SDR

Session3-11

# Realtime Information Systems for Tokyo Metro and Others

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# INTRODUCTION

- The essentials for emergency response right after a big earthquake are the EEW and the information to grasp the exact shaking situation of the event.
- The EEW and the information are desired useful not only for a big plate boundary earthquake causing widespread seismic damage but also for an epicentral earthquake causing seismic damage locally.
- In particular, it would be possible to take a quick and certain response after the earthquake with “the EEW system” and “the system for exact and quickly shaking information in the relative area”.

# This presentation introduces

- The importance of EEW system & shaking information.

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The earthquake warning system of "Tokyo Metro".

# This presentation introduces

- The example of the comparison between our EEW system “FREQL” and EEW system of Japan Metrological Agency (JMA).

↓

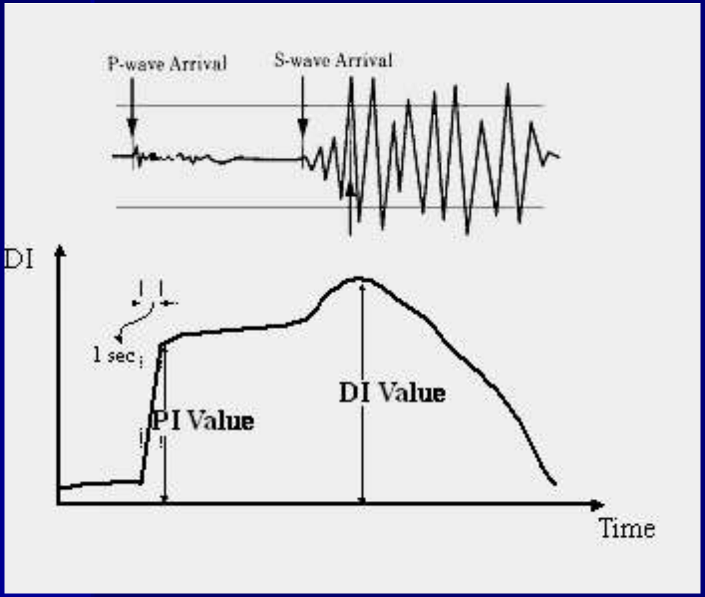
In case of “Onagawa nuclear power station” of Tohoku Electric Co.

# FREQL (Early earthquake alarm system)


- FREQL is developed for the earthquake alarm system based on the experiences of development and operation of the world first P wave alarm system UrEDAS. (Y. Nakamura. 1986)
- Estimation of the magnitude and location of the earthquake is available in 1 second after P wave detection. (UrEDAS function)
- P wave alarm is available the fastest time 0.2 second after P wave detection. (PI value. Y. Nakamura. 1998).
- S wave alarm is also available. (triggered by both acceleration and real-time seismic intensity.)

