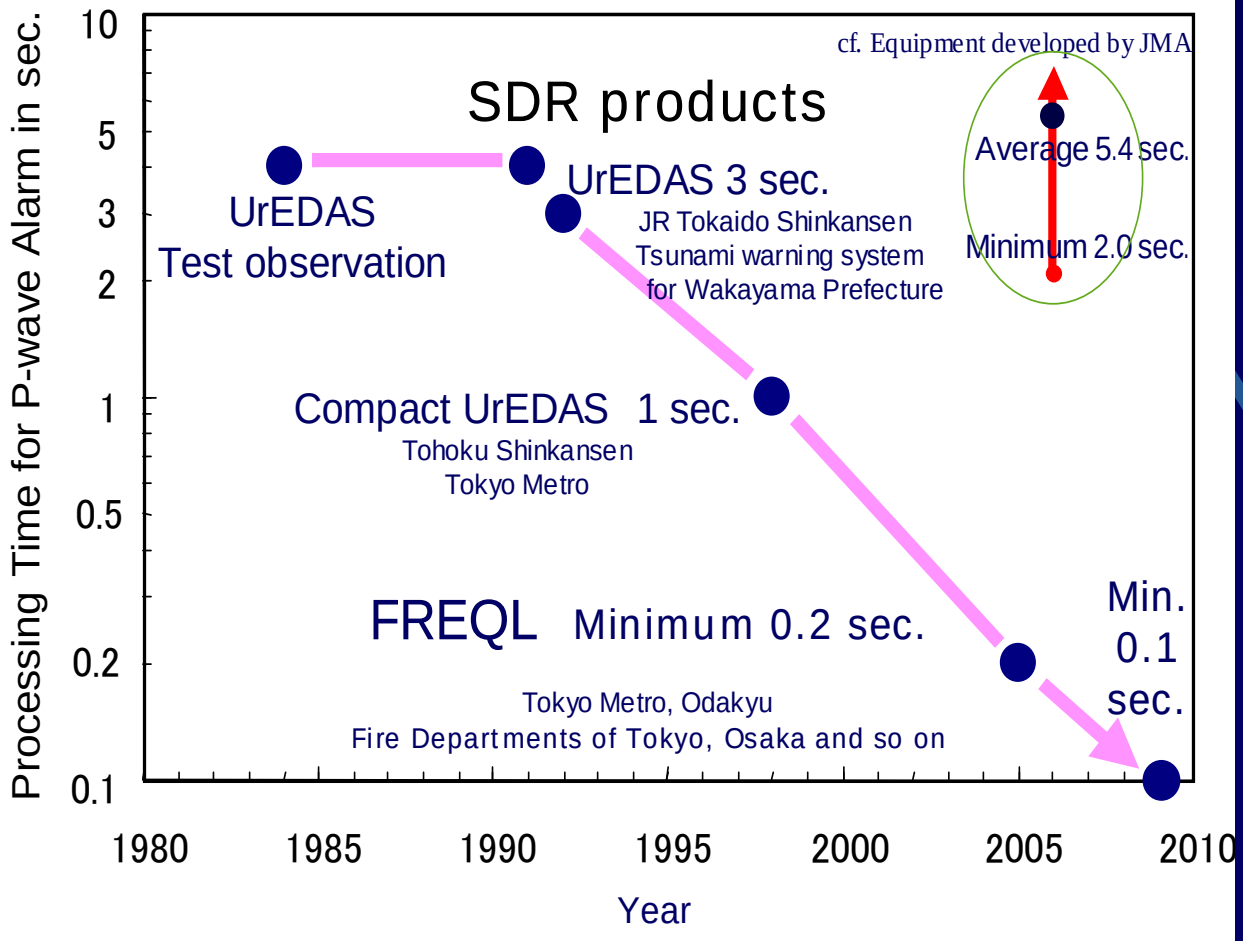
FREQL

(Fast Response Equipment against Quake Load)

- FREQL is developed for the earthquake warning system based on the experiences of development and operation of the world first P wave alarm system UrEDAS.
- FREQL function is combined the functions of UrEDAS, Compact UrEDAS and AcCo.
- P wave alarm is available 0.2 seconds in minimum after P wave detection (the fastest time will be 0.1 seconds in 2009)
- S wave alarm is also available. (based on acceleration and real-time seismic intensity RI.)

Change of processing time for EEW



Development of Processing Time

This figure shows the change of the processing time for EEW.

While JMA system performs every one second for the alarm processing intermittently with stored data, UrEDAS and FREQL perform the procedure continuously in every sampling time.

FREQL is toward to the new field, as for the Hyper Rescue Team in the risk of aftershocks


the 2004 Niigataken -Chuetsu Earthquake


Rescue Activity of Hyper Rescue Team

Hyper rescue team acts in a risk of large after shocks.

After the Niigataken Chuetsu Earthquake, the hyper rescue team approached us to adopt FREQL as a support system for the rescue activity.

Tokyo fire department and other departments in nation wide have adopted the portable FREQL as an equipment to keep the safety against the risk of the second hazards caused by aftershocks during their rescue activity, not only in Japan but also in Pakistan and China.

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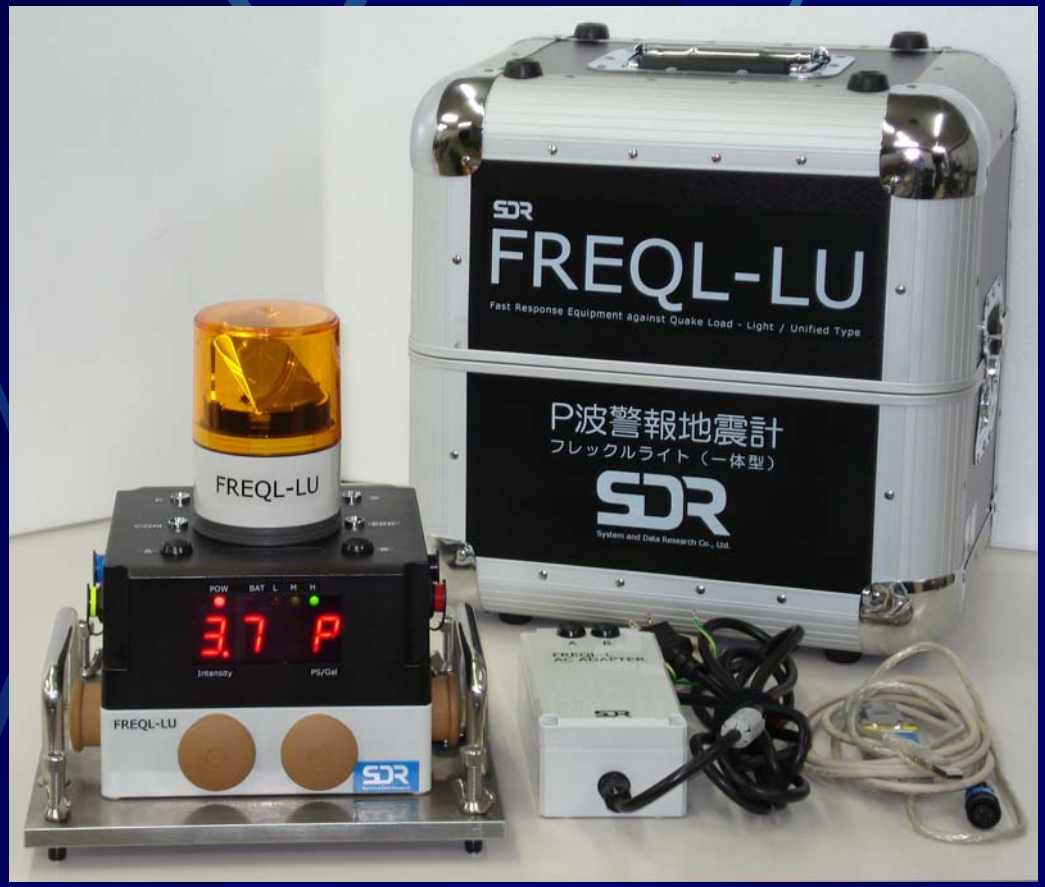
FREQL: Portable Type