# FREQL (Early earthquake alarm system)

## PI value (Y. Nakamura. 1998)



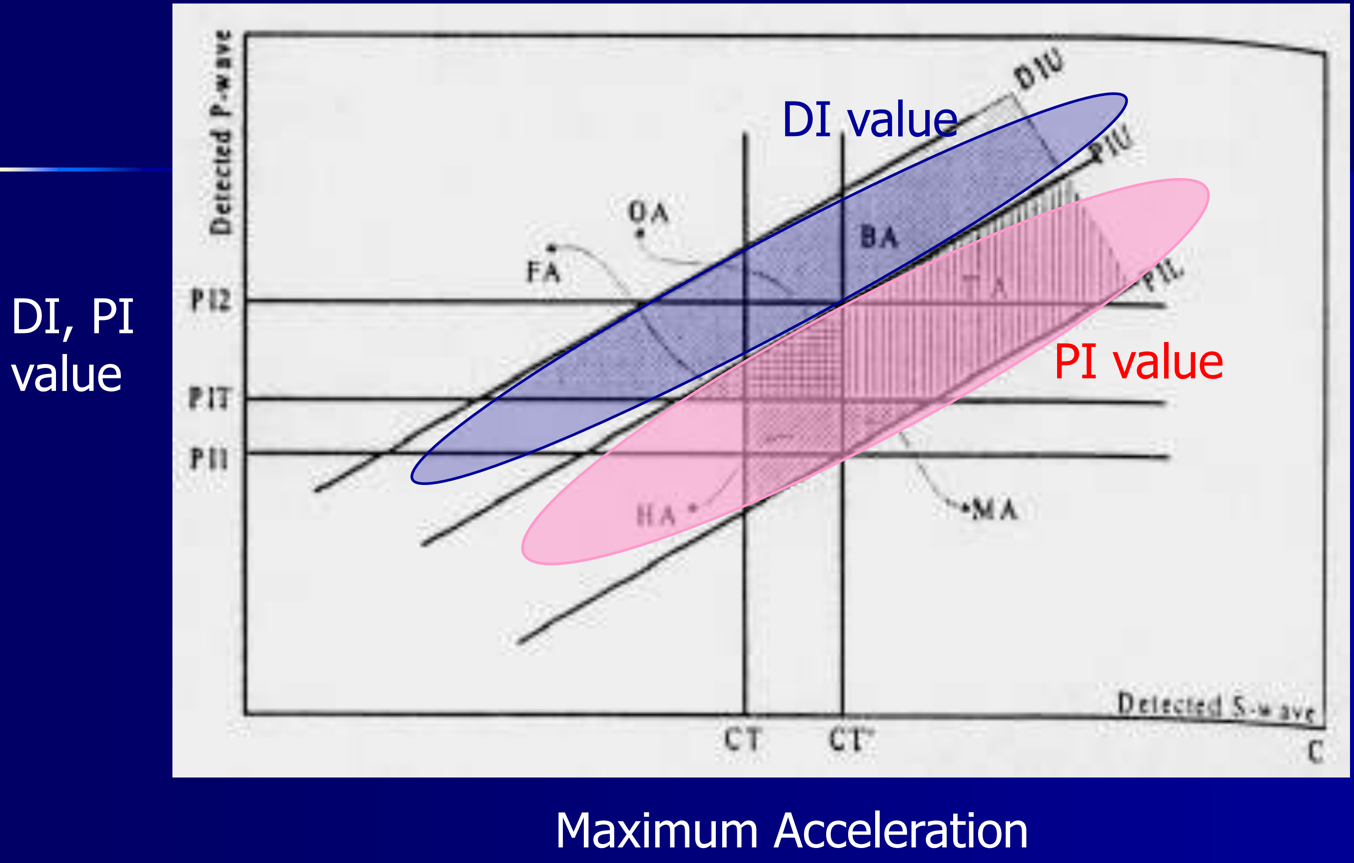

**PI value is defined as the maximum DI value during P wave.**

$$DI = \log| a * v |$$

**where, a: Acceleration (Gal),**

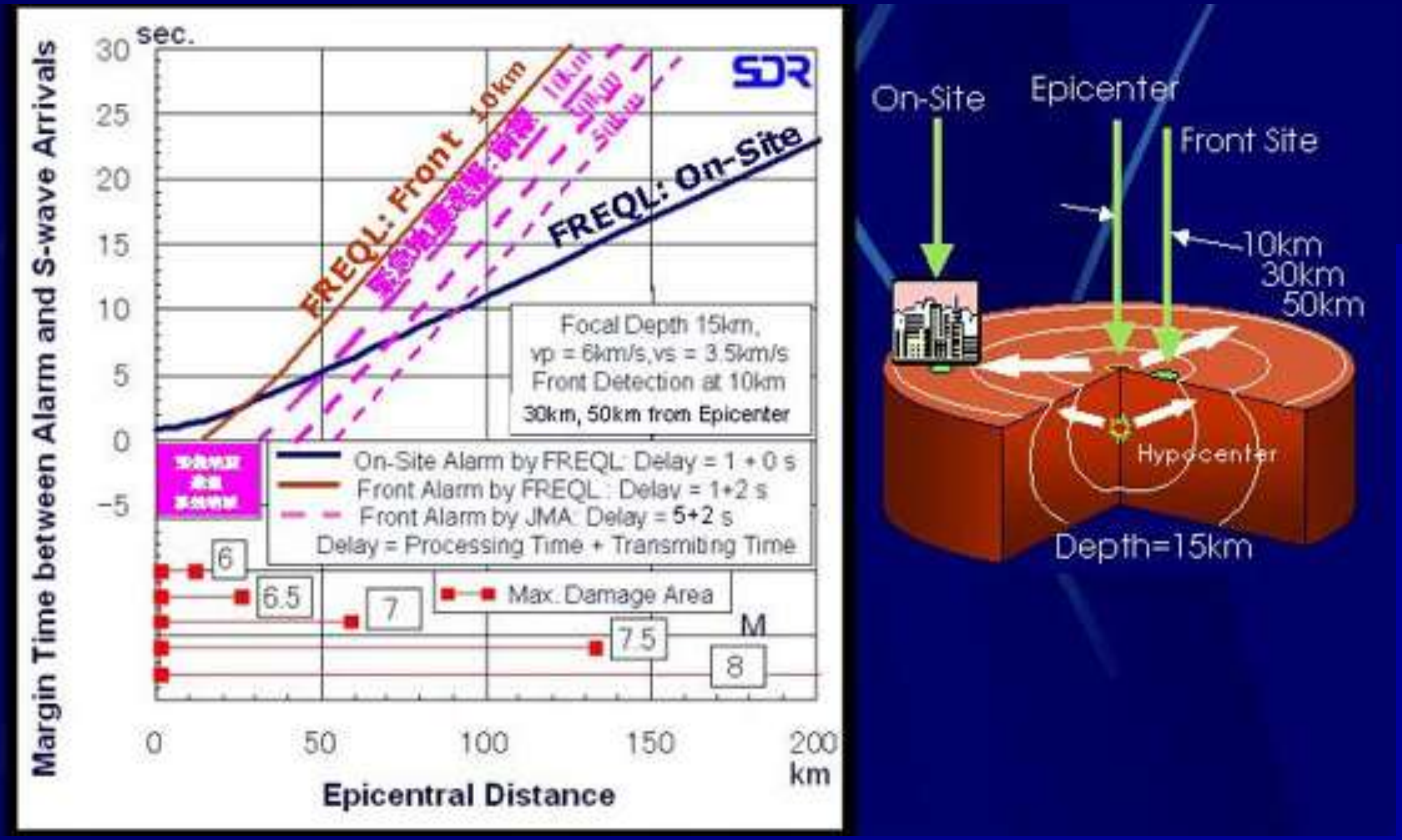
**v: Velocity (mkine)**

***: inner product operator**




**The relationship between PI, DI value and maximum acceleration**

**Maximum acceleration can be estimated by PI value.**




## The comparison between the time margin of FREQL and JMA information

In case of 50km from epicentral distance, even onsite warning of FREQL faster than JMA information.