First model in 2005

Second model in 2007

Going to New Horizons

AcCo–PS
for Surviving
and Quick Response



Third Model for Various Purposes

Comparison between JMA system and SDR system

This video is NHK news “UrEDAS Information Service will start in this year” that broadcasted at **1993/01/18**. Unfortunately, this project could not be realize because of strong opposition from JMA. Fourteen years later, October 2007, JMA began EEW service same as UrEDAS Information service. I would like to compare EEW by JMA and EEW by our system

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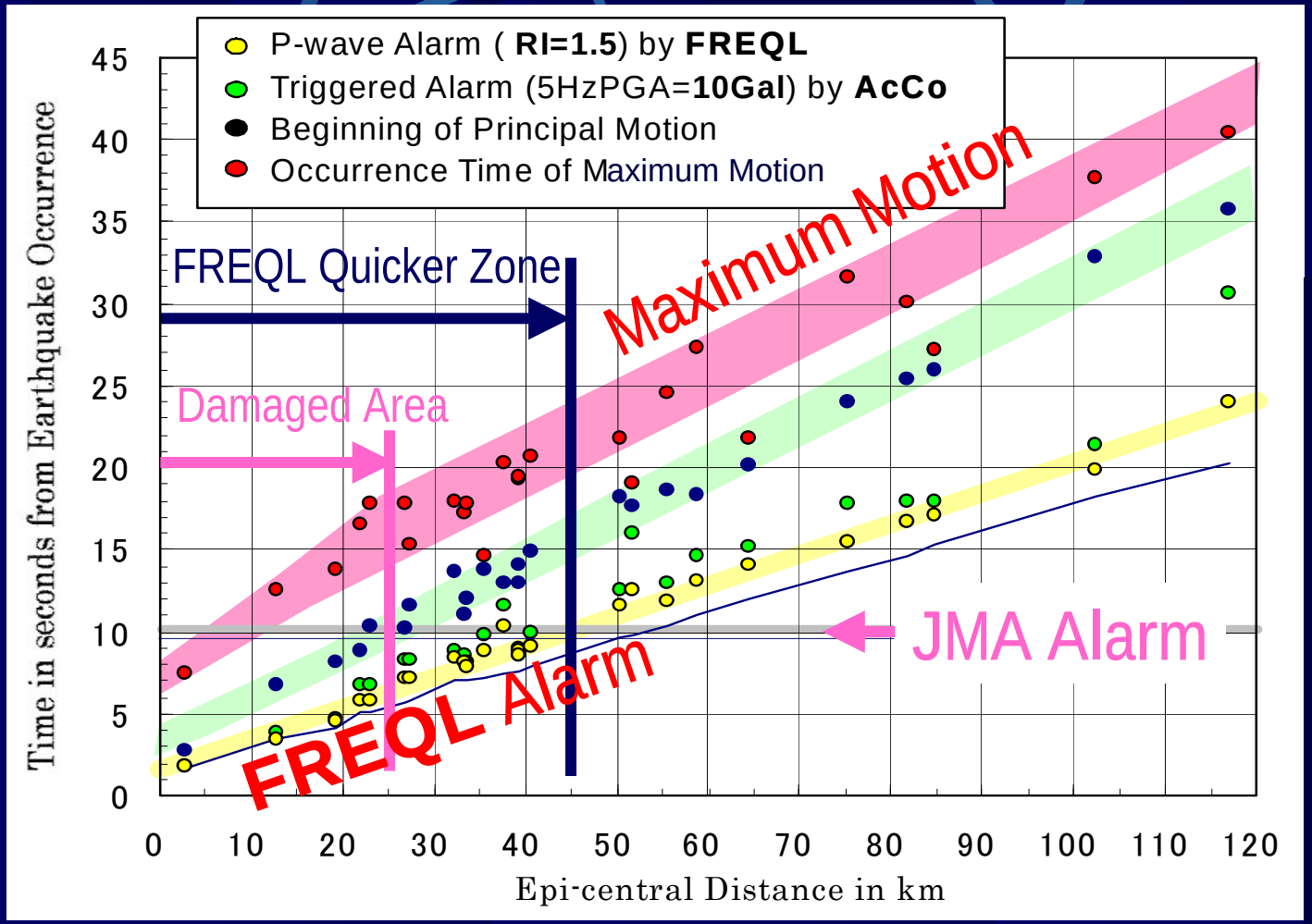
Actual Example with Simulated Results of FREQL or AcCo for Recent Damaged Earthquake



2008.6.14
Mjma 7.2
Depth 8km

This figure shows comparison between the EEW by JMA and simulated on-site alarm of FREQL and AcCo using strong motion records.
You can see that JMA alarm spread after the strong motion in damaged area.

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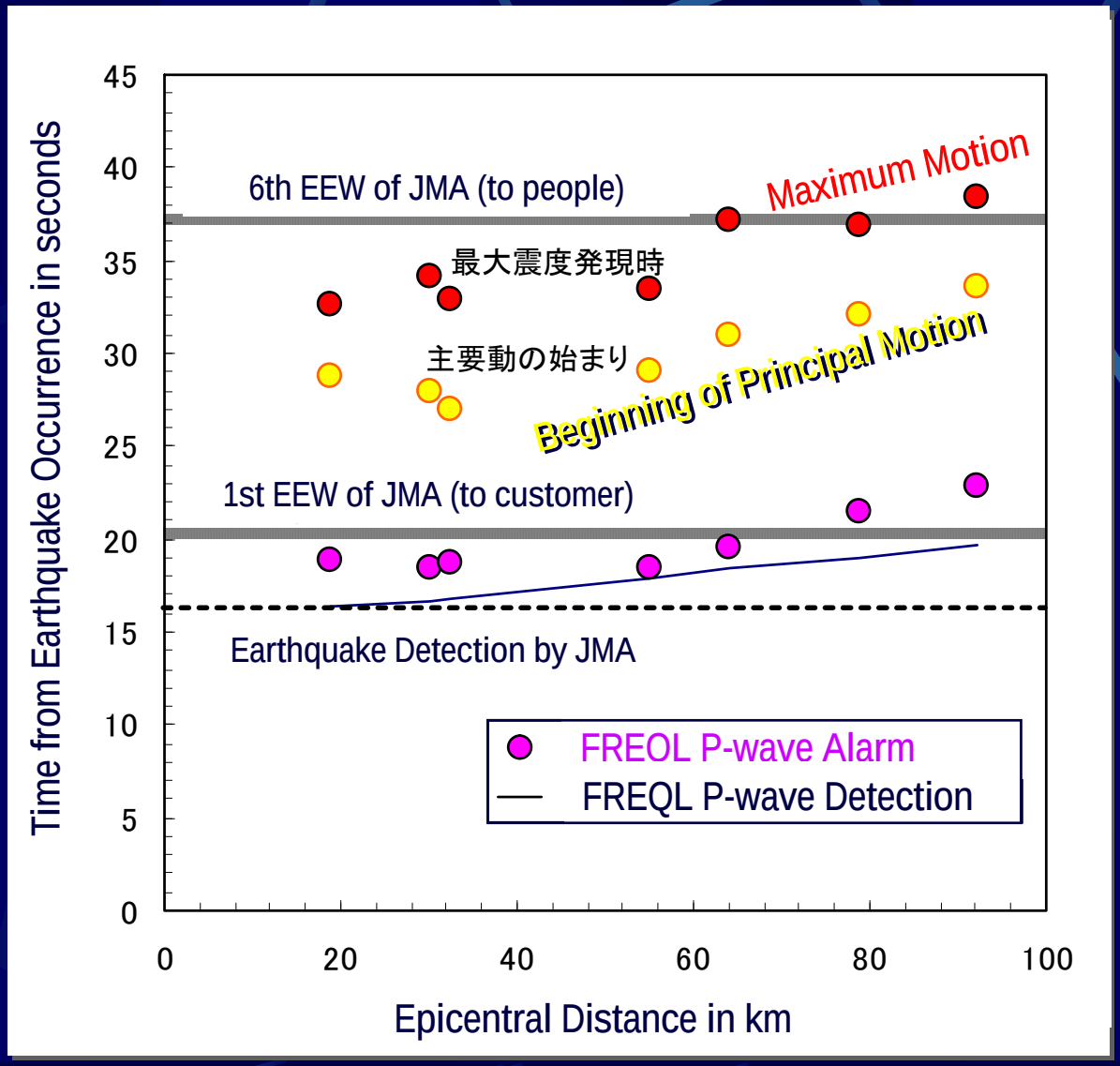
Comparison between EEW of JMA and on-site FREQL