# Onagawa nuclear power station


- **Number of units:**

  **3 units**

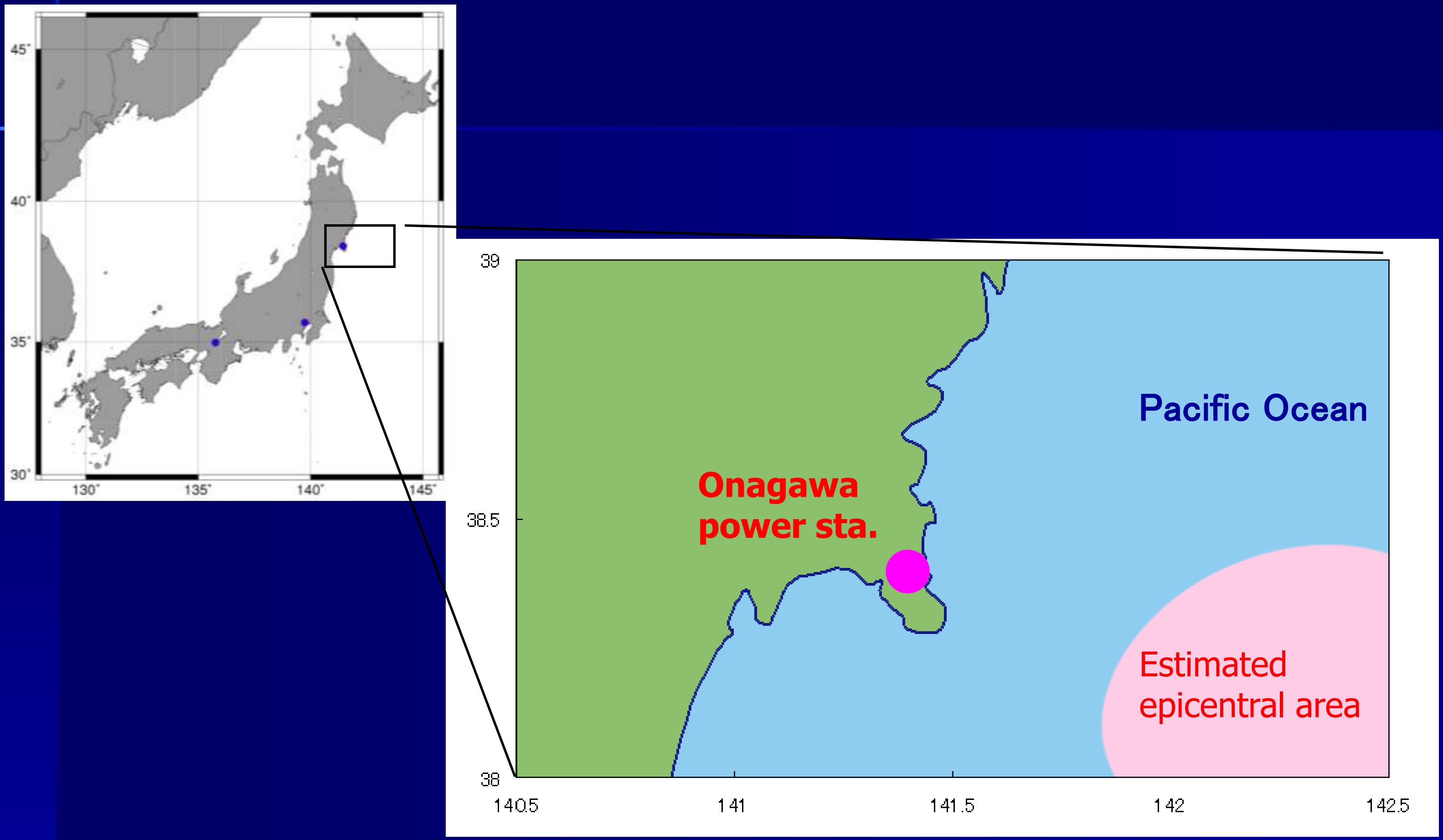
- **Total capacity:**

  **2174MW**

- **Location:**

  **Onagawa-cho and Ishinomaki City along the coast of the Pacific Ocean**

# Onagawa nuclear power station




The power station locates near estimated epicentral area.

The area occurs a earthquake (over M7) per about 37years.

# Onagawa nuclear power station

The power station locates near estimated epicentral area.

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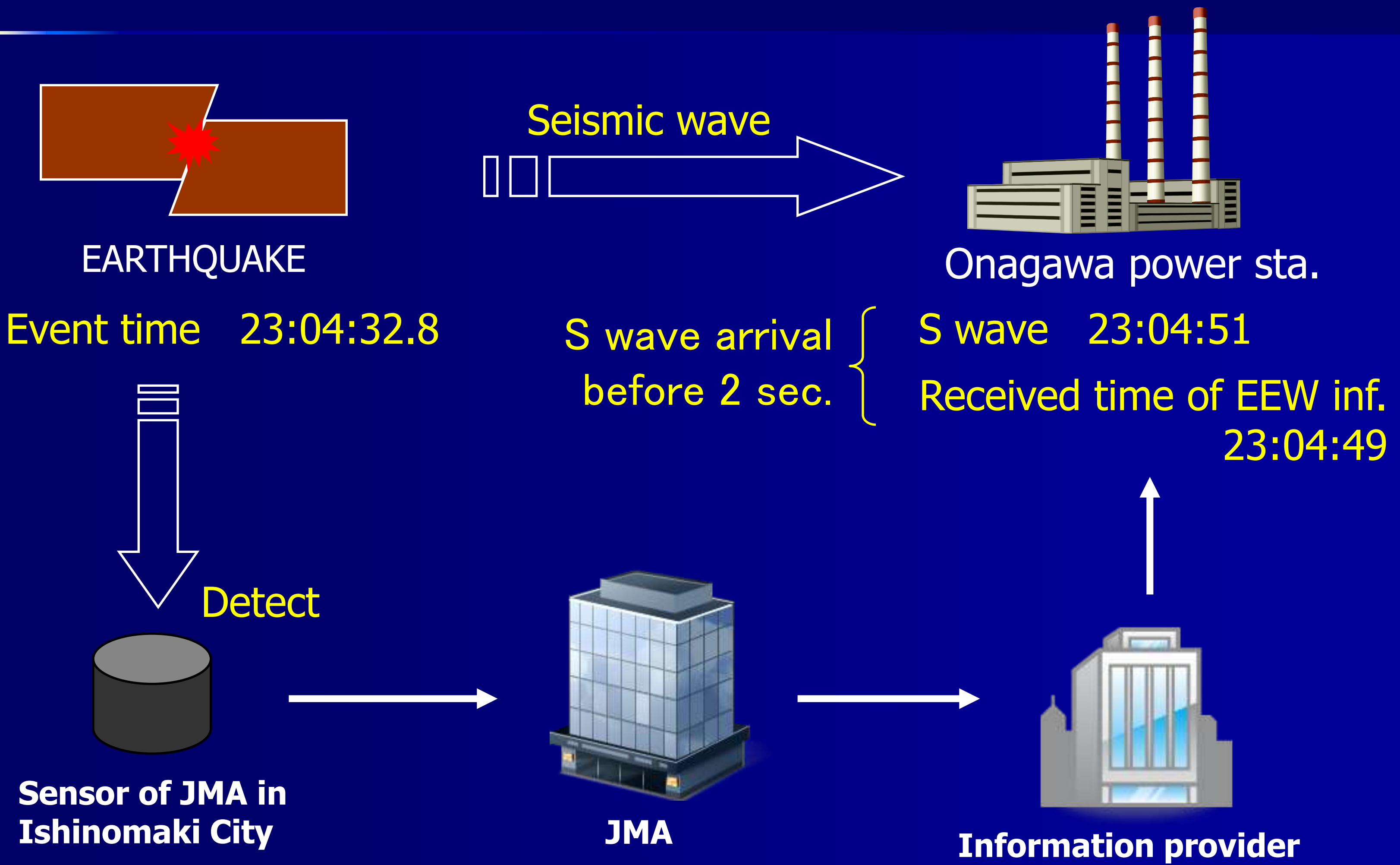
They have installed the earthquake warning system
for staffs of the power station since 2005.