2009/04/22



2008.7.24
Mjma 6.8
Depth 120km

EEW by JMA for public arrived after maximum motion

Even EEW by JMA for customer arrived after On-site FREQL information

Even for a deep earthquake EEW by JMA can be significantly later than On-site FREQL

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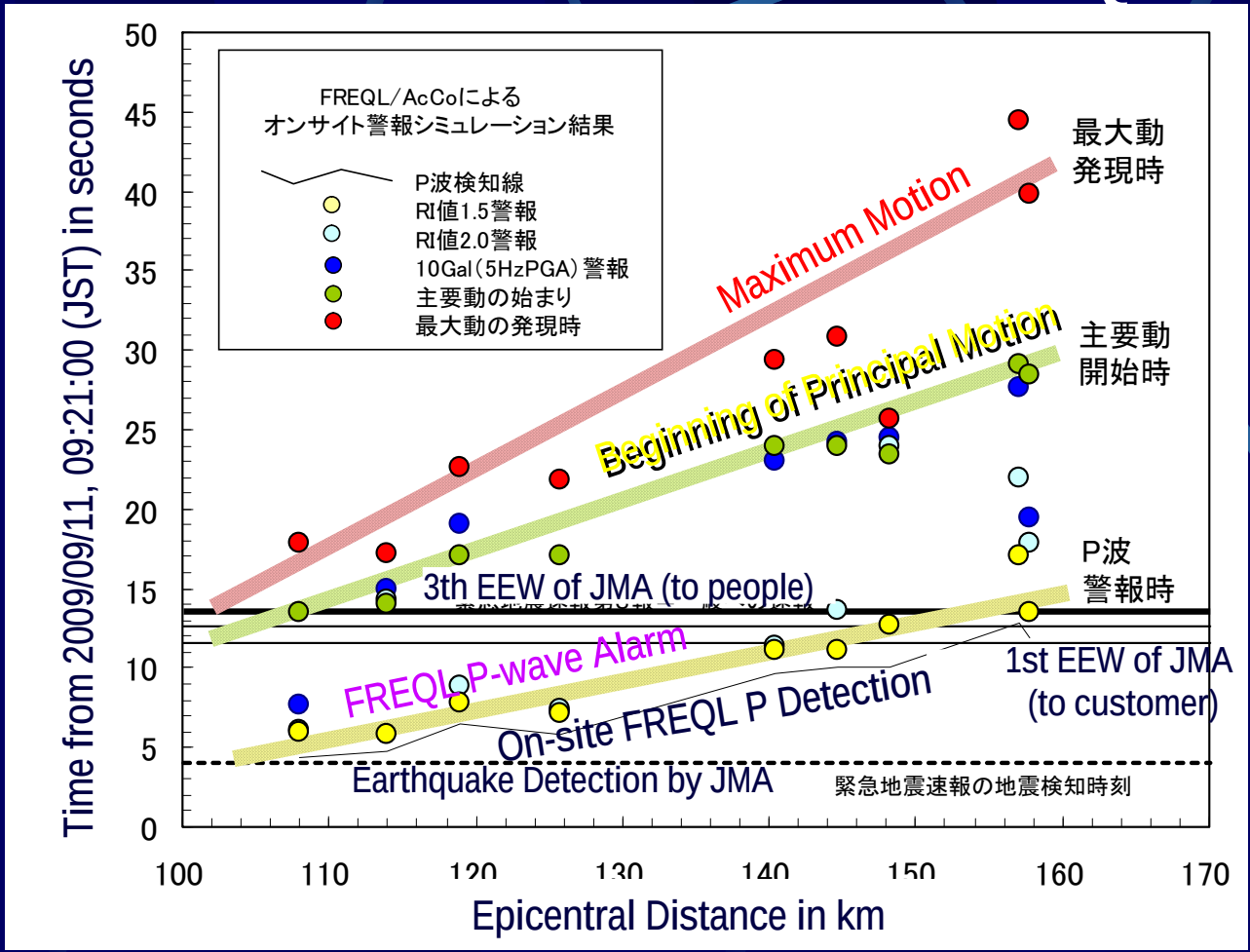
Comparison between EEW of JMA and on-site FREQL