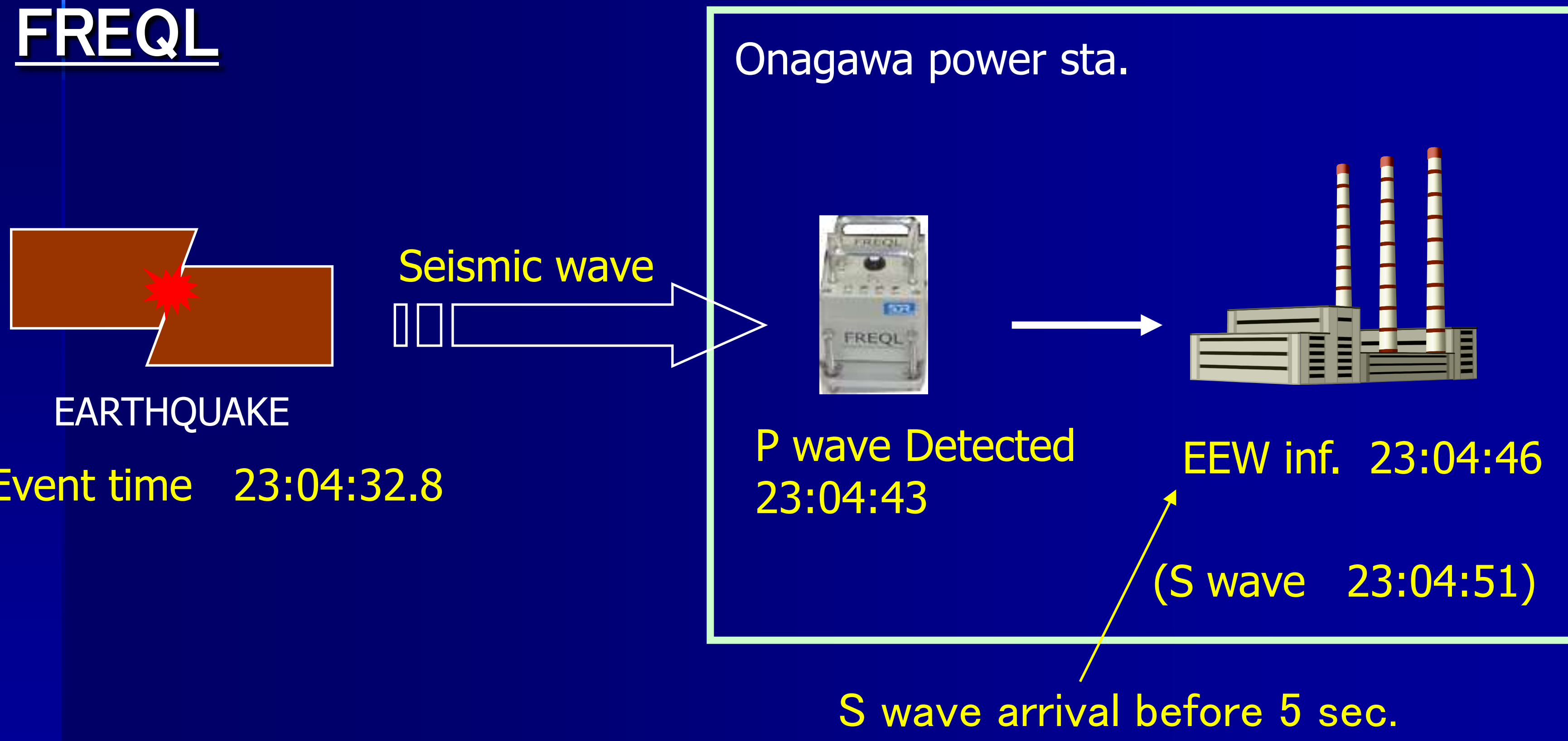
# Example of the comparison

## JMA system



# Example of the comparison

## FREQL



# Example of the comparison

**EEW inf. of JMA**

Time margin to S wave arrival: 2 sec.

**EEW inf. of FREQL**

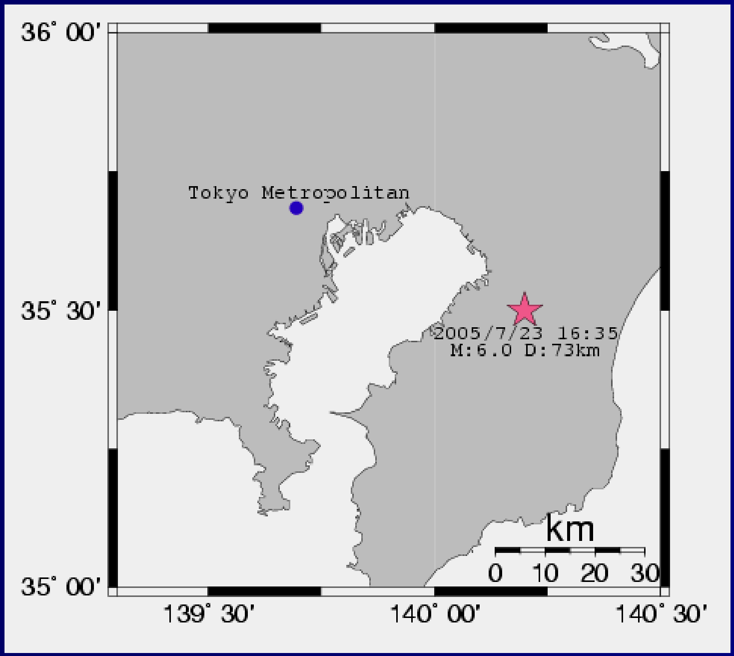
Time margin to S wave arrival: 5 sec.

FREQL made more margin compared with JMA system.

The margin is very short, but it's very important for an epicentral earthquake causing seismic damage locally.

# About Tokyo Metro

- We (SDR) built the new earthquake early warning/quick response system for Tokyo Metro based on the experience of the 2005 Chiba north-west earthquake.

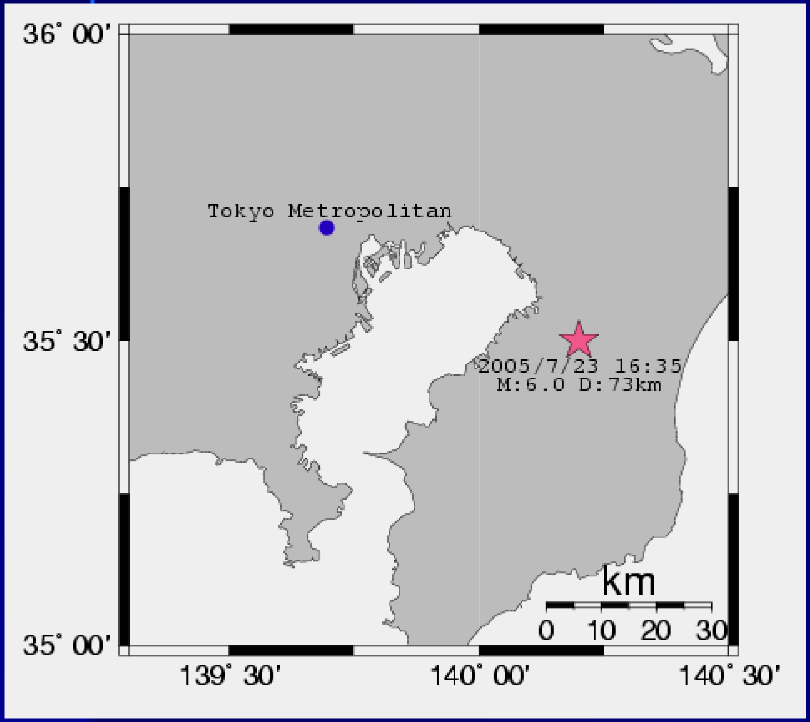



- Date: July, 23, 2005 16:35
- Magnitude: $M_{jma}$ 6.0
- Max. JMA intensity: 5+ corresponding to MMI VIII approximately.

Epicentral distance to Tokyo:

About 50km

# The 2005 Chiba north-west Earthquake




- This earthquake caused a traffic disturbance widely in Tokyo metropolitan area.
- Severe damage was not caused even in the area of high intensity.
- All the train operation had been stopped for a long time after the earthquake.
(The longest down time was 7 hours at JR. That of Tokyo Metro was 4 hours.)

# After the Earthquake

We proposed the earthquake early warning/quick response system.

- New earthquake early warning system.
  (for epicentral earthquake.)
- Integration system for detailed seismic motion on their service area.
  (to grasp the damage in detailed)