2008.9.11
Mjma 7.1
Depth 20km

EEW by JMA arrived in almost same time of S-wave arrival

On-site FREQL information arrived over 10s before the S-wave arrival

Even for a distant earthquake EEW by JMA can be later than On-site FREQL up to 10s

The EEW by JMA always arrives after strong motion in damaged area. We would like to request to JMA to provide exact and accurate information just after the Earthquake instead of late EEW.

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What kind of information is required for earthquake disaster mitigation?

JMA restricts providing the earthquake information by unnecessary lows since December 2007.

But what truly important for EEW is to develop the "grass roots" network to build awareness to keep safety by ourselves.

Public authorities with dense observation network are expected to provide the exact and precise earthquake information immediately after the event.

JMA must abolish the restriction not only for the earthquake information but also for the tsunami warning.

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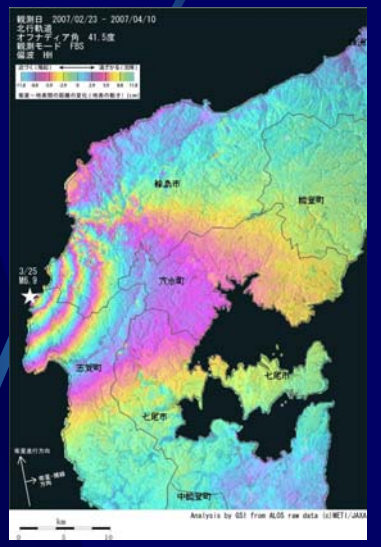
An Example of Issuing Late Warning and Wrong Focal Information

Corrected Information



After the 2007 Noto-Hanto-Oki earthquake, during over three hours, Seismic Information (Location, Depth and Magnitude) was reported with wrong information. According to this wrong seismic information, no damage and no tsunami were assessed. But, unfortunately sever damage was reported in hours later. Quick response may be cased by the late result from this wrong information.

What is necessary for earthquake disaster prevention?

2009/04/22

Before and During Quake

Quick Response
Using On-Site Alarm
against Sudden Quake

Escape to Safety Zone based on Each Feeling or On-Site Alarm, Needless Alarm by Authorities as JMA Because it is Too Late

Check the Safety Zone Constantly

Image and Real Training to Escape

After Quake

Disaster Imagination is required

Quick Rescue at the Possible Damage Area based on the Exact Earthquake Information by Authorized Organizations

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Concluding Remarks

According to the recent earthquakes of M7 class, the epicentral region is almost completely damaged. For the epicentral area, the EEW by JMA cannot be issued before the beginning of the strong motion; only the On-site P wave alarm is valid for surviving.

The nationwide system is not necessary to realize the On-site P wave alarm, and it is better to utilize the “grass root” network by each facilities.

In the complete damaged area, task forces are required from the outside of the damaged area. Because it is very important to know exactly where the complete damaged area is, exact information of the earthquake include the aftershocks are required.

Not only JMA but also the regional universities or NIED, having dense observation network, must issue this kind of detailed information.

JMA should not restrict issuing the information by these organizations.

According to this information, the task force should concentrate to the complete damaged area for quick rescue activities in several tens minutes.

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END

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