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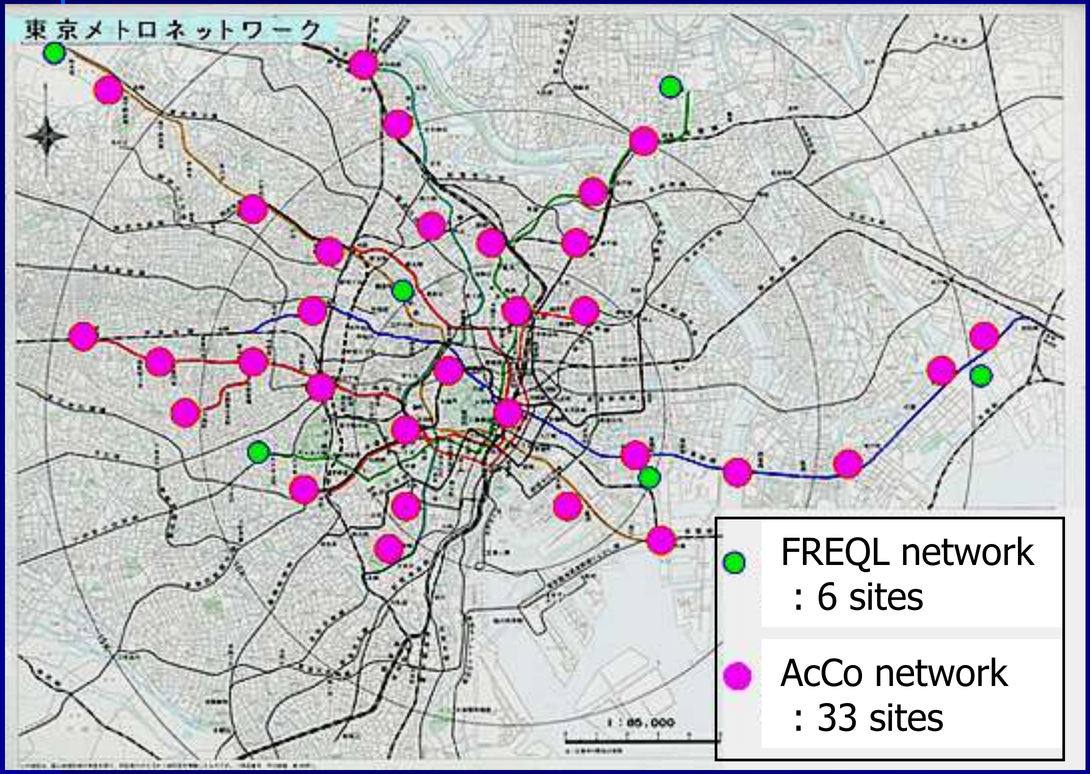
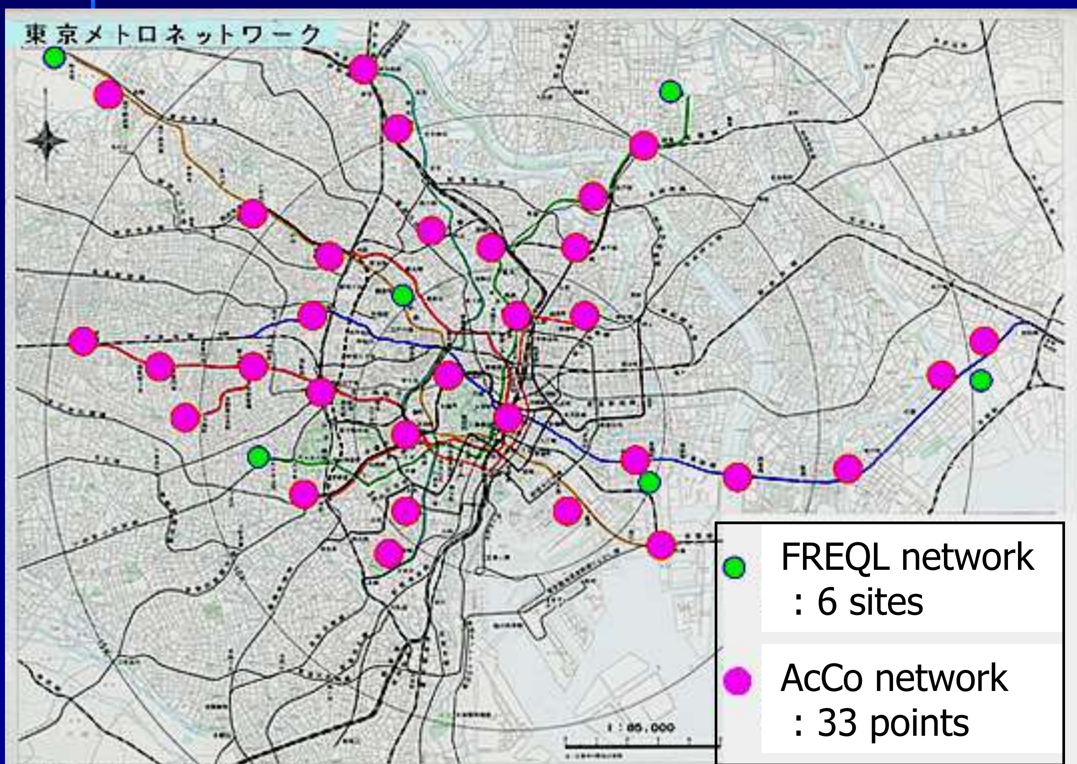
The system consists of two seismometer networks.

# New Earthquake Early Warning System (FREQL network)




- Consisted with six seismometers.
- To control or stop the train operation immediately after the earthquake.

# Integration System for detailed seismic motion (AcCo network)




- The network is called "area seismometer network" at Tokyo Metro.
- Consisted with 33 seismometers in every about three kilometers mesh.
- To grasp more detailed seismic motion on their service area.

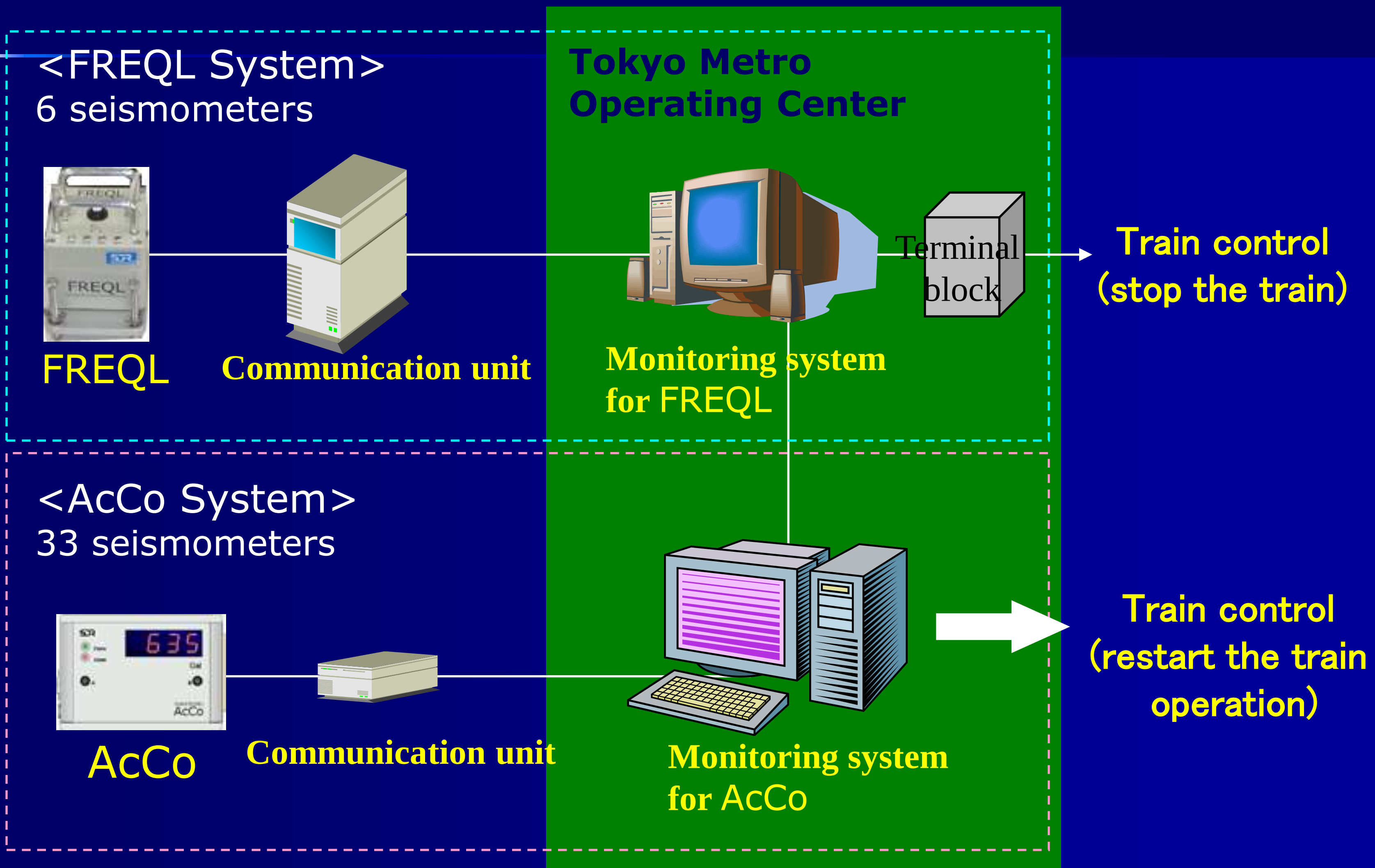
# AcCo (Palmtop size Digital Seismometer)



MMI and Acceleration are displayed alternately by 0.5 seconds.

- Digital display of acceleration and seismic intensity in real-time.
- Possible to save the best two waveforms in the event memory.
- Low cost.

# System Overview



# Simulation of the System

<FREQL System>

FREQL

**Early waning**
after P wave detected

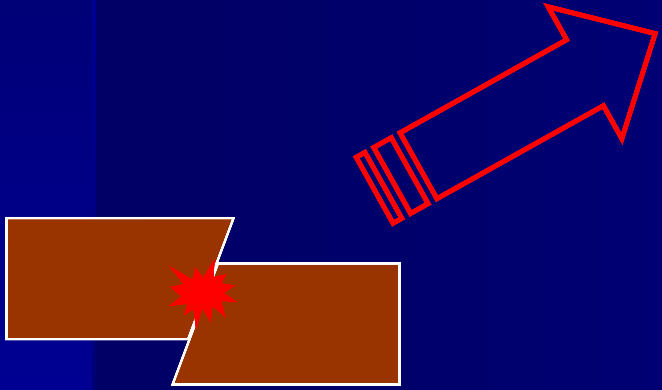
**Detect P wave**

<AcCo System>

Sending seismic
information (Acc. etc.)

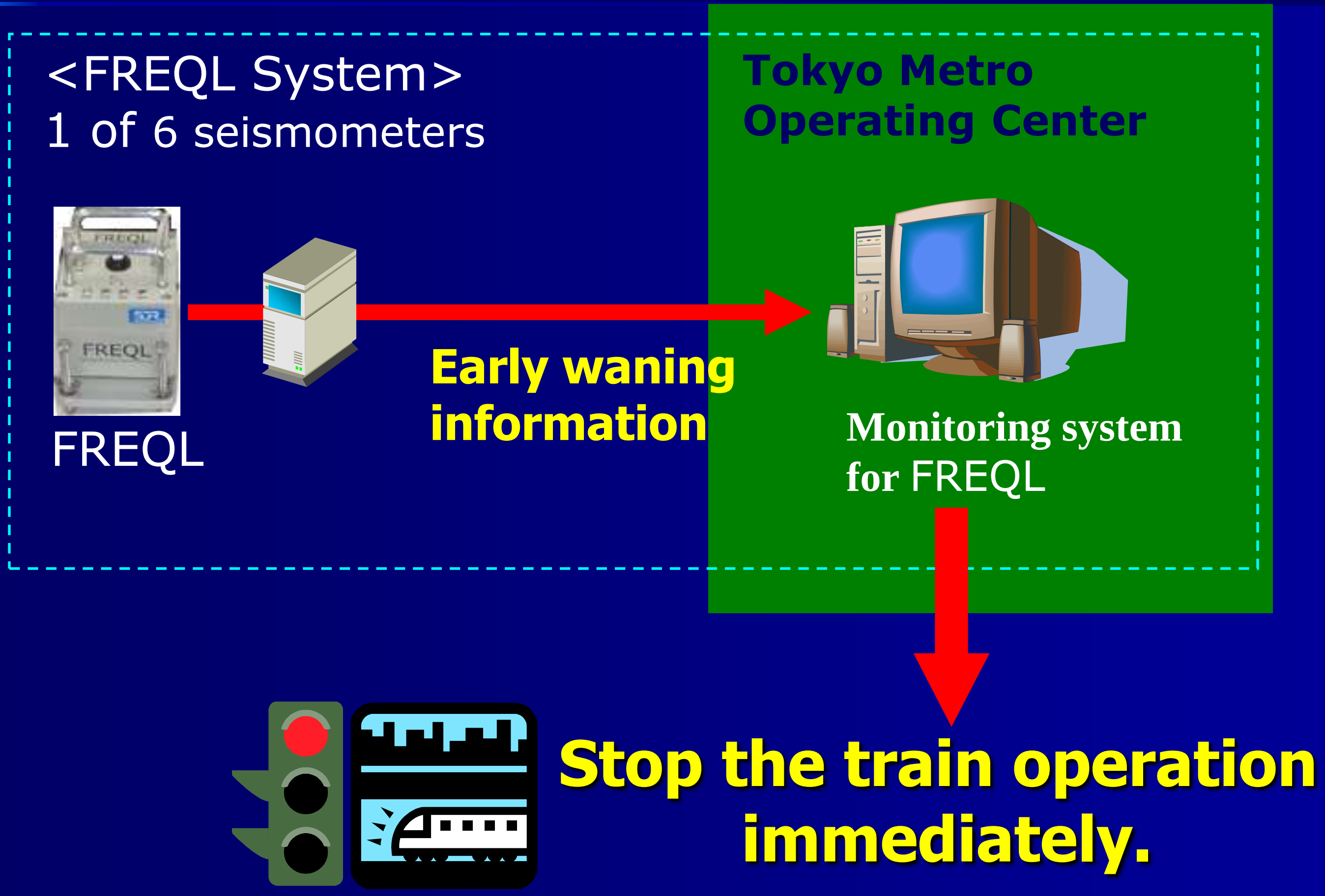
AcCo

**Detect Acceleration**
(monitor earthquake motion)

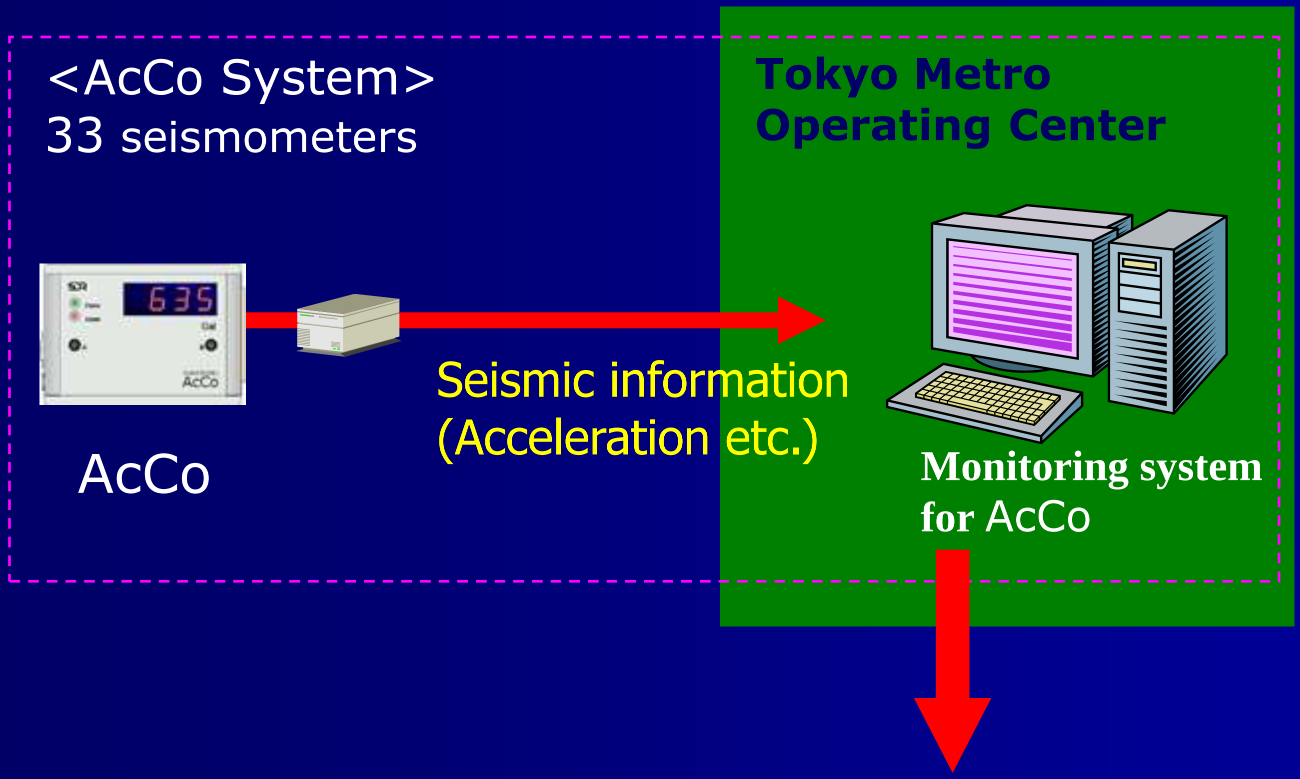


EARTHQUAKE

# Simulation of the System



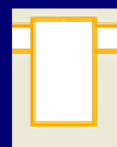
# Simulation of the System




**Display the collected seismic motion immediately.**

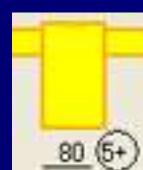
# Simulation of the System

<AcCo System>

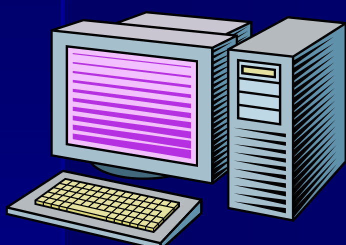
None: no warning, (under 39 Gal)


Blue: Level 3 warning, (40 – 79 Gal)
Check the track on the train




Yellow: Level 2 warning, (80 – 99 Gal)
Check the track on the train


Red: Level 1 warning, (over 100 Gal)
Check the track on foot



**Monitoring system for AcCo**

Display and classify the each warning section by acceleration.

# Simulation of the System

<Before AcCo System installed>

They had to check all track on foot,
when the reference acceleration exceeded 100Gal.

<AcCo System>

Classify the each warning section by acceleration.

↓

Select the checking area (track).

↓

Check the area (track).
It's not all area.

Restart the train operation efficiently.

# Conclusion

- FREQL made more time margin compared with JMA system, because the processing time of EEW by JMA is several seconds depending on the system algorism and the complex system.

- For the large system as the train operation, it is necessary for the control against the earthquake to equip the system not only to issue the early warning but also to support the quick and rational recovery work after the earthquake